

**Annual Report on the  
Mathematical Sciences Research Institute  
2014–2015 activities supported by  
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# Mathematical Sciences Research Institute

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### 2015 Summer Graduate School Reports

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# 1. Overview of Activities

This annual report covers MSRI's projects and activities that occurred during the last 14.5 months of the NSF core grant, DMS-0932078. Following the new reporting timeline, this report includes two summers, 2014 and 2015.

## 1.1 New Developments

The year 2014–15, was a busy and exciting year. We held four (4) one-semester programs: *New Geometric Methods in Number Theory and Automorphic Forms* and *Geometric Representation Theory* were paired during the fall semester and *Dynamics on Moduli Spaces of Geometric Structures* and *Geometric and Arithmetic Aspects of Homogeneous Dynamics* were held during the spring semester. All four programs were very popular, and their workshops well attended. All programs had stellar researchers. Five (5) of them, Joseph Bernstein, Marc Burger, Pierre Colmez, Elon Lindenstrauss, and Ngo Bao Chau, were funded by the Clay Mathematics Institute.

Joseph Bernstein is an internationally respected and accomplished researcher. He is the noted recipient of a wide array of honors, including the 2004 Israel Prize in Mathematics, and has been awarded membership in the Israeli Academy of Sciences, the USA National Academy of Sciences, and is a Fellow of the American Mathematical Society. Aside from his research contributions, Bernstein's leadership and mentorship are legendary. Many of those who have studied under him are now leaders in the area of Geometric Representation Theory.

Marc Burger's accomplishments and status have been internationally recognized many times over. He is a member of Leopoldina, the German National Academy, as well as a Fellow of the American Mathematical Society. He is serving on several boards and scientific committees, such as the Board of Trustees of the Institut des Hautes Études Scientifiques, the Scientific Advisory Committee of the University of Vienna, and the Editorial Board of *Commentarii Mathematici Helvetici*.

Pierre Colmez is one of the very prominent researchers in number theory, as his strong international reputation corroborates. In 1999, he received the distinguished Gabrielle Sand et Guido Triossi prize from the French Academy of Sciences; a few years later, in 2005, he received the Prix Fermat from the Institut Mathématiques de Toulouse, which makes him a member of an exceptional class of recipients such as Andrew Wiles (1995), Richard Taylor and Wendelin Werner (2001), and Manjul Bhargava and Igor Rodnianski (2012). He was a Professor at the École Polytechnique (France) for almost 20 years before moving to the Institut Mathématiques de Jussieu, and he has visited countless mathematics research departments across the world.

Ngô Bảo Châu's proof of the Fundamental Lemma of Langlands-Shelstad earned him the Fields Medal in 2010. Prior to that, he won the Clay Research Award (with G. Laumon) in 2004 and the Prix Sophie Germain de l'Académie des Sciences de Paris in 2007. He is a fellow of the American Academy of Arts and Sciences (since 2012) and gave a plenary address at the ICM 2010 in Hyderabad. Even entities outside of the mathematical research community have acknowledged his incredible potential: In 2009, Time magazine chose his proof of the Fundamental Lemma as one of the top ten scientific discoveries of the year.

Elon Lindenstrauss' fame precedes him, and there is not much we can say that is not already well known. In 2010, he was awarded the Fields Medal for his results on measure rigidity in ergodic theory and their applications to number theory. Starting in early 2000, his Ph.D. thesis won him both the Kennedy-Lee Prize (2000) and, a year later, the Nessyahu Prize; in 2003, he received the Salem Prize (with Kannan Soundararajan), which is awarded to young researchers for outstanding contributions to the field of analysis; in 2004, he received the European Mathematical Society Prize; in 2008, he received the Michael Bruno Memorial Award, and, in 2009, he was honored with the Anna and Lajos Erdős Prize in Mathematics and the Fermat Prize. Since 2012, he has been a member of the Israel Academy of Sciences and Humanities as well as a member of the Academia Europea.

Another outstanding member was Maryam Mirzakhani a Research Professor in the Dynamics on Moduli Spaces of Geometric Structures program. In 2014 she was awarded a Fields Medal for her outstanding contributions to the dynamics and geometry of Riemann surfaces and their moduli spaces. She became the first female, and first Iranian, to win this prestigious prize. Mirzakhani became known to the international math scene as a teenager, winning gold medals at both the 1994 and 1995 International Math Olympiads – she finished with a perfect score in the latter competition. She received her Ph.D. from Harvard University in 2004 under the guidance of Curtis McMullen. From 2004 to 2008 she was a Clay Mathematics Institute Research Fellow and an assistant professor at Princeton University. In 2008, she became professor at Stanford University. Many consider her work to be “truly spectacular”. One of Mirzakhani's more recent contributions — a monumental collaboration with Eskin about the dynamics of abstract surfaces connected to billiard tables — is “probably the theorem of the decade” in Mirzakhani's highly competitive field, said Benson Farb, a University of Chicago mathematician.

Another twenty-three (33) researchers were MSRI Eisenbud and Simons Professors.

All four programs reported striking results (see the Appendix for more details), and a significant factor in this success was the care taken to ensure synergistic pairings among the programs. Such pairing are not easily made, and their success is not always predictable. However, when the 2014 -15 Fall and Spring programs were being solicited, the Scientific Advisory Committee made a conscious and determined effort to find subjects that would enrich one another with potentially unexpected interactions. Largely due to the Committee members' depth and breadth of expertise, their pairings yielded astonishing results.

In Fall 2014, some of the most striking results came from the geometric arithmetic Langlands program. The seminal work of Scholze and Fargues presented in the Chancellor's Lectures (given on the UC Berkeley campus by Peter Scholze) set the foundations for a bridge between the topics of the two fall programs, Geometric Representation Theory (GRT) and New Geometric Methods in Number Theory. A new curve, the Fargues-Fontaine curve, emerged as the fundamental geometric object, which to be understood requires the new machinery of Scholze. That is, the theory of perfectoid spaces and its elaboration, that of diamonds. That theory allows one to effectively treat algebra over  $\mathbb{Q}_p$  as geometry over a curve. The vision of Scholze and Fargues embeds the local Langlands program into the (newly formulated) geometric Langlands program on this curve, bringing the key ideas underlying the GRT program into direct contact with number theory. These Chancellor's Lectures were oversubscribed, and

enthusiastically followed by graduate students, program members, and faculty from the UCB math department.

To elaborate a bit further, let us add that Laurent Fargues, a member of the number theory program, exploited the techniques introduced by Scholze during his Chancellor's Lectures in an unexpected way. Fargues proposed a compelling geometric framework for formulating the local Langlands correspondence, in the spirit of the Geometric Langlands correspondence and in the style of the work of Adams-Barbasch-Vogan for the Archimedean case. More precisely, given a quasi-split reductive group  $G$  over the field of  $p$ -adic numbers, Fargues proved that the points of the stack of  $G$ -bundles on the Fargues-Fontaine curve are in bijection with the Kottwitz set of  $\delta$ -conjugacy classes in  $G$ . Fargues formulated a conjecture asserting the existence of a functor associating to each Langlands parameter with values in the Langlands dual group of  $G$ , a perverse sheaf on the stack of  $G$ -bundles together with a long list of natural properties. The work of Scholze and the conjectures of Fargues will surely serve as a roadmap for the future development of the local Langlands correspondence and are bound to frame the interactions between geometry and algebra for years to come.

One of the factors that led to the success of the Geometric and Arithmetic Aspects of Homogeneous Dynamics (GAAHD) Spring 2015 program was the overlap with the parallel Dynamics of Moduli Spaces of Geometric Structures (DMSGGS) program. As the program names suggest, the common denominator of both programs is the role of dynamics in understanding various phenomena. Thus, while the objects of study in the two groups are different, there is much overlap in techniques and there is a common language, which includes such notions as group actions, symmetric spaces, and discrete subgroups of Lie groups. An example of a research collaboration involving members of both programs is provided by Maryam Mirzakhani (a member of the DMSGGS program) and Alex Wright (a postdoc from the GAAHD program). Building on earlier work of Mirzakhani with Alex Eskin and Amir Mohammadi (also from the GAAHD program) that showed that all  $SL(2;R)$  orbit closures in moduli spaces of translation surfaces are affine submanifolds, they investigated the boundary of these affine invariant manifolds in the Deligne Mumford compactification. A preprint of their paper has appeared.

This year, the MSRI's annual *Hot Topics workshop* was on *Kadison-Singer, Interlacing Polynomials, and Beyond*. In a recent paper, Marcus, Spielman and Srivastava solved the Kadison-Singer Problem by proving Weaver's KS2 conjecture and the Paving Conjecture. Their proof involved a technique they called the "method of interlacing families of polynomials" and a "barrier function" approach to proving bounds on the locations of the zeros of real stable polynomials. Using these techniques, they also proved that there are infinite families of Ramanujan graphs of every degree, and they developed a very simple proof of Bourgain and Tzafriri's Restricted Invertibility Theorem. The goal of this workshop was to help build upon this recent development by bringing together researchers from the disparate areas related to these techniques, including Functional Analysis, Spectral Graph Theory, Free Probability, Convex Optimization, Discrepancy Theory, and Real Algebraic Geometry. A full report can be found in the appendix.

The talks of all of our workshops were recorded and can be seen on our website at <http://www.msri.org/web/msri/online-videos>.

**Funding.** In 2014–15, MSRI’s overall expenditures totaled \$9,729,070 with \$6,886,772 (71%) dedicated to science. This was the year when MSRI, in partnership with the IAS, held a Math Festival in Washington DC. Of the overall **scientific** expenditures, \$4,965,474 (73%) came from the NSF, \$443,873 (6%) from the NSA, and the rest, \$1,477,425 (21%) came from private funds such as, Simons Foundation, Clay Mathematical Institute, donors, other foundations, and MSRI’s Endowment returns. For example, of the support for program members (long-term visitors) 62.5% came from the NSF, 7.4% from NSA, and 30.12% from private funds. Of the support for workshop participants (short term visitors) 72.7% came from the NSF, 7.6% from the NSA, and 19.7% from private funds. These numbers demonstrate MSRI’s ability to leverage the support that the NSF provides and thereby amplify its benefits; we feel that this is possible because the core NSF support provides such a strong foundation for, and endorsement of, MSRI’s scientific quality.

**Postdoctoral Program.** Thirty-six (36) Postdoctoral Fellows participated in our four scientific programs, of which twenty-five (25) were funded by the NSF Core Grant. Yaping Yang and Qionglng Li were the Cha-Chern postdoctoral Fellows; Sam Gunningham and Guillaume Dreyer were the Viterbi Fellows; Jasmin Matz was the Strauch Fellow; Han Li was the Gamelin Fellow; Sara Maloni was the Huneke Fellow; and Bao Le Hung was the Berlekamp Fellow. As for the past years, there was a consensus among them that the wealth of connections they were able to establish with the top researchers in their field and with fellow postdocs was extremely beneficial, as was the possibility of learning directly from the leaders of their fields. These connections have played an important role in their professional development. For details, please see Section 3 and the Appendix.

**Summer Graduate Schools.** In 2014, 92 institutions nominated 280 graduate students for one of MSRI’s summer schools. Of those 222 were accepted, and in the end, 198 participated in one of the six (6) offered schools. Three were held at MSRI, and the others were held at the Park City Mathematics Institute in Utah, the Centre de Recherche Mathématiques in Montréal and in Guanajuato, Mexico.

In 2015, 119 institutions nominated 327 graduate students for one of MSRI’s summer schools. Of those 253 were accepted, and in the end, 217 participated in one of the eight (8) offered schools. Five were held in Berkeley, two were held at the Centre de Recherche Mathématiques in Montréal and one at the National Institute for Mathematical Sciences in Daejeon, South Korea.

For most of the summer graduate schools, enrollment is based on a first-come, first-served policy. The schools are so popular that some schools reach their maximum capacity within the first 24 hours. Detailed descriptions and reports for each of the SGS can be found in Section 4 and in the Appendix.

**MSRI-UP.** The MSRI Undergraduate Program (MSRI-UP) is a research program for undergraduates (an REU) that targets underrepresented minorities, with the goal of increasing their interest and enrollment in mathematics graduate programs. In the summer of 2015, the lead director was Dr. Duane Cooper of Morehouse College, and the primary instructor and research director was Dr. Francis Su of Harvey Mudd College. The research topics for the summer were on Geometric Combinatorics Motivated by the Social Sciences, and the students worked in teams of three on various projects motivated by 'fair division' questions and voting theory, using a mix of techniques from combinatorics, convex geometry, and analysis. Students wrote technical

reports and presented the results of their research at the MSRI-UP Student Colloquium the last day of the program. One poster from 2015 MSRI-UP was selected as outstanding presentations in the undergraduate poster session at the JMM.

Please note that since MSRI-UP is funded by an NSF grant independent of MSRI's core grant, the detailed report has been filed independently.

**Collaborative Diversity Initiative.** The *Diversity Initiative* consists of a series of workshops for members of groups that have been historically underrepresented in the mathematical sciences. These workshops are sponsored by a collaborative grant involving the eight NSF-funded US mathematical sciences institutes (AIM, ICERM, IMA, IPAM, MBI, MSRI, NIMBioS, and SAMSI). MSRI is the institute administering the grant. During the 2014–15 year, three events were supported by the Initiative: *Modern Math Workshop*, held in Fall 2014 in Los Angeles, California, and organized by the SAMSI; the *Blackwell Tapia Conference*, also held in fall 2014 and organized by the IPAM; and *Infinite Possibilities*, held in Spring 2015 in Corvallis, Oregon, and co-organized by the MBI. The reports for those last two workshops are part of each institute annual report as agreed upon with the NSF. The one on Modern Math workshop, having been organized by the MSRI, is part of this report and attached in the appendix with all workshop report.

**Critical Issues in Mathematics Education.** The Critical Issues in Mathematics Education (CIME) series of workshops addresses key problems in education today. They are designed to engage professional mathematicians in discussions with education researchers, teachers, and policy makers to improve mathematics education. This year's topic was on *Developmental Mathematics: For whom? Toward what ends?* There were about 125 attendees, all very engaged in the discussions. It was funded through grants from the Division of Education at the NSF and thus reported to them directly.

### **Public Understanding of Mathematics.**

*National Math Festival.* The first ever National Math Festival drew more than 20,000 children and adults to the Smithsonian Museums in Washington, DC, on Saturday, April 18, 2015. There were games, puzzles, demos, performances, lectures, and more. The festival also addressed math policy, with a congressional briefing on the importance of teacher preparation in mathematics as well as a math education forum on college and career readiness standards. The National Math Festival will run every two years, so it will return to Washington, D.C. in April 2017.

*Mathical: Books for Kids from Tots to Teens.* MSRI, in conjunction with The Children's Book Council and with support from the Simons Foundation, launched the Mathical Book Prize, which cultivates a love of mathematics in the everyday world. Each year's winners and honor books join a selective and ever-growing list of new and previously published fiction and non-fiction titles for kids of all ages. These titles are as varied as the intersection between literature and mathematics — that is to say, they encompass picture books, novels, poetry collections, puzzle books, biographies, and more. The prize seeks to expand the public understanding and enjoyment of mathematics through highlighting titles that will inspire young people of all ages to see the world in new ways.



*Numberphile*. Since January 2014, MSRI has supported Brady Haran’s “Numberphile” channel on YouTube. MSRI has contributed both support and connections to some of the world’s great mathematicians — we recommend the charming piece by Barry Mazur on right triangles, and the deep interview with John Conway — and with young mathematicians such as Holly Krieger, a postdoc in arithmetic dynamics at MIT who was at MSRI for a semester last year. We were amazed by the result on primes and iterated functions that she explains in her video. These and other treats can be found at <http://www.numberphile.com/>.

*Not on The Test*, MSRI and Berkeley City College (BCC) continued their partnership with the lecture series, “Not on the Test: The Pleasures and Uses of Mathematics.” Held in BCC’s auditorium in downtown Berkeley, the series of four free, public talks was made possible through generous funding from the Simons Foundation. Topics included *Search Engines Through the Ages*; *I’m in the Database (But Nobody Knows)*; *Making Music Socially: A Story of People and Technology in the 21st Century*; and *Universal Access to All Knowledge*.

*Chicago Mercantile Exchange Prize*. The 9th annual CME Group-MSRI Prize in Innovative Quantitative Applications was awarded to José A. Scheinkman, on February 9 in Chicago. Dr. Scheinkman is the Edwin W. Rickert Professor of Economics at Columbia University, Theodore A. Wells ‘29 Professor of Economics (emeritus) at Princeton University and a Research Associate at the NBER. The annual CME Group-MSRI Prize recognizes originality and innovation in the use of mathematical, statistical or computational methods for the study of the behavior of markets, and more broadly of economics. Read more about the prize at [www.msri.org/general\\_events/21197](http://www.msri.org/general_events/21197).

## 1.2 Summary of Demographic Data for 2014–15 Activities

The Postdoctoral program was particularly successful and is described in detail in Section 3. Of the Fellows, 24% were female, 24% were U.S. Citizens or Permanent Residents, and 52% listed a U.S. university as home institution. Of those institutions, 20% are located in the Northeast, 27% in the West, 27% in the Midwest, and the remaining 26% in the South.

MSRI had a total of 261 long-term members. Members spent an average of 75 days at MSRI, with peak attendance in September for the fall semester and March for the spring semester. Of the members, 18.8% were female, 42% reported being U.S. Citizens or Permanent Residents and 43% listed a U.S. university as their home institution. Of those institutions, 33% are located in the Midwest, 28% in the West, 20% in the Northeast, and 19% in the South. Of the members, 60% had received a Ph.D degree on or after 2000, 31% received one between 1981 and 1999, and the remaining 9% had received a Ph.D. on or prior to 1980. Detailed demographic data can be found in Section 2.

In the 2014–15 workshops, MSRI hosted 1405 separate visits (some visitors attended multiple events). Of the workshop participants, 26% were female, 48% were U.S. Citizens or Permanent Residents, of which 7% reported being a member of an under-represented minority. In addition, 62% of the 1405 participants came from a U.S. institution. Demographic data on workshop participants can be found in Sections 2 and 4.

The Summer Graduate Schools of 2014 & 2015 had 417 participants. Of those participants, 28% were female, 50% were U.S. Citizens or Permanent Residents and 86% students came from a

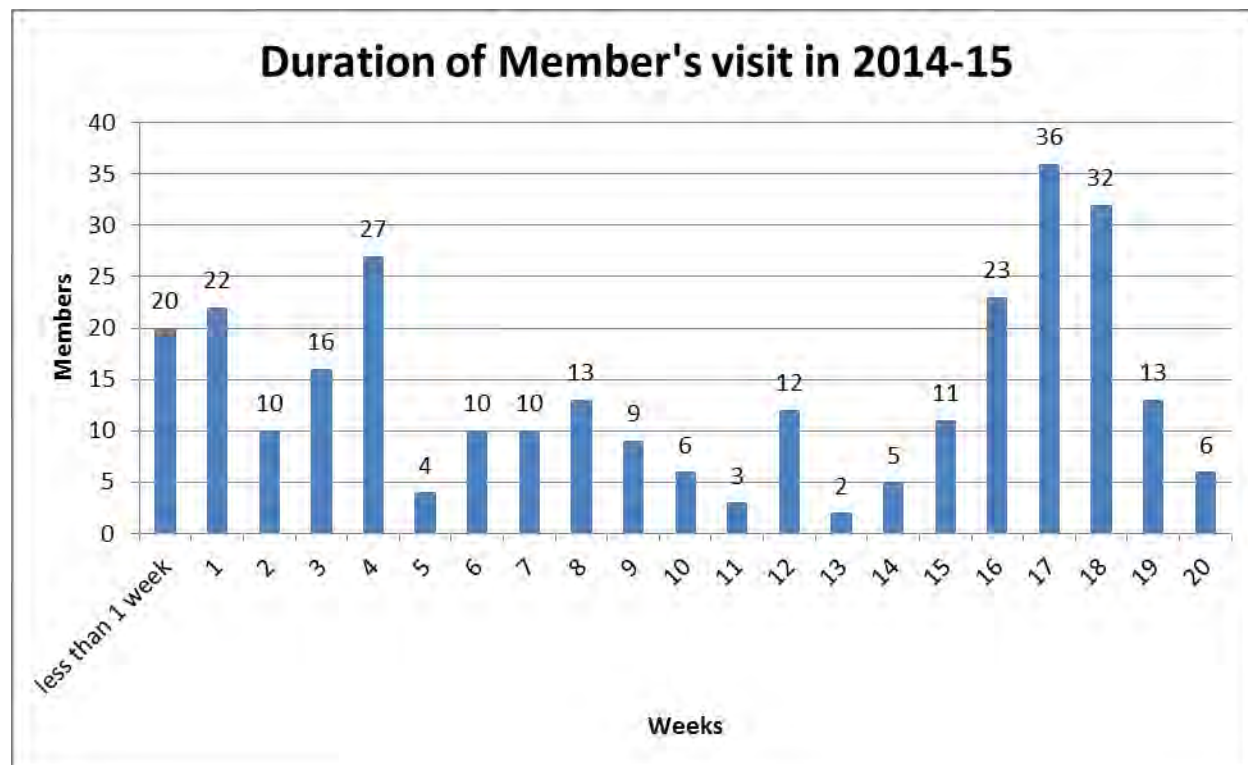
U.S. institution. Demographic data on the participants of the summer graduate schools can be found in Section 4.2.

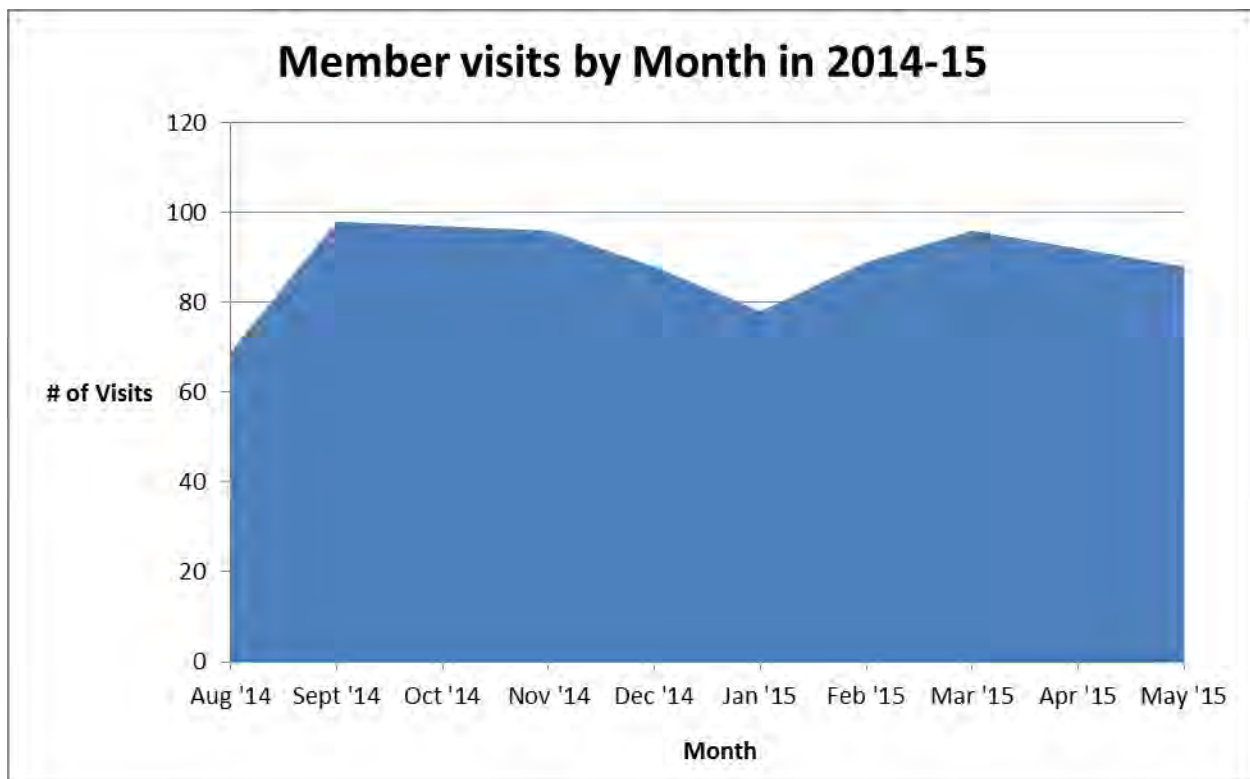
In the summer of 2014, the MSRI Undergraduate Program (MSRI-UP) hosted 18 students. Of those students, 44% were female and 100% were U.S. Citizens or Permanent Residents, of which 78% reported being a member of an under-represented minority. In addition, 100% participants came from a U.S. institution.

In the summer of 2015, the MSRI Undergraduate Program (MSRI-UP) hosted 17 students. Of those students, 35% were female and 94% were U.S. Citizens or Permanent Residents, of which 88% reported being a member of an under-represented minority. In addition, 94% participants came from a U.S. institution. Demographic data on both MSRI-UP participants can be found in Section 5.2.

### Member Visits Summary

All program members	Fall 2014	Spring 2015	2014–15	2004–15
Total Member Days	10716	10833	21549	191715
Total # of Members (non-distinct)	145	144	289	2679
Average # of Days per Member	73.90	75.23	74.56	71.56
Average # of Months per Member	2.5	2.5	2.5	2.4
All female program members	Fall 2014	Spring 2015	2014–15	2009–15
Total Member Days	1814	2327	4141	25604
Total # of Members (non-distinct)	26	27	53	362
Average # of Days per Member	69.77	86.19	78.13	70.73
Average # of Months per Member	2.3	2.9	2.6	2.4





### 1.3 Scientific Programs and their Associated Workshops

There were four major and one complementary programs for the MSRI fiscal year 2014–15, and 12 workshops were associated with them.

Note: Brief descriptions of scientific topics for each activity were reported in the Brief Report submitted in 2015. Full descriptions of each activity can be found in the Appendix Section of this Final Report. In the lists of organizers of each activity below, an asterisk (\*) denotes lead organizer(s).

#### **Program 1: New Geometric Methods in Number Theory and Automorphic Forms**

August 11, 2014 - December 12, 2014

*Organizers: Pierre Colmez (Institut de Mathématiques de Jussieu), \*Wee Teck Gan (National University of Singapore), Michael Harris (Institut de Mathématiques de Jussieu), Elena Mantovan (California Institute of Technology), Ariane Mézard (Institut de Mathématiques de Jussieu), Akshay Venkatesh (Stanford University)*

#### **Workshop 1: Connections for Women: New Geometric Methods in Number Theory and Automorphic Forms**

August 14, 2014 - August 15, 2014

*Wenching Li (Pennsylvania State University), \*Elena Mantovan (California Institute of Technology), Sophie Morel (Princeton University), Ramdorai Sujatha (University of British Columbia)*

**Workshop 2: Introductory Workshop: New Geometric Methods in Number Theory and Automorphic Forms**

August 18, 2014 - August 22, 2014

*Laurent Berger (École Normale Supérieure de Lyon), Ariane Mézard (Institut de Mathématiques de Jussieu), \*Akshay Venkatesh (Stanford University), Shou-Wu Zhang (Princeton University)*

**Workshop 3: Automorphic forms, Shimura varieties, Galois representations and L-functions**

December 01, 2014 - December 05, 2014

*Organizers: \*Pierre Colmez (Institut de Mathématiques de Jussieu), Stephen Kudla (University of Toronto), Elena Mantovan (California Institute of Technology), Ariane Mézard (Institut de Mathématiques de Jussieu), Richard Taylor (Institute for Advanced Study)*

**Program 2: Geometric Representation Theory**

August 18, 2014 - December 19, 2014

*Organizers: \*David Ben-Zvi (University of Texas), Ngô Bảo Châu (University of Chicago), Thomas Haines (University of Maryland), Florian Herzig (University of Toronto), Kevin McGerty (University of Oxford), David Nadler (University of California, Berkeley), Catharina Stroppel (Hausdorff Research Institute for Mathematics, University of Bonn), Eva Viehmann (TU München)*

**Workshop 1: Connections for Women: Geometric Representation Theory**

August 28, 2014 - August 29, 2014

*\*Monica Vazirani (University of California, Davis), Eva Viehmann (TU München)*

**Workshop 2: Introductory Workshop: Geometric Representation Theory**

September 02, 2014 - September 05, 2014

*\*David Ben-Zvi (University of Texas), Kevin McGerty (University of Oxford)*

**Workshop 3: Categorical Structures in Harmonic Analysis**

November 17, 2014 - November 21, 2014

*Thomas Haines (University of Maryland), Florian Herzig (University of Toronto), \*David Nadler (University of California, Berkeley)*

**Program 3: Dynamics on Moduli Spaces of Geometric Structures**

January 12, 2015 to May 22, 2015

*Richard Canary (University of Michigan), William Goldman (University of Maryland), François Labourie (Université de Nice Sophia Antipolis), \*Howard Masur (University of Chicago), Anna Wienhard (Ruprecht-Karls-Universität Heidelberg)*

**Workshop 1: Connections for Women: Dynamics on Moduli Spaces of Geometric Structures**

January 15, 2015 - January 16, 2015

*Virginie Charette (University of Sherbrooke), \*Fanny Kassel (Université de Lille I (Sciences et Techniques de Lille Flandres Artois)), Karin Melnick (University of Maryland), Anna Wienhard (Ruprecht-Karls-Universität Heidelberg)*

**Workshop 2: Introductory Workshop: Dynamics on Moduli Spaces of Geometric Structures**

January 20, 2015 - January 23, 2015

*Richard Canary (University of Michigan), \*William Goldman (University of Maryland), Ursula Hamenstädt (Universität Bonn), Alessandra Iozzi (Eidgenössische TH Zürich-Hönggerberg)*

**Workshop 3: Dynamics on Moduli Spaces**

April 13, 2015 - April 17, 2015

*Marc Burger (Eidgenössische TH Zürich-Hönggerberg), \*David Dumas (University of Illinois at Chicago), Olivier Guichard (Université de Strasbourg I (Louis Pasteur)), François Labourie (Université de Nice Sophia Antipolis), Anna Wienhard (Ruprecht-Karls-Universität Heidelberg)*

**Program 4: Geometric and Arithmetic Aspects of Homogeneous Dynamics**

January 19, 2015 to May 29, 2015

*\*Dmitry Kleinbock (Brandeis University), Elon Lindenstrauss (Hebrew University), Hee Oh (Yale University), Jean-François Quint (Université de Bordeaux I), Alireza Salehi Golsefidy (University of California, San Diego)*

**Workshop 1: Connections for Women: Geometric and Arithmetic Aspects of Homogeneous Dynamics**

January 29, 2015 - January 30, 2015

*Elon Lindenstrauss (Hebrew University), \*Hee Oh (Yale University)*

**Workshop 2: Introductory Workshop: Geometric and Arithmetic Aspects of Homogeneous Dynamics**

February 02, 2015 - February 06, 2015

*Manfred Einsiedler (Eidgenössische TH Zürich-Hönggerberg), Dmitry Kleinbock (Brandeis University), \*Jean-François Quint (Université de Bordeaux I), Barbara Schapira (Université de Picardie (Jules Verne))*

**Workshop 3: Advances in Homogeneous Dynamics**

May 11, 2015 - May 15, 2015

*Dmitry Kleinbock (Brandeis University), Hee Oh (Yale University), Alireza Salehi Golsefidy (University of California, San Diego), Ralf Spatzier (University of Michigan)*

**Program 5: Complementary Program (2014–15)**

August 11, 2014 to May 29, 2015

MSRI had a small Complementary Program comprised of ten researchers, Valerio Capraro (University of Southampton), Indira Chatterji (Université d'Orléans), Hailong Dao (University of Kansas), Christopher Douglas (University of Oxford), Eric Flapan (Pomona College), Elon Lindenstrauss (Hebrew University of Jerusalem), Ariane Mezard (Institut de Mathématiques de Jussieu), Grigory Mikhalkin (University of Geneva), Stephen Morgan (University of Toronto), Frank Schreyer (Universität des Saarlandes), Volkmar Welker (Universität Marburg) and Gufang Zhao (Northeastern University).

## 1.4 Scientific Activities Directed at Underrepresented Groups in Mathematics

### **Undergraduate Program: MSRI-UP 2014: Arithmetic Aspects of Elementary Functions**

June 21, 2014 - August 03, 2014

*Duane Cooper (Morehouse College), Ricardo Cortez (Tulane University), \*Herbert Medina (Loyola Marymount University), Ivelisse M. Rubio (University of Puerto Rico), Suzanne Weekes (Worcester Polytechnic Institute)*

### **Undergraduate Program: MSRI-UP 2015: Geometric Combinatorics Motivated by the Social Sciences**

June 13, 2015 - July 26, 2015

*Federico Ardila (San Francisco State University), \*Duane Cooper (Morehouse College), Herbert Medina (Loyola Marymount University), Ivelisse M. Rubio (University of Puerto Rico), Suzanne Weekes (Worcester Polytechnic Institute)*

### **\*Mathematics Institutes' Modern Math Workshop at SACNAS**

NSF supplemental grant DMS 1126721

**Location: Los Angeles, California**

October 15, 2014 to October 16, 2014

*Organized by Statistical and Applied Mathematical Sciences Institute (SAMSI)*

### **\*Blackwell-Tapia Conference and Awards Ceremony**

NSF supplemental grant DMS 1126721

**Location: Los Angeles, California**

November 14, 2014 to November 15, 2014

*Organized by IPAM*

### **\*Infinite Possibilities Conference 2015: Celebrating and Promoting Diversity in the Mathematical Sciences**

NSF supplemental grant DMS 1126721

**Location: Oregon State University, Corvallis, Oregon**

March 2, 2015 to March 3, 2015

*Organized by MBI*

### **\*Spring Opportunities: Careers in Mathematical Sciences: Workshop for Underrepresented Groups**

NSF supplemental grant DMS 1126721

**Location: University of Minnesota**

March 2, 2015 to March 3, 2015

*Organized by IMA*

\*Please note: The report of this activity is included in each respective institute's annual report, thus there is no report attached in Section 11. Appendix.

## 1.5 Summer Graduate Schools (Summer 2014 and 2015)

### Summer 2014

#### **SGS 1: Dispersive Partial Differential Equations**

June 16, 2014 - June 27, 2014

*Organizers: Natasa Pavlovic (University of Texas), Nikolaos Tzirakis (University of Illinois at Urbana-Champaign)*

#### **SGS 2: Seminaire de Mathematiques Superieures 2014: Counting Arithmetic Objects**

**Location: Montreal, Canada**

June 23, 2014 - July 04, 2014

*Organizers: Henri Darmon (McGill University), Andrew Granville (Université de Montréal), Benedict Gross (Harvard University)*

#### **SGS 3: IAS/PCMI 2014: Mathematics and Materials**

June 29, 2014 - July 19, 2014

**Location: Park City, Utah**

*Organizers: Mark Bowick (Syracuse University), David Kinderlehrer (Carnegie Mellon University), Govind Menon (Brown University), Charles Radin (University of Texas)*

#### **SGS 4: Algebraic Topology**

June 30, 2014 - July 11, 2014

*Organizers: \*Jose Cantarero-Lopez (Centro de Investigación en Matemáticas), Michael Hill (University of Virginia)*

#### **SGS 5: Stochastic Partial Differential Equations**

July 07, 2014 - July 18, 2014

*Organizers: Yuri Bakhtin (New York University, Courant Institute), Ivan Corwin (Columbia University), James Nolen (Duke University)*

#### **SGS 6: Geometry and Analysis**

July 28, 2014 - August 08, 2014

*Organizers: Hans-Joachim Hein (Imperial College, London), Aaron Naber (Massachusetts Institute of Technology)*

### Summer 2015

#### **SGS 1: CRM-PIMS Summer School in Probability**

June 15, 2015 - July 11, 2015

**Location: Montreal, Canada**

*Organizers: Luigi Addario-Berry (McGill University), Louis-Pierre Arguin (Université de Montréal), Alexander Fribergh (Université de Montréal), Lea Popovic (Concordia University)*

#### **SGS 2: Geometric Group Theory**

June 15, 2015 - June 26, 2015

*Organizers: John Mackay (University of Bristol), Anne Thomas (University of Sydney), Kevin Wortman (University of Utah)*

**SGS 3: Seminaire de Mathematiques Superieures 2015: Geometric and Computational Spectral Theory**

June 15, 2015 - June 26, 2015

**Location: Montreal, Canada**

*Organizers: Alexandre Girouard (Laval University), Dmitry Jakobson (McGill University), Michael Levitin (University of Reading), Nilima Nigam (Simon Fraser University), Iosif Polterovich (Université de Montréal), Frederic Rochon (Université du Québec à Montréal)*

**SGS 4: NIMS Summer School on Random Matrix Theory**

June 29, 2015 - July 10, 2015

**Location: Daejeon, South Korea**

*Organizers: Jinho Baik (University of Michigan)*

**SGS 5: Mathematical Topics in Systems Biology**

June 29, 2015 - July 10, 2015

*Organizers: Steven Altschuler (University of California, San Francisco), Lani Wu (UCSF)*

**SGS 6: Berkeley summer course in mining and modeling of neuroscience data**

July 06, 2015 - July 17, 2015

**Location: UC Berkeley**

*Organizers: Ingrid Daubechies (Duke University), Bruno Olshausen (University of California, Berkeley), Christos Papadimitriou (University of California, Berkeley), Fritz Sommer (University of California, Berkeley), Jeff Teeters (University of California, Berkeley)*

**SGS 7: Gaps between Primes and Analytic Number Theory**

July 13, 2015 - July 24, 2015

*Organizers: Dimitris Koukoulopoulos (Université de Montréal), Emmanuel Kowalski (ETH Zuerich), James Maynard (University of Oxford), Kannan Soundararajan (Stanford University)*

**SGS 8: Incompressible Fluid Flows at High Reynolds Number**

July 27, 2015 - August 07, 2015

*Organizers: Jacob Bedrossian (University of Maryland), Vlad Vicol (Princeton University)*

## **1.6 Other Scientific Workshops**

**Workshop 1: Breaking the Neural Code**

October 29, 2014 - November 01, 2014

*Larry Abbott (Columbia University), Ingrid Daubechies (Duke University), Michael Jordan (University of California), \*Liam Paninski (Columbia University)*

**Workshop 2: Bay Area Differential Geometry Seminar (BADGS) Fall 2014**

November 01, 2014

*David Bao (San Francisco State University), Joel Hass (University of California, Davis), \*David Hoffman (Stanford University), Rafe Mazzeo (Stanford University), Richard Montgomery (University of California, Santa Cruz)*



### Workshop 3: Pacific Northwest and Bay Area Differential Geometry Seminar (BADGS) Spring 2015

**Location: Stanford University**

February 21, 2015

*Organizers: David Bao (San Francisco State University), Joel Hass (University of California, Davis), \*David Hoffman (Stanford University), Rafe Mazzeo (Stanford University), Richard Montgomery (University of California, Santa Cruz)*

### Workshop 4: Hot Topics: Kadison-Singer, Interlacing Polynomials, and Beyond

March 09, 2015 - March 13, 2015

*Sorin Popa (University of California), \*Daniel Spielman (Yale University), Nikhil Srivastava (University of California, Berkeley), Cynthia Vinzant (North Carolina State University)*

## 1.7 Education & Outreach Activities

### Workshop 1: Critical Issues in Mathematics Education (CIME) 2015: Developmental Mathematics: For whom? Toward what ends?

NSF independent grant DMS-1461358

March 18, 2015 - March 20, 2015

*Organizers: Duane Cooper (Morehouse College), Mark Hoover (University of Michigan), \*Robert Megginson (University of Michigan), Richard Sgarlotti (Bay College), Katherine Stevenson (California State University, Northridge)*

Please note: CIME is funded by an independent NSF grant, DMS 1461358. The report will be filed independently to the NSF, thus there is no report attached in Section 11. Appendix.

## 1.8 Program Consultants List in 2014–15

Consultant Name	Consultant Disciplinary Specialty	Consultant Employer	Activity Title
Mathias Beck	Discrete geometry	San Francisco State University	Bay Area Circle for Teachers
Moris Kalka	Differential geometry	Tulane University	Summer Graduate Workshops
William Macallum	Education	University of Arizona	Educational workshops
Rafe Mazzeo	Differential geometry	Stanford University	Differential geometry seminar
Donald McClure	Image processing	Brown University	AMS Open Access
Robert Megginson	Functional Analysis	University of Michigan	Critical Issues in Math Education
Mark Saul	Education	Education Development Center	Great Circles
Myron Scholes	Economics	Stanford University	MSRI-CME Group Prize
Tatiana Shubin	Number theory	San Jose State University	Bay Area Circle for Teachers
Hugo Sonnenschein	Economics	University of Chicago	MSRI-CME Group Prize
Zvesda Stankova	Algebraic geometry	Mill College	Math Circles
Sam Vandervelde	Number theory	St. Lawrence University	Math Circles
Diana White			National Association of Math Circles
Educational Advisory Committee (EAC)	See Section 10: Committee Membership		Using Partnerships to Strengthen Elementary Mathematics Teacher Education
Human Resources Advisory Committee (HRAC)	See Section 10: Committee Membership		MSRI - UP
Scientific Advisory Committee (SAC) & Board of Trustees (BOT)	See Section 10: Committee Membership		Geometric Representation Theory
			New Geometric Methods in Number Theory and Automorphic Forms
			Dynamics on Moduli Spaces of Geometric Structures
			Geometric and Arithmetic Aspects of Homogeneous Dynamics
			Complementary Program

## 2. Program and Workshop Data

### 2.1 Program Members List (See e-mail attachment)

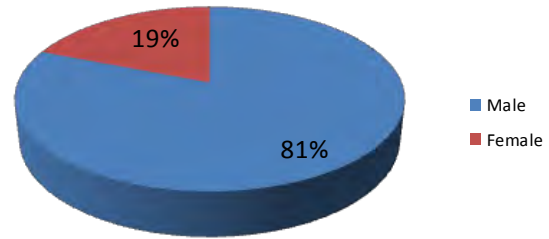
### 2.2 Program Members Summary

Programs	# of Members	# of Citizens & Perm. Res.	%	# of Female	%	# of Minorities <sup>1</sup>	%	US Home Institution	%
Dynamics on Moduli Spaces of Geometric Structures	59	30	50.8%	12	20.3%	3	12.0%	33	55.9%
Geometric and Arithmetic Aspects of Homogeneous Dynamics	64	24	37.5%	11	17.2%	0	0.0%	25	39.1%
Geometric Representation Theory	62	35	56.5%	11	17.7%	0	0.0%	37	59.7%
New Geometric Methods in Number Theory and Automorphic Forms	66	16	24.2%	13	19.7%	0	0.0%	15	22.7%
Complementary Program (2014-15)	10	4	40.0%	2	20.0%	0	0.0%	3	30.0%
<b>Total # of Distinct Members</b>	<b>261</b>	<b>109</b>	<b>41.8%</b>	<b>49</b>	<b>18.8%</b>	<b>3</b>	<b>3.8%</b>	<b>113</b>	<b>43.3%</b>

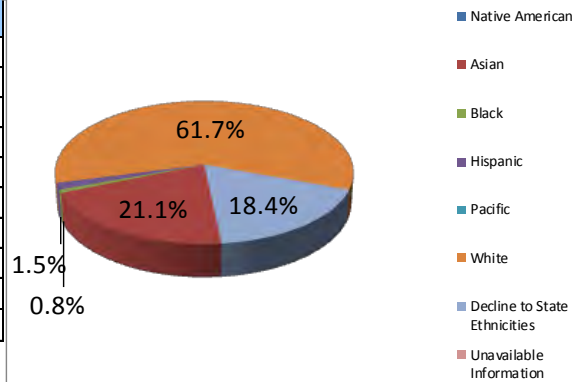
<sup>1</sup> Minorities are US citizen who declare themselves American Indian, Black, Hispanic, or Pacific Islander. Minority percentage is calculated by dividing the number of Minorities by the total number of US citizens.

## 2.3 Program Members Demographic Data

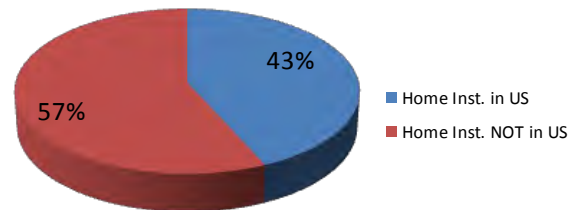
Gender	#	% (No Decl.)*	%
# of Distinct Members	261		100.0%
Male	208	80.93%	79.7%
Female	49	19.07%	18.8%
Decline to State Gender	4		1.5%



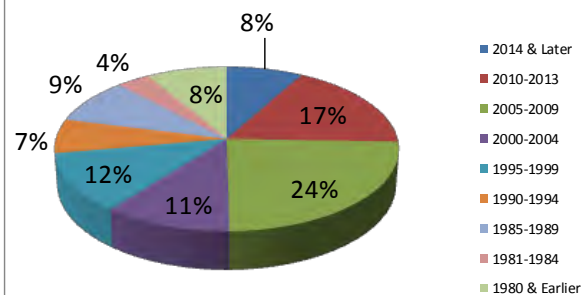
Ethnicities	#	% (No Decl.)*	%
Native American	0	0.00%	0.0%
Asian	55	24.77%	21.1%
Black	2	0.90%	0.8%
Hispanic	4	1.80%	1.5%
Pacific	0	0.00%	0.0%
White	161	72.52%	61.7%
Decline to State Ethnicities	48		18.4%
Unavailable Information	0		0.0%
Minorities	3		3.8%



Citizenships	#	%
US Citizen & Perm. Residents	109	41.8%
Foreign	152	58.2%
Unavailable information	0	0.0%
# of Distinct Members	261	100.0%
US Citizen	80	30.7%
Perm Residents	29	11.1%
Home Inst. in US	113	43.30%



Year of Ph.D	#	%
Program Associates (GS)	38	14.6%
2014 & Later	18	6.9%
2010-2013	39	14.9%
2005-2009	54	20.7%
2000-2004	24	9.2%
1995-1999	26	10.0%
1990-1994	15	5.7%
1985-1989	20	7.7%
1981-1984	8	3.1%
1980 & Earlier	19	7.3%
Unavailable Info.	0	0.0%
Total # of Distinct Members	261	100.0%



\*Statistic Calculation based on all participants that did not decline.

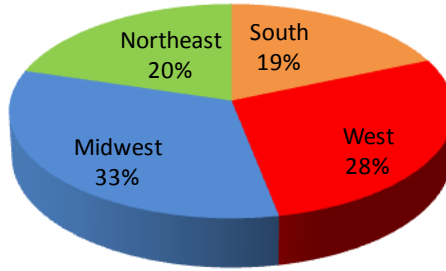
### Programs

*Dynamics on Moduli Spaces of Geometric Structures*  
*Geometric and Arithmetic Aspects of Homogeneous Dynamics*  
*Geometric Representation Theory*  
*New Geometric Methods in Number Theory and Automorphic Forms*  
*Complementary Program (2014-15)*

**2014–15 Program Members Home Institution Classified by States**

*\*Regions based on US Census classification*

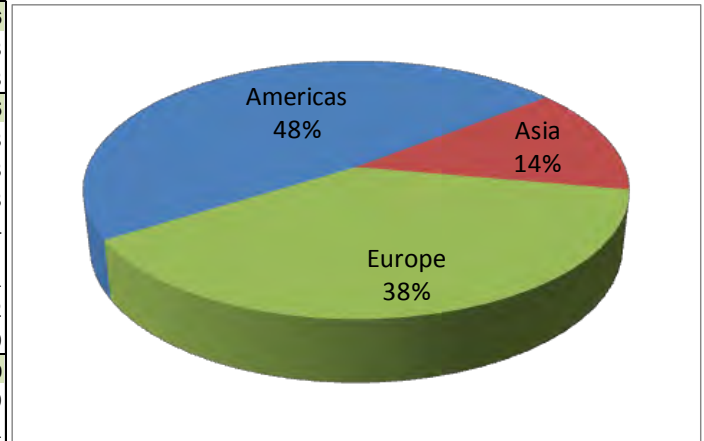
State	#	%	2007 Census Population
<b>South</b>	<b>21</b>	<b>18.6%</b>	<b>36.6%</b>
AL	-	0.0%	1.5%
AR	-	0.0%	0.9%
DE	-	0.0%	0.3%
DC	1	0.9%	0.2%
FL	-	0.0%	6.1%
GA	-	0.0%	3.2%
KY	-	0.0%	1.4%
LA	3	2.7%	1.4%
MD	6	5.3%	1.9%
MS	-	0.0%	1.0%
NC	-	0.0%	3.0%
OK	-	0.0%	1.2%
SC	-	0.0%	1.5%
TN	-	0.0%	2.0%
TX	10	8.8%	7.9%
VA	1	0.9%	2.6%
WV	-	0.0%	0.6%
<b>West</b>	<b>32</b>	<b>28.3%</b>	<b>23.2%</b>
AK	-	0.0%	0.2%
AZ	1	0.9%	2.1%
HI	-	0.0%	0.4%
ID	-	0.0%	0.5%
MT	-	0.0%	0.3%
CA	28	24.8%	12.1%
CO	-	0.0%	1.6%
NV	-	0.0%	0.9%
NM	-	0.0%	0.7%
OR	1	0.9%	1.2%
UT	2	1.8%	0.9%
WA	-	0.0%	2.1%
WY	-	0.0%	0.2%
<b>Midwest</b>	<b>37</b>	<b>32.7%</b>	<b>22.0%</b>
IL	20	17.7%	4.3%
IN	5	4.4%	2.1%
IA	-	0.0%	1.0%
KS	1	0.9%	0.9%
MI	5	4.4%	3.3%
MN	2	1.8%	1.7%
MO	-	0.0%	1.9%
ND	-	0.0%	0.2%
NE	-	0.0%	0.6%
OH	3	2.7%	3.8%
SD	-	0.0%	0.3%
WI	1	0.9%	1.9%
<b>Northeast</b>	<b>23</b>	<b>20.4%</b>	<b>18.1%</b>
CT	4	3.5%	1.2%
ME	-	0.0%	0.4%
MA	7	6.2%	2.1%
NH	-	0.0%	0.4%
NJ	4	3.5%	2.9%
NY	3	2.7%	6.4%
PA	2	1.8%	4.1%
RI	3	2.7%	0.4%
VT	-	0.0%	0.2%
Other	-	<b>0.0%</b>	<b>0%</b>
PR	-	0.0%	0%
Other	-	0.0%	0%
<b>Total</b>	<b>113</b>	<b>100%</b>	<b>100%</b>



## 2014–15 Program Members Home Institution Classified by Countries

\*Regions based on United Nations classification

<b>Americas</b>			<b>126</b>
North America	Canada		13
	United States		113
<b>Asia</b>			<b>35</b>
East Asia	China		3
	Japan		3
	Korea, Republ		3
South-central Asia	India		4
	Kazakhstan		1
South-eastern Asia	Singapore		2
Western Asia	Israel		19
<b>Europe</b>			<b>100</b>
Northern Europe	England		19
	Finland		1
Southern Europe	Spain		2
Western Europe	France		49
	Germany		23
	Netherlands		1
	Switzerland		5
<b>Grand Total</b>			<b>261</b>



## 2.4 Workshop Participant List (See e-mail attachment)

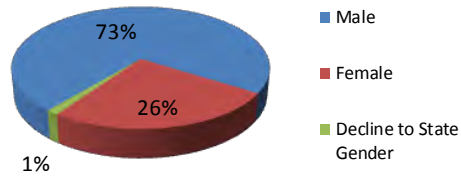
## 2.5 Workshop Participant Summary

Workshops	# of Participants	# of Citizens & Perm. Res.	%	# of Female	%	# of Minorities <sup>1</sup>	%	US Home Institution	%
<b>13 Scientific Workshops</b>									
Advances in Homogeneous Dynamics	107	52	48.6%	23	21.5%	4	10.8%	60	56.1%
Automorphic forms, Shimura varieties, Galois representations and L-functions	191	73	38.2%	22	11.5%	2	3.4%	98	51.3%
Categorical Structures in Harmonic Analysis	110	38	34.5%	17	15.5%	0	0.0%	60	54.5%
Connections for Women: Dynamics on Moduli Spaces of Geometric Structures	62	26	41.9%	30	48.4%	3	13.6%	32	51.6%
Connections for Women: Geometric and Arithmetic Aspects of Homogeneous Dynamics	63	22	34.9%	21	33.3%	2	12.5%	32	50.8%
Connections for Women: Geometric Representation Theory	50	21	42.0%	28	56.0%	1	5.6%	24	48.0%
Connections for Women: New Geometric Methods in Number Theory and Automorphic Forms	36	16	44.4%	23	63.9%	0	0.0%	20	55.6%
Dynamics on Moduli Spaces	134	63	47.0%	27	20.1%	6	12.2%	84	62.7%
Hot Topics: Kadison-Singer, Interlacing Polynomials, and Beyond	46	25	54.3%	5	10.9%	0	0.0%	36	78.3%
Introductory Workshop: Dynamics on Moduli Spaces of Geometric Structures	132	62	47.0%	31	23.5%	5	9.4%	80	60.6%
Introductory Workshop: Geometric and Arithmetic Aspects of Homogeneous Dynamics	118	41	34.7%	19	16.1%	3	10.3%	57	48.3%
Introductory Workshop: Geometric Representation Theory	120	53	44.2%	25	20.8%	1	2.0%	82	68.3%
Introductory Workshop: New Geometric Methods in Number Theory and Automorphic Forms	100	50	50.0%	25	25.0%	3	7.3%	69	69.0%
<b>All 13 Workshops Total</b>	<b>1,269</b>	<b>542</b>	<b>42.7%</b>	<b>296</b>	<b>23.3%</b>	<b>30</b>	<b>6.8%</b>	<b>734</b>	<b>57.8%</b>
<b>2 Education &amp; Outreach Workshops</b>									
Breaking the Neural Code	13	13	100.0%	1	7.7%	0	0.0%	13	100.0%
Critical Issues in Mathematics Education 2015: Developmental Mathematics: For whom? Toward what ends?	123	120	97.6%	66	53.7%	12	10.3%	122	99.2%
<b>All 2 Workshops Total</b>	<b>136</b>	<b>133</b>	<b>97.8%</b>	<b>67</b>	<b>49.3%</b>	<b>12</b>	<b>9.2%</b>	<b>135</b>	<b>99.3%</b>
<b>All 15 Workshops Total</b>	<b>1,405</b>	<b>675</b>	<b>48.0%</b>	<b>363</b>	<b>25.8%</b>	<b>42</b>	<b>7.4%</b>	<b>869</b>	<b>61.9%</b>

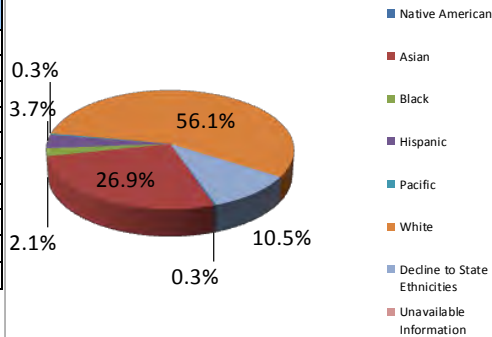
<sup>1</sup> Minorities are US citizens who declare themselves American Indian, Black, Hispanic, or Pacific Islander. Minority percentage is calculated by dividing the number of Minorities by the total number of US citizens.

## 2.6 Workshop Participant Demographic Data

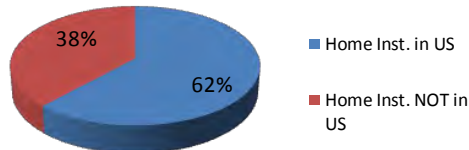
Gender	#	% (No Decl.)*	%
# of Participants	1405		100.0%
Male	1023	73.81%	72.8%
Female	363	26.19%	25.8%
Decline to State Gender	19		1.4%



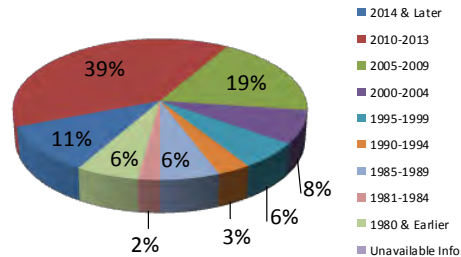
Ethnicities	#	% (No Decl.)*	%
Native American	4	0.31%	0.3%
Asian	391	30.10%	26.9%
Black	31	2.39%	2.1%
Hispanic	54	4.16%	3.7%
Pacific	5	0.38%	0.3%
White	814	62.66%	56.1%
Decline to State Ethnicities	152		10.5%
Unavailable Information	0		0.0%
Minorities	42		7.4%



Citizenships	#	%
US Citizen & Perm. Residents	675	48.0%
Foreign	724	51.5%
Unavailable information	6	0.4%
# of Participants	1405	100.0%
US Citizen	570	40.6%
Perm Residents	105	7.5%
Home Inst. in US	869	61.85%



Year of Highest Degree	#	%
2014 & Later	153	10.9%
2010-2013	551	39.2%
2005-2009	262	18.6%
2000-2004	107	7.6%
1995-1999	87	6.2%
1990-1994	46	3.3%
1985-1989	82	5.8%
1981-1984	30	2.1%
1980 & Earlier	87	6.2%
Unavailable Info.	0	0.0%
Total # Participants	1405	100.0%



\*Statistic Calculation based on all participants that did not decline.

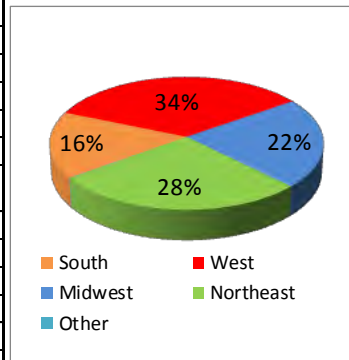
### 2014–15 Workshops

- Advances in Homogeneous Dynamics*
- Automorphic forms, Shimura varieties, Galois representations and L-functions*
- Breaking the Neural Code*
- Categorical Structures in Harmonic Analysis*
- Connections for Women: Dynamics on Moduli Spaces of Geometric Structures*
- Connections for Women: Geometric and Arithmetic Aspects of Homogeneous Dynamics*
- Connections for Women: Geometric Representation Theory*
- Connections for Women: New Geometric Methods in Number Theory and Automorphic Forms*
- Critical Issues in Mathematics Education 2015: Developmental Mathematics: For whom? Toward what ends?*
- Dynamics on Moduli Spaces*
- Hot Topics: Kadison-Singer, Interlacing Polynomials, and Beyond*
- Introductory Workshop: Dynamics on Moduli Spaces of Geometric Structures*
- Introductory Workshop: Geometric and Arithmetic Aspects of Homogeneous Dynamics*
- Introductory Workshop: Geometric Representation Theory*
- Introductory Workshop: New Geometric Methods in Number Theory and Automorphic Forms*

**2014–15 Workshop Participants Home Institution Classified by States**

*\*Regions based on US Census classification*

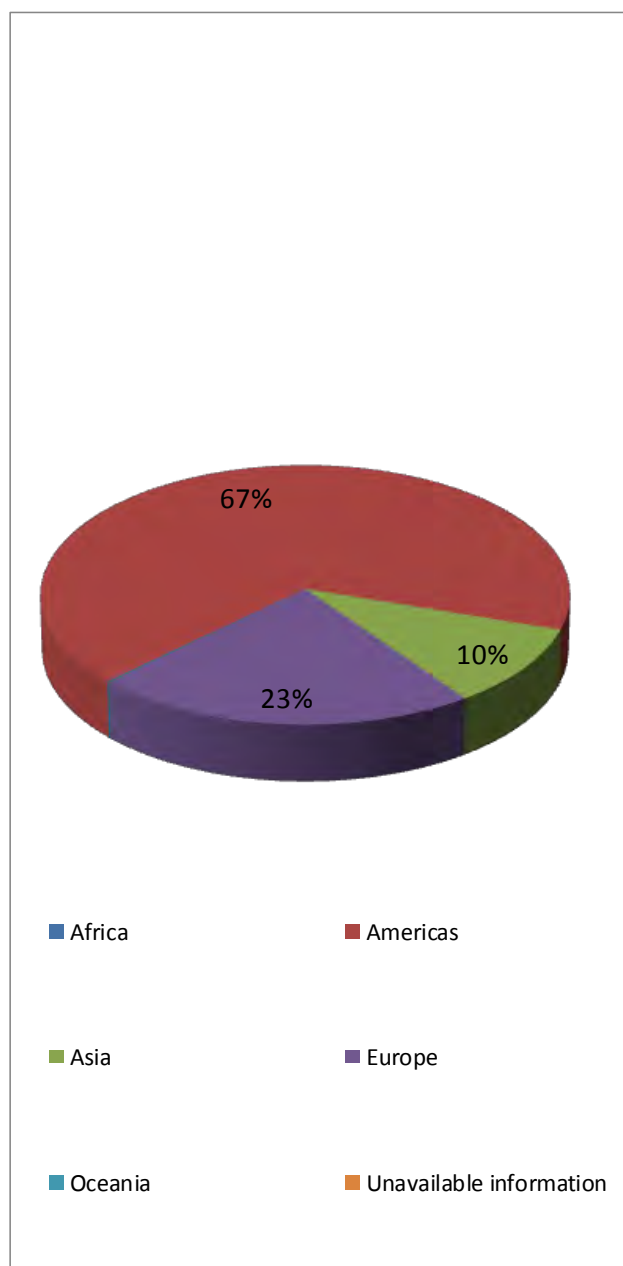
State	#	%	2007 Census Population
<b>South</b>	<b>141</b>	<b>16.2%</b>	<b>36.6%</b>
AL	-	0.0%	1.5%
AR	-	0.0%	0.9%
DE	-	0.0%	0.3%
DC	6	0.7%	0.2%
FL	6	0.7%	6.1%
GA	4	0.5%	3.2%
KY	-	0.0%	1.4%
LA	8	0.9%	1.4%
MD	29	3.3%	1.9%
MS	1	0.1%	1.0%
NC	16	1.8%	3.0%
OK	3	0.3%	1.2%
SC	2	0.2%	1.5%
TN	-	0.0%	2.0%
TX	62	7.1%	7.9%
VA	4	0.5%	2.6%
WV	-	0.0%	0.6%
<b>West</b>	<b>296</b>	<b>34.1%</b>	<b>23.2%</b>
AK	-	0.0%	0.2%
AZ	13	1.5%	2.1%
HI	-	0.0%	0.4%
ID	1	0.1%	0.5%
MT	-	0.0%	0.3%
CA	260	29.9%	12.1%
CO	4	0.5%	1.6%
NV	1	0.1%	0.9%
NM	-	0.0%	0.7%
OR	7	0.8%	1.2%
UT	8	0.9%	0.9%
WA	2	0.2%	2.1%
WY	-	0.0%	0.2%
<b>Midwest</b>	<b>192</b>	<b>22.1%</b>	<b>22.0%</b>
IL	92	10.6%	4.3%
IN	20	2.3%	2.1%
IA	1	0.1%	1.0%
KS	7	0.8%	0.9%
MI	38	4.4%	3.3%
MN	7	0.8%	1.7%
MO	-	0.0%	1.9%
ND	-	0.0%	0.2%
NE	-	0.0%	0.6%
OH	19	2.2%	3.8%
SD	-	0.0%	0.3%
WI	8	0.9%	1.9%
<b>Northeast</b>	<b>239</b>	<b>27.5%</b>	<b>18.1%</b>
CT	32	3.7%	1.2%
ME	-	0.0%	0.4%
MA	72	8.3%	2.1%
NH	2	0.2%	0.4%
NJ	29	3.3%	2.9%
NY	64	7.4%	6.4%
PA	26	3.0%	4.1%
RI	14	1.6%	0.4%
VT	-	0.0%	0.2%
<b>Other</b>	<b>1</b>	<b>0.0%</b>	<b>0%</b>
VI	1	0.0%	0%
<b>Unavailable</b>	<b>-</b>	<b>0.0%</b>	<b>0%</b>
<b>Total</b>	<b>869</b>	<b>100%</b>	<b>100%</b>



## 2014–15 Workshop Participants Home Institution Classified by Countries

\*Regions based on United Nations classification

<b>Africa</b>			<b>1</b>
	Southern Africa	South Africa	1
<b>Americas</b>			<b>944</b>
	Central America	Mexico	6
	North America	Canada	64
		United States	869
	South America	Brazil	3
		Chile	1
		Colombia	1
<b>Asia</b>			<b>142</b>
	East Asia	China	11
		Japan	20
		Korea, Republic	44
	South-central Asia	India	9
		Kazakhstan	1
	South-eastern Asia	Singapore	2
	Western Asia	Israel	48
		Saudi Arabia	4
		Turkey	3
<b>Europe</b>			<b>317</b>
	Eastern Europe	Poland	2
	Northern Europe	Denmark	1
		England	46
		Finland	4
		Ireland	2
		Sweden	3
	Southern Europe	Italy	7
	Western Europe	Austria	1
		Belgium	2
		France	143
		Germany	69
		Luxembourg	2
		Switzerland	35
<b>Oceania</b>			<b>1</b>
	Australia & NZ	Australia	1
<b>Unavailable information</b>			
<b>Grand Total</b>			<b>1405</b>



### 2.7 Program Publication List (Attachment in Research.gov)

### 2.8 Program Publication Work-In-Progress List (Attachment in Research.gov)



## 3. Postdoctoral Program

### 3.1 Description of Activities

The postdoctoral program at MSRI is central to MSRI's mission of continued excellence in mathematics research. The programs MSRI organizes and hosts produce the leading research in that field of study. MSRI's postdocs engage with fellow mathematicians from all over the world to develop their interests and contribute to the Science community. During the 2014–15 academic year, MSRI selected 29 postdoctoral scholars with research interests in the programs that MSRI offers. Of those postdocs, 25 were funded by the NSF Core Grant and 4 were funded by the NSA. There were 8 named postdoctoral fellows who received additional funding from the Berlekamp, Cha-Chern, Gamelin, Huneke, and Viterbi Endowments, as well as the Strauch Post-Doctoral Fellowship Grant.

Of the 29 Postdoctoral Fellows at MSRI, seven (24%) were female, seven (24%) were a U.S. Citizen or Permanent Resident, and 15 (52%) came from a US institution. The program organizers were extremely satisfied with the Postdoctoral program and believed that it was by all accounts an enormous success.

Here are additional details on the NSF Postdoctoral Fellows for each program.

## Geometric Representation Theory



**Bouthier, Alexis**

Name: Alexis Bouthier

Year of Ph.D: 2014

Institution of Ph.D.: Université Paris-Sud Orsay

Dissertation title: Geometrization of the orbital side of the trace formula

Ph.D. advisor: Laumon, B.C. Ngo.

Mentor while at MSRI: Edward Frenkel

Institution prior to obtaining the MSRI PD fellowship: Université de Paris XI

Position at that institution: Graduate student

Mentor (if applicable): Laumon, B.C. Ngo

Institution (or company) where you are going after the MSRI PD fellowship: Hebrew University of Jerusalem.

Position at that institution: Postdoc

Postdoctoral fellow comments:

My work concerned the geometrisation of fundamental lemma of spherical Hecke algebra, initiated in my Phd and the study the intersection complex on the monoids introduced by Ngô which should give a geometric interpretation of the test function of the Local-unramified L-factors. Publication with Ngô & Sakellaridis, and work in progress on the geometrisation of the fundamental lemma for spherical Hecke algebra.



**Dancso, Zsuzsanna**

Name: Zsuzsanna Dancso

Year of Ph.D: 2011

Institution of Ph.D.: University of Toronto

Dissertation title: Homomorphic expansions for knotted trivalent graphs

Ph.D. advisor: Dror Bar-Natan

Mentor while at MSRI: Monica Vazirani

Institution prior to obtaining the MSRI PD fellowship: Fields Inst.

Position at that institution: NSERC post-doc Mentor

(I also spent a semester as a research visitor at the University of Toronto.)

Institution where you are going after the MSRI PD fellowship: Australian National University

Position: Post-doctoral fellow

Anticipated length: 2 years

Mentor (if applicable): Anthony Licata and Scott Morrison

Postdoctoral fellow's comments:

While at MSRI I started a new project with a new collaborator, Vivek Shende at UC Berkeley, on the "graphical  $W=2P$ " conjecture. This work is still in progress, some preliminary result have been written up (working notes towards a paper). I have also made a significant progress on a joint paper with Dror Bar-Natan on the Kashiwara-Vergne conjecture and knotted objects in  $R^4$ , and edited two other papers according to referees' reports which are in the process of publication.

I have given several talks while based at MSRI (Evans lecture, post-doc seminar, UC Davis, Oberwolfach), and appreciated the freedom and opportunities to do so.

I benefited greatly from Monica's mentorship: she gave me feedback on talks, helped me with job applications, invited me to give a talk at Davis, and provided general career advice and support.

Overall I had a productive and enjoyable semester and formed many new professional contacts.



**Dodd, Christopher**

Name: Christopher Dodd

Year of Ph.D: 2011

Institution of Ph.D.: Massachusetts Institute of Technology

Dissertation title: Equivariant Coherent Sheaves, Soergel Bimodules, and Categorification of Affine Hecke Algebras

Ph.D. advisor: Roman Bezrukavnikov

Mentor while at MSRI: Kevin McGerty

Institution prior to obtaining the MSRI PD fellowship: University of Toronto

Position at that institution: Postdoctoral Fellow

Mentor (if applicable): Joel Kamnitzer

Institution (or company) where you are going after the MSRI PD fellowship: University of Toronto

Position: Postdoctoral Fellow

Anticipated length: 1 semester

At MSRI, I mostly worked on understand flat connections in two contexts: first of all, the theory of wild flat connections in characteristic zero and its analogues in positive characteristic, and secondly, the theory of connection with  $p$ -curvature zero. In both cases, I made substantial progress during the semester; in particular, conversations with other members allowed me to correct misconceptions, fix errors in my thinking, and prove several new theorems. I haven't published anything from this time, but I expect the ideas formulated there to be the basis of several publications in the future. So the whole semester was highly beneficial.



**Fratila, Dragos**

Name: Dragos Fratila

Year of Ph.D.: 2014

Institution of Ph.D.: Universite Paris Diderot

Dissertation title: Hall algebras, automorphisms forms and the geometry of principal bundles over an elliptic curve

Ph.D. advisor: Olivier Schiffmann

Mentor while at MSRI: Pramod Achar

Institution prior to obtaining the MSRI PD fellowship: Universite Paris Diderot

Position at that institution: Ph.D. student

Mentor (if applicable): Olivier Schiffmann

Institution where you are going after the MSRI PD fellowship: Max Planck, Bonn, Germany

Position: Post Doc

Anticipated length: (if it is a tenure track position just write tenure-track) 1.5 years

Mentor (if applicable): Geordie Williamson

Postdoctoral fellow's comments:

I mostly worked on the classification of simple summands of spherical Eisenstein sheaves for an elliptic curve and a reductive group  $G$ . I had numerous discussions with Penghui Li and Sam Gunningham about the geometry of semistable bundles. In particular, thanks to Penghui Li, I realized that the stratification (according to some regularity conditions) of the stack of semistable  $G$ -bundles that I thought I've found was pretty wrong. That led me to learn much more about reductive subgroups of reductive groups as well as about nilpotent orbits. Eventually, even the stratification of the stack of semistable bundles seems to require a bit of work and might be interesting in itself so in collaboration with P. Li and S. Gunningham we decided to write an article about this. We have an initial draft on this. We're also planning in a future work to use this stratification to study in more depth the category of perverse sheaves on this stack



**Gunningham, Sam**

Name: Sam Tomas Powaga Gunningham

Year of Ph.D.: 2013

Institution of Ph.D.: Northwestern University

Dissertation Title: "Categorified Harmonic Analysis on a Complex Reductive Group"

Ph.D. Advisor: David Nadler

Mentor while at MSRI: Zhiwei Yun

Position prior to MSRI: University of Texas, Austin, Instructor (with R.H. Bing Postdoctoral Fellowship). Mentors: David Ben-Zvi, Dan Freed.

Position post MSRI: University of Texas, Austin, Instructor (with R.H. Bing Postdoctoral Fellowship). I have 3 semesters more in this position.

Postdoctoral fellow's comments:

My research is in the field of Geometric Representation Theory. Whilst at MSRI, I have been focusing in two directions, both concerning the categories of D-modules on certain stacks associated to a reductive group (for example the adjoint quotient stack).

The first direction is building on work from my thesis, to understand parabolic induction and restriction functors, and the resulting structure on categories of D-modules. I am currently writing a paper, "Generalized Springer Theory on a Reductive Lie Algebra", in which I recover, extend, and present simpler proofs of results from Springer theory. A sequel to this paper is also in preparation. During the preparation of this work I have had many helpful conversations with fellow MSRI members, including Pramod Achar, David Ben-Zvi, Dragos, Fratila, Daniel Juteau, Carl Mautner, Kevin McGerty, David Nadler, Tom Nevins, and Zhiwei Yun. I hope to start a project extending this work to the stack of semistable bundles on an elliptic curve, joint with Dragos Fratila and (Berkeley graduate student) Penghui Li.

The second direction concerns a certain category associated to the group scheme of regular centralizers. This work is in its early stages, and is joint with (MSRI members) David Ben-Zvi and David Nadler. Helpful new perspectives were obtained from conversations with (MSRI member) Ivan Mirkovic.

Overall, my experience at MSRI was overwhelmingly beneficial. The seminars and workshops exposed me to new ideas as well as providing new perspectives on my research. Most notably, the abundance of researchers in my field coupled with a fantastic working environment lead to a very productive semester. The math I have learned and the connections I have made will have a strong and lasting effect on my career.



**Hamacher, Paul**

Name: Paul Hamacher

Year of Ph.D: 2014

Institution of Ph.D.: Technische Universität München

Dissertation title: The geometry of the Newton stratification in the reduction modulo  $p$  of Shimura varieties of PEL type

Ph.D. advisor: Eva Viehmann

Mentor while at MSRI: Xinwen Zhu

Institution prior to obtaining the MSRI PD fellowship: TU München

Position at that institution:

Mentor (if applicable):

Institution (or company) where you are going after the MSRI PD fellowship:

Harvard University

Position: PostDoc on a DAAD scholarship

Anticipated length: 1 year

Mentor: Mark Kisin

Postdoctoral fellow's comments:

I continued my research on the Newton stratification and how it could be generalised to Shimura varieties of Hodge type. The aim is to generalise Mantovan's construction and describe the Newton strata as "almost product" of a central leaf and a subspace of a RZ space. Moreover, I tried to get a better description of a cellular decomposition of superbasic hyperspecial RZ spaces.

No publications were made yet.

During our time at the MSRI, Daniel Desegni, Andreas Mihatsch, Daniel Kirch and I held a reading course about Hilbert Blumenthal spaces.

Was your experience at MSRI beneficial? Yes



**Rostami, Sean**

Name: Sean Rostami

Year of Ph.D: 2012

Institution of Ph.D.: University of Maryland, College Park

Dissertation title: Kottwitz's nearby cycles conjecture for a class of unitary Shimura varieties

Ph.D. Advisor: Thomas Haines

Mentor while at MSRI: Matthias Strauch

Institution prior MSRI: University of Wisconsin, Madison

Position at that institution: Van Vleck Visiting Assistant Professor (postdoc)

Mentor (if applicable): Tonghai Yang

Institution (or company) where you are going after the MSRI PD fellowship: will return to UW for AY2015/2016

Position/Mentor: same as above

Anticipated length: (if it is a tenure track position just write tenure-track)  
1 year (continue and finish existing 3-year postdoc position)

Postdoctoral fellow's comments:

(1) For approximately the first month, I worked on a dessin d'enfants project that was started in the middle of Spring 2014, and I was able to state and prove a nice characterization theorem (I tried to do this in summer but was unsuccessful). This is an important first step in the bigger project, which I will return to in the coming months.

(2) For approximately the next 2 months, I mainly did a mixture of three things. The first was to begin an algebraic geometry question with obvious value to geometric representation theory. Although I learned something and enjoyed thinking about it, no compelling progress was made and I was eventually convinced to postpone the question. The second was to prepare my thesis for publication (for various reasons, it was not published at the time of graduation), which required both expositional and mathematical changes (correcting errors and filling gaps, which required me to read and understand some things that I did not know before). The third was to edit a paper submitted in January 2014, in response to a referee report that I received while at MSRI.

(3) For the past three weeks, and probably for the next couple weeks and into 2015, I am working with a collaborator on a question concerning Gross-Reeder "simple" supercuspidal representations. It's going very well so far.

(4) Finally, there is another potential project that arose from conversations I had with another visitor to MSRI, and we plan to work on this together in the next few months. I think I could have 2 preprints, based on material (1) and (3), ready by summer; I'm not totally sure if anything conclusive will ever come of (2), and I think (4) is a good project but may require more time. The time I spent here was extremely beneficial. Besides the great working conditions (people, environment, freedom from distractions), I feel like I have a lot of momentum and energy to carry into the next year. I suspect it will allow me to be much more successful in the future than I would have been otherwise.





**Rozenblyum, Nikita**

Your Name: Nikita Rozenblyum  
Year of Ph.D: 2011  
Institution of Ph.D.: MIT  
Dissertation title: Connections on conformal blocks  
Ph.D. advisor: Jacob Lurie  
Mentor while at MSRI: David Treumann

Institution prior to obtaining the MSRI PD fellowship: Northwestern University  
Position at that institution: Simons Postdoctoral Fellow  
Mentor (if applicable):

Institution (or company) where you are going after the MSRI PD fellowship: University of Chicago  
Position: Assistant Professor  
Anticipated length: 3 years  
Mentor (if applicable):

Postdoctoral fellow's comments:

I have benefitted a great deal from the program. Particularly beneficial for me were discussions between the geometric representation theory program and the number theory program. During the semester many new connections were established, and it was a wonderful learning experience for me. I expect these ideas will play a significant role in my future work.



**Yang, Yaping**

Name: Yaping Yang

Year of Ph.D.: 2014

Institution of Ph.D.: Northeastern University

Dissertation title: Three contributions to topology, algebraic geometry and representation theory: homological finiteness of abelian covers, algebraic elliptic cohomology theory and monodromy theorems in the elliptic setting

Ph.D. advisor: Valerio Toledano Laredo

Mentor while at MSRI: Edward Frenkel

Institution prior to obtaining the MSRI PD fellowship: Northeastern University

Position at that institution: PhD student

Mentor (if applicable): Valerio Toledano Laredo

Institution (or company) where you are going after the MSRI PD fellowship: UMass, Amherst

Position: Visiting assistant professor

Anticipated length: 2.5 years

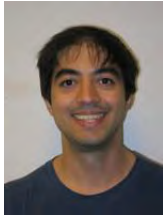
Mentor (if applicable): Ivan Mirkovic

Postdoctoral fellow's comments:

It was an enjoyable and productive semester at MSRI. I had the opportunity to talk to many experts and young researchers, especially Prof. Edward Frenkel, Prof. Ivan Mirkovic and Prof. Valerio Toledano Laredo. Prof. Edward Frenkel is my mentor. We had several official meetings. Frenkel is very kind and helpful. He explains things very well and clear. He gave useful suggestions and down to earth answers. He taught me the theory of conformal blocks for any Riemann surfaces. In particular, the twisted conformal blocks for the elliptic curve give rise to the Knizhnik-Zamolodhikov-Bernard (KZB) connection. It is closely related to the project I have been working on with Toledano Laredo.

I had a regular weekly meeting with Prof. Ivan Mirkovic and started a new project with him.

**NEW GEOMETRIC METHODS IN NUMBER THEORY  
AND AUTOMORPHIC FORMS**



**Amir-Khosravi, Zavosh**

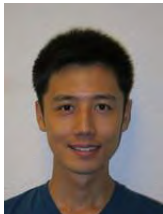
Name: Zavosh Amir-Khosravi  
Year of Ph.D: 2013  
Institution of Ph.D.: University of Toronto  
Dissertation title: Moduli of Abelian Schemes and Serre's Tensor Construction  
Ph.D. advisor: Stephen S. Kudla

Institution prior to obtaining the MSRI PD fellowship: Fields Institute of Mathematical Research  
Position at that institution: Visting Member

Institution (or company) where you are going after the MSRI PD fellowship: University of Pittsburgh  
Position: Post-Doctoral Associate

Postdoctoral fellow's comments:

None



**Diao, Hansheng**

Name: Hansheng Diao  
Year of Ph.D: 2014  
Institution of Ph.D.: Harvard University  
Dissertation title: The Eigencurve is Proper  
Ph.D. advisor: Mark Kisin

Institution prior to obtaining the MSRI PD fellowship: Harvard University  
Position at that institution: Ph.D Candidate  
Mentor (if applicable): Mark Kisin

Institution (or company) where you are going after the MSRI PD fellowship: Princeton University  
Position: Instructor

Postdoctoral fellow's comments:

None



**Disegni, Daniel**

Name: Daniel Disegni  
Year of Ph.D: 2013  
Institution of Ph.D.: Columbia  
Dissertation title: p-adic Heights of Heegner points on Shimura curves  
Ph.D. advisor: Shouwu Zhang  
Mentor while at MSRI: Stephen Kudla

Institution prior to obtaining the MSRI PD fellowship: CRM  
Position at that institution: Postdoc  
Mentor (if applicable): Henri Darmon

Institution (or company) where you are going after the MSRI PD fellowship: CRM  
Position: Postdoc  
Anticipated length: 2 years  
Mentor (if applicable): Henri Darmon

Postdoctoral fellow's comments:

I made final revisions to and submitted the paper "p-adic Heights of Heegner points on Shimura curves", and I mostly completed the manuscript "The p-adic Gross-Zagier formula on Shimura curves". Additionally I gave talks at UCSC and UCLA.

Was your experience at MSRI beneficial? Yes.



**Johansson, Christian**

Name: Christian Johansson

Year of Ph.D: 2013

Institution of Ph.D.: Imperial College London

Dissertation title: Classicality for overconvergent automorphic forms

Ph.D. advisor: Prof. Kevin Buzzard and Prof. Toby Gee

Mentor while at MSRI: Prof. Pierre Colmez

Institution prior to obtaining the MSRI PD fellowship: University of Oxford

Position at that institution: Postdoctoral Research Fellow

Institution (or company) where you are going after the MSRI PD fellowship: Institute for Advanced Study, Princeton

Position: Member

Anticipated length: 20 months

Postdoctoral fellow's comments:

During my stay here at the MSRI I have worked on a few different projects; two of them started prior to my arrival (in the area of overconvergent automorphic forms) and three started whilst I was here, in collaboration with other MSRI visitors (in the area of p-adic representation theory of p-adic groups). None of these projects have been finalized during my time here, though three are getting close to completion. I have also been active in the rich mathematical life here at the MSRI and at UC Berkeley, attending numerous talk and giving two myself (one at MSRI and one at Stanford) and made many new connections that will be of great benefit to my future career as a mathematician.

Was your experience at MSRI beneficial?

Very much so. This semester has brought together a very large number of experts from the areas of mathematics most closely related to my research and it has been very valuable to meet and interact with them. I expect this semester will have a lasting impact on my career.



**Kret, Arno**

Name: Arno Kret  
Year of Ph.D.: 2013  
Institution of Ph.D.: Orsay  
Dissertation title: Stratification de Newton des varietes de Shimura et  
formule des traces d'Arthur-Selberg  
Ph.D. advisor: Clozel, Fargues  
Mentor while at MSRI: Rapoport

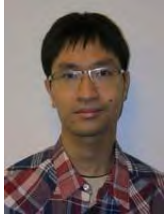
Institution prior to obtaining the MSRI PD fellowship: Institute for  
Advanced Study  
Position at that institution: Member  
Mentor (if applicable): Taylor

Institution (or company) where you are going after the MSRI PD  
fellowship: MPIM  
Position: Post-Doc  
Anticipated length: 1.5 years

Postdoctoral fellow's comments:

I worked on a paper on Langlands conjecture for the group  $GSp$ , also I  
tried to compute dimensions of Newton strata  
I published a paper on Equidistribution in supersingular locus of Shimura  
varieties  
I published a paper called "Combinatorics of the Basic Stratum".

Was your experience at MSRI beneficial? Yes. There were a lot of  
experts, and I had the chance to ask a lot of questions, which were very  
beneficial to my research. Also I worked on a collaboration with one of  
the mathematicians that followed the program as well



**Le, Bao Hung**

Name: Bao Le Hung

Year of Ph.D.: 2014

Institution of Ph.D.: Harvard University

Dissertation title: Modularity of some elliptic curves over totally real fields

Ph.D. advisor: Richard Taylor

Mentor while at MSRI: Ken Ribet

Institution before MSRI: Harvard University

Position: Graduate student

Institution after MSRI: University of Chicago

Position: Postdoc

Anticipated length: 2.5 years

Postdoctoral fellow's comments:

I finished writing up some on-going project, and started on a few new ones. Was your experience at MSRI beneficial? Yes.



**Lomeli, Luis**

Name: Luis Lomeli  
Year of Ph.D.: 2007  
Institution of Ph.D.: Purdue University  
Dissertation title: Functoriality for the classical groups over function fields  
Ph.D. advisor: Freydoon Shahidi  
Mentor while at MSRI: Dipendra Prasad

Institution prior to obtaining the MSRI PD fellowship: University of Oklahoma  
Position at that institution: Visiting Assistant Professor (Postdoc)  
Mentor (if applicable): Alan Roche

Institution (or company) where you are going after the MSRI PD fellowship: Max-Planck Institute for Mathematics  
Position: Postdoctoral fellow  
Anticipated length: (if it is a tenure track position just write tenure-track)  
Spring/Summer 2015  
Mentor (if applicable): Unknown

Postdoctoral fellow's comment:

I have completed a crucial step that makes the Langlands-Shahidi method available in complete generality in the case of function fields. The Langlands-Shahidi method over number fields, being due to Shahidi. I am currently working on writing the article and working on a couple of interesting applications which include a proof of the Ramanujan conjecture for the unitary groups over function fields. Unfortunately, I will probably finish writing the article in Max-Planck, yet much of the work was done here at MSRI and I am very thankful.

Was your experience at MSRI beneficial?

Extremely beneficial. In addition to solving the problem of completing the Langlands-Shahidi method over function fields, I was able to network properly and meet many great professors. My travels were professional. At my undergraduate institution in the neighboring state of Baja California, I was invited to give a general audience Number Theory talk, which went well and I linked it to a trip to LA. I gave seminar talks at UCLA and Caltech.





**Matz, Jasmin**

Name: Jasmin Matz

Year of Ph.D: 2011

Institution of Ph.D.: Heinrich-Heine Universitaet Duesseldorf

Dissertation title: Arthur's trace formula for  $GL(2)$  and  $GL(3)$  and non-compactly supported test functions

Ph.D. advisor: Tobias Finis

Mentor while at MSRI: Erez Lapid

Institution prior to obtaining the MSRI PD fellowship: Universitaet Bonn

Position at that institution: scientific assistant

Mentor (if applicable): Werner Mueller

Institution (or company) where you are going after the MSRI PD fellowship: IAS, Princeton

Position: Postdoctoral fellow

Anticipated length: one semester

Postdoctoral fellow's comments:

I mainly worked on two different topics during my time at the MSRI: On the one hand, a joint project with Nicolas Templier about the distribution of Hecke eigenvalues for automorphic forms for  $GL(n)/\mathbb{Q}$  (extending my previous work for  $GL(n)$ /imaginary quadratic number fields), and, on the other hand, a project on limit multiplicities for the family of quotients  $SL_2(\mathcal{O}_F)\backslash SL_2(\mathbb{R}^r + \mathbb{C}^s)$  for  $F$  varying over number fields of fixed archimedean signature  $(r,s)$ .

In both cases detailed drafts exist but have not yet been submitted for publication.

I benefited from my stay at the MSRI in several ways. First of all, it was Erez Lapid who motivated me to look at the above mentioned limit multiplicity problem. I also benefited a lot from the other ongoing program on geometric representation theory as it gave me the chance to catch up with recent developments in constructing certain L-functions by Ngo, Sakellaridis, and others (a topic I was interested in a while ago, and I hope that I can return to it in the near future).

Finally, I had the chance to talk to many new people.

## DYNAMICS ON MODULI SPACES OF GEOMETRIC STRUCTURES



**Ashley, Caleb**

Name: Caleb Ashley

Year of Ph.D: 2013

Institution of Ph.D.: Howard University

Dissertation title: Towards A Discreteness Algorithm For Non-Elementary Rank 3 Subgroups Of  $PSL(2;R)$

Ph.D. advisor: Todd A. Drumm

Institution prior to obtaining the MSRI PD fellowship: Howard

Position at that institution: Math Instructor

Institution (or company) where you are going after the MSRI PD fellowship: Howard University

Position: Faculty

Postdoctoral fellow's comments:

None



**Baba, Shinpei**

Name: Shinpei Baba

Year of Ph.D: 2009

Institution of Ph.D.: University of California, Davis

Dissertation title: Decomposition theorems for complex projective structures

Ph.D. advisor: Michael Kapovich

Mentor while at MSRI: David Dumas

Institution prior to obtaining the MSRI PD fellowship: Universität Heidelberg

Position at that institution: Postdoctoral Researcher

Mentor (if applicable): Anna Wienhhard

Institution (or company) where you are going after the MSRI PD fellowship: Universität Heidelberg

Position: Postdoctoral Researcher

Anticipated length: 1 year and 3 months

Mentor (if applicable): Anna Wienhard

Postdoctoral fellow's comments:

My experience at MSRI was beneficial both to complete my on-going work and initiate new projects. It was unique experience to have so many experts in the area and spend time together. In particular the projects that I worked at MSRI includes the following:

1. I worked on writing a draft "degeneration of  $CP^1$ -structures by neck pinching" and I gave a talk on it in the postdoc seminar. Discussion with and feed back from people at MSRI were beneficial and also helped to me formulate the proof.
2. I worked on my project with Subhojy Gupta on asymptotic Teichmüller rays. I gave a talk on this Geometry and Analysis of Surface group seminar at MSRI. As result of working at MSRI, I think that we are ready to start writing a paper in order to publish.
3. I and Subhjoy Gupta completed the finial version of "Holonomy map fibers of  $CP^1$ -structures in moduli space" being published in Journal of Topology.



**Dreyer, Guillaume**

Name: Guillaume, Dreyer

Year of Ph.D: 2012

Institution of Ph.D.: University of Southern California

Dissertation title: Geometric properties of Anosov representations

Ph.D. advisor: Francis Bonahon

Mentor while at MSRI:

Institution prior to obtaining the MSRI PD fellowship: University of Norte Dame

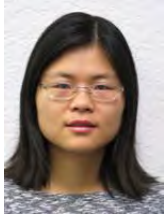
Position at that institution: Visiting Assitant Professor

Institution (or company) where you are going after the MSRI PD fellowship: University of Southern California

Position: Lecturer

Postdoctoral fellow's comments:

None



**Li, Qionglng**

Name: Qionglng Li  
Year of Ph.D: Dec 2014  
Institution of Ph.D.: Rice University  
Dissertation title: Hitchin components, Riemannian metrics and Asymptotics  
Ph.D. advisor: Mike Wolf  
Mentor while at MSRI: Richard Canary

Institution prior to obtaining the MSRI PD fellowship: Rice University  
Position at that institution: Graduate student  
Mentor (if applicable): Mike Wolf

Institution (or company) where you are going after the MSRI PD fellowship: QGM(Aarhus)  
Position: Joint Caltech-QGM postdoc position  
Anticipated length: 3 years  
Mentor (if applicable): Jorgen Anderson and Vladimir Markovic

Postdoctoral fellow's comments:

I mainly worked on three projects during my time at MSRI:

(1) (working with Brain Collier) continuing asymptotics of Higgs bundles in Hitchin components, we start to consider asymptotics of Higgs bundles for maximal representations. Moreover, we even generalize to consider asymptotics of quiver bundles; This work is partially finished and still working in progress.

(2) (working with Tengren Zhang) we consider the Anosov property of tensor products of Anosov representations. In particular, we find a rigidity of the Anosov property. This work is finished and is in preparation.

(3) (working with Daniele Alessandrini) we consider the relation between Higgs bundles and AdS geometry. In particular, we recover many results by the viewpoint of Higgs bundles, like, the AdS geometry, the property of circle fiber, and the volume. This work is finished and is in preparation.

Was your experience at MSRI beneficial? Why or why not?

Yes, my experience at MSRI is very beneficial. I got the chance to talk to many people and learn a lot. I got to know more fields other than my phd work area. For example, the above work (2) and (3) are very different areas from what I've done in my phd. Also, I began to think about more problems in different subjects and I found them very interesting. This experience in MSRI is a very helpful process between my phd and new postdoc position.



**Maloni, Sara**

Name: Sara Maloni

Year of Ph.D: 2013

Institution of Ph.D.: University of Warwick, UK

Dissertation title:

Ph.D. advisor: Caroline Series

Mentor while at MSRI: Howie Masur

Institution prior to obtaining the MSRI PD fellowship: Brown University

Position at that institution: Tamarkin Assistant Professor

Mentor (if applicable): Jeff Brock

Institution (or company) where you are going after the MSRI PD fellowship: Brown University

Anticipated length: 1 year

Mentor (if applicable): Jeff Brock

Postdoctoral fellow's comments:

See next page

## REPORT OF MY EXPERIENCE AT MSRI (SPRING 2015)

My experience as a Huneke Postdoctoral Fellow at the MSRI has been wonderful, and very fruitful. I have been able to participate in most of the activities, to organize a reading seminar (which I think was of interest to a large group of other members), and above all it was great to be surrounded by colleagues and experts in the field which made my stay very productive.

As a postdoc, I was assigned to a mentor, Howie Masur. Our frequent discussions spanned mathematical and professional development topics. I think this was a good tool to help me keep track of the improvements over time, and to overcome some fears mathematicians often have at an early stage of their career.

These are the activities in which I participated weekly:

- (1) Lorentzian seminar;
- (2) Research Seminar for the program “Dynamics on the moduli space of geometric structures”;
- (3) Analysis and Geometry Seminar;
- (4) Mini-course “Geometric finiteness in higher rank symmetric spaces” by Prof. Michael Kapovich and Prof. Bernhard Leeb;
- (5) Postdoc Seminar.

I tried not to attend too many seminars, so that I could dedicate enough time to research and discussions with colleagues. After discussing with my mentor, I tried to choose two or three events each week to attend, so that I could reserve some time to think about my research projects. Of course, many weeks I ended up attending more seminars, but, in general, I succeeded in my plan.

These are the seminars I gave:

- (1) Connection for women, January 16: ‘Introduction to quasi-Fuchsian groups’.
- (2) Postdoc Seminar, March 2: ‘Mapping class group actions on character varieties’.
- (3) Sponsor Day, March 6: ‘Polyhedra inscribed in quadrics and their geometries’.
- (4) Research Seminar, April 9: ‘Mapping class group actions on character varieties’.

People were interested in my work, and, thanks to the discussions, I certainly have now a much more deep understanding of my results, and of their relationship with similar other results in the field. In addition, when I was preparing the talk for the Sponsor Day, Prof. Francis Bonahon, who was also speaking, gave me lots of advices for giving a good ‘colloquium style’ talk.

I also organised a dinner at my house with the women at MSRI and the women grad students at Berkeley. I think it was a successful idea, so it might be worth thinking about some event of this kind in the future semesters as well.

These are the projects I discussed with people while I was a postdoc at MSRI:

- (1) *Exotic Delaunay triangulation*, joint with Jeff Danciger (also at MSRI) and Jean-Marc Schlenker: We develop an analog of the classical Delaunay decomposition with hyperbolas and parabolas, instead of spheres. We then characterize this exotic Delaunay triangulations as the ones satisfying some optimization results.
- (2) *On the character variety of the three holed projective plane*, joint with Frederic Palesi (also at MSRI): We study the (relative)  $SL(2, \mathbb{C})$ -character varieties of the three-holed projective plane and the action of the mapping class group on it. We describe a domain of discontinuity for this action, and we consider the relationship with the previous work of the authors and S. P. Tan on the character variety of the four-holed sphere.
- (3) *The  $SL(2)$ -geometry of the space of Lagrangians*, joint with Daniele Alessandrini and Anna Wienhard (both also at MSRI): We study Anosov representations in  $Sp(4, \mathbb{C})$  and their action on the Lagrangian space  $Lag(\mathbb{C}^4)$ . Using a nice geometrical interpretation of  $Lag(\mathbb{C}^4)$  as the space of regular ideal hyperbolic tetrahedra and their degenerations, we are able to define a natural projection of the domain of discontinuity in  $\mathbb{H}^2$  and study their fiber.
- (4) *Dynamics on  $PSL(2, \mathbb{C})$ -character varieties of manifolds with compressible boundary*, joint with Cyril Lecuire (also at MSRI) and Michelle Lee: We study the  $PSL(2, \mathbb{C})$ -character variety of a general hyperbolizable 3-manifold  $M$  with compressible boundary. In particular, we examine the dynamics of the action of the outer automorphism group, and, we find an open set, on which the action is properly discontinuous, that is strictly larger



than the interior of the deformation space of marked hyperbolic 3-manifolds homotopy equivalent to  $M$ .

- (5) *Interesting examples of primitive stable representations in higher rank groups*, joint with Fanny Kassel (also at MSRI) and Michelle Lee: Using the recent characterization of Anosov representation studied independently by Kapovich–Leeb–Porti and Kassel–Gueritaud–Guichard–Wienghard, there is a natural definition of primitive stable representations in higher rank Lie groups. Kim–Kim studied it in some cases. We want to have a deep understanding of these representations.

The first two papers are almost finished, while the third and the fourth need more work to be terminated. The last project needs a lot more of work, and we want to advance it by developing a more general theory about limits of Anosov representations. In addition to the first project, in joint work with Danciger and Schlenker, we plan to apply one of our earlier result to some conjectures for the universal Teichmüller space. I also interacted a lot with other members or visitors: Ian Agol, Marc Burger, Dick Canary, Bill Goldman, Steve Kerckhoff, Maryam Mirzakhani, Maxime Wolff, and many others.

In addition to these activities I found particularly useful the environment. For example, the schedule during the conference wasn't too busy, so there was lots of time to discuss with colleagues, which I think it is very important. In addition, just to underline the general nice atmosphere, I want to underline that we often organised hikes or gathering during the weekend, with junior and senior members. I found that quite emblematic as well.

Finally, I want to underline how efficient, friendly, and useful was all the staff at MSRI. A big part of this success is certainly due to their effort to make our semester going smoothly every day. Thanks a lot!



**Mann, Kathryn**

Name: Kathryn Mann  
Year of Ph.D.: 2014  
Institution of Ph.D.: University of Chicago  
Dissertation title: Components of spaces of surface group representations  
Ph.D. advisor: Benson Farb  
Mentor while at MSRI: Francis Bonahon

Institution prior to obtaining the MSRI PD fellowship: UC Berkeley  
Position at that institution: Postdoc  
Mentor (if applicable): Ian Agol

Institution (or company) where you are going after the MSRI PD fellowship: UC Berkeley  
Position: Postdoc  
Anticipated length: 2 years  
Mentor (if applicable): Ian Agol

Postdoctoral fellow's comments:

- I have a new collaboration with Maxime Wolff, which is solving a conjecture of mine, and should (hopefully) become a major paper
- I have also been finishing a paper that I started before arriving at MSRI and I spoke about this work at the postdoc seminar.
- I was asked to write a survey paper based on one of my talks, this I have also started to work on
- I learned an immense amount of new material, thanks especially to our program seminar and the minicourse taught by Kapovich and Leeb.
- I was made aware of new techniques (markov maps and symbolic dynamics, work of Bowen) applicable to my research that might help solve a question I raised in my talk, I have just began working on learning this material.

Was your experience at MSRI beneficial? Why or why not?

Yes! Here are just a few of the many reasons:

- I met many senior researchers in my field and related fields, and established relationships with them.
- Speaking at the workshops let me advertise my own work to others
- I gained a broad perspective on a large family of related problems and techniques
- I started a new collaboration which has already produced results (though not written down formally yet); I think it will be a productive, long-term working relationship
- I have collected many questions and new problems that I plan to work on over the next year
- The feedback and career advice from my mentor was immensely helpful.



**Pozzetti, Maria  
Beatrice**

Name: Maria Beatrice Pozzetti  
Year of Ph.D: 2014  
Institution of Ph.D.: ETH Zurich  
Dissertation title: Boundary maps and maximal representations of complex hyperbolic lattices  
Ph.D. advisor: Alessandra Iozzi  
Mentor while at MSRI: Prof. Ursula Hamenstädt

Institution prior to obtaining the MSRI PD fellowship: ETH Zurich  
Position at that institution: PhD Student  
Mentor (if applicable): Prof. Alessandra Iozzi

Institution (or company) where you are going after the MSRI PD fellowship: Warwick University  
Position: Postdoctoral Position  
Anticipated length: 2 years  
Mentor (if applicable): Prof. Karen Vogtmann

Postdoctoral fellow's comments:

I have spent most of the time at MSRI working with Marc Burger on maximal representations. We studied geometric properties of the associated locally symmetric manifolds and degenerations of those. Apart from that I profited a lot from the abundance of interesting talks of both programs, and from the relaxed interaction with many people at the institute. I hope that in the future some of the discussions we had here will turn in new joint works. I also profited a lot from the mentoring program, it gave me the opportunity to interact a lot with Prof. Hamenstädt, discuss ideas with her and get useful feedback about many different issues related both to research and career-planning. All in all the experience at MSRI has been very beneficial.

## GEOMETRIC AND ARITHMETIC ASPECTS OF HOMOGENEOUS DYNAMICS



**de Saxce, Nicolas**

Name: Nicolas de Saxce

Year of Ph.D: 2012

Institution of Ph.D.: Université Paris-Sud (11)

Dissertation title: Borelian subgroups of Lie groups

Ph.D. advisor: Emmanuel Breuillard

Mentor while at MSRI: Yves Benoist

Institution prior to obtaining the MSRI PD fellowship: Hebrew University in Jerusalem

Position at that institution: Postdoc

Mentor (if applicable): Elon Lindenstrauss

Institution (or company) where you are going after the MSRI PD fellowship: CNRS - Université Paris-Nord (13)

Position: Chargé de recherches

Anticipated length: permanent position

Postdoctoral fellow's comments:

Work while in MSRI:

- Convolution in perfect groups, with Yves Benoist (notes).

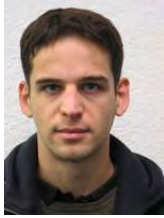
The purpose of this work is to show that in a connected perfect Lie group, any compactly supported continuous function has a convolution power that is  $k$ -times differentiable, for  $k$  an arbitrary integer. This is in sharp contrast with the abelian case, where there exist compactly supported continuous functions such that all of their convolution powers are nowhere differentiable. As an application, we show that if  $A$  is a borelian subset of a connected perfect Lie group with sufficiently large Hausdorff dimension, then some product set of  $A$  contains a non-empty open set.

- Quantum ergodicity in compact simple Lie groups, with Étienne Le Masson (draft).

I was introduced to the study of eigenfunctions of the Laplacian by Étienne Le Masson, and we plan to generalize his work with Elon Lindenstrauss and Shimon Brooks "Quantum Ergodicity and Averaging Operators on the Sphere" (arXiv:1505.03887v1) to the setting of arbitrary homogeneous spaces of compact semi-simple Lie groups. We have a sketch of proof when the homogeneous space is the compact semi-simple Lie group itself.

My experience at MSRI was beneficial, it allowed me to learn about the quantum ergodicity statements and the unique quantum ergodicity conjectures.

Organizing the postdoc seminar was also a great experience, this allowed me to meet the other postdocs from both programs and to discuss math with them.



**Le Masson, Etienne**

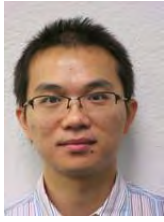
Name: Etienne Le Masson  
Year of Ph.D: 2013  
Institution of Ph.D.: Université Paris-Sud (Orsay)  
Dissertation title: Ergodicity and eigenfunctions of the Laplacian on large regular graphs  
Ph.D. advisor: Nalini Anantharaman  
Mentor while at MSRI: Elon Lindenstrauss

Institution prior to obtaining the MSRI PD fellowship: The Hebrew University of Jerusalem  
Position at that institution: Postdoctoral fellow  
Mentor (if applicable): Elon Lindenstrauss

Institution (or company) where you are going after the MSRI PD fellowship: University of Bristol  
Position: Postdoctoral research assistant  
Anticipated length: 1,5 years  
Mentor (if applicable): Jens Marklof

Postdoctoral fellow's comments:

I finished working on a paper in collaboration with Elon Lindenstrauss that was submitted during my stay at the MSRI. I learned more about homogeneous dynamics thanks in particular to the introductory workshop and have now a better understanding of the domain in general. Although the short time spent here made it difficult to start and finish a project, I had the opportunity to meet new people and start new projects that will hopefully lead to publications in the future. My experience at MSRI was thus very beneficial.



**Li, Han**

Name: Han Li

Year of Ph.D: 2008-2014

Institution of Ph.D.: Yale University

Dissertation title: Some effective results in homogeneous dynamics and number theory

Ph.D. advisor: Professor Gregory A. Margulis

Mentor while at MSRI: Professor Shahar Mozes

Institution prior to obtaining the MSRI PD fellowship: University of Texas at Austin

Position at that institution: Bing Instructor (Postdoc)

Mentor (if applicable): Professor Amir Mohammadi

Institution (or company) where you are going after the MSRI PD fellowship: Wesleyan University

Position: Assistant Professor of Mathematics

Anticipated length: tenure-track

Mentor (if applicable): N.A.

Postdoctoral fellow's comments:

With Dave Witte Morris I have been working on a project about the small generators of arithmetic groups. MSRI had also kindly funded me traveling to Yale University so that I was able to continue my work with Gregory A. Margulis on reduction theory of integral quadratic forms. I have also learned some geometric ideas from my academic mentor, Shahar Mozes, who I met regularly throughout the semester and who have been very responsible and supportive. These experiences have helped me better present my work in the introductory workshop, the advanced workshop, and the postdoc seminar of our program. I want to take this opportunity to express my sincere gratitude to the support from MSRI.



**Shi, Ronggang**

Name: Ronggang Shi

Year of Ph.D: 2009

Institution of Ph.D.: the Ohio State University

Dissertation title:

EQUIDISTRIBUTION OF EXPANDING MEASURES WITH  
LOCAL MAXIMAL DIMENSION AND DIOPHANTINE  
APPROXIMATION

Ph.D. advisor: Manfred Einsiedler

Mentor while at MSRI: Nimish Shah

Institution prior to obtaining the MSRI PD fellowship: Tel Aviv University

Position at that institution: Postdoc

Mentor (if applicable): Barak Weiss

Institution (or company) where you are going after the MSRI PD  
fellowship: Xiamen University

Position: Assistant Professor

Anticipated length: tenure-track

Postdoctoral fellow's comments:

My experience at MSRI is very beneficial.

I almost completed a paper joint with Barak Weiss and Dimitry Kleinbock:  
Pointwise equidistribution with an error rate and with respect to unbounded  
functions. Talking with experts here help me understand many things which  
otherwise may take me longer time.



**Wright, Alexander**  
**Clay postdoc**

Name: Alexander Wright

Year of Ph.D: 2014

Institution of Ph.D.: University of Chicago

Dissertation title: Affine invariant submanifolds in the moduli space of Abelian differentials

Ph.D. advisor: Alex Eskin

Mentor while at MSRI: Maryam Mirzakhani

Institution prior to obtaining the MSRI PD fellowship: Stanford University, and Clay Math Institute

Position at that institution: Clay Research Fellow

Mentor (if applicable): Maryam Mirzakhani

Institution (or company) where you are going after the MSRI PD fellowship: Stanford University, and Clay Math Institute

Position: Clay Research Fellow

Anticipated length: (if it is a tenure track position just write tenure-track): 3-5 years

Mentor (if applicable): Maryam Mirzakhani

Please give a brief description of your work while you were at MSRI as well as any publications made.

I collaborated with Alex Eskin (present at MSRI) and Simion Filip on a project about finiteness of Teichmuller curves and the algebraic hull of the Kontsevich-Zorich cocycle.

I collaborated with Maryam Mirzakhani (my MSRI mentor) on a project "The boundary of an affine invariant submanifold".

I wrote a paper "Finiteness of Teichmuller curves in non-arithmetic rank 1 orbit closures" with Erwan Lanneau and Duc-Manh Nguyen, who both visited MSRI.

Was your experience at MSRI beneficial? Why or why not?

Yes, it was beneficial to get to talk to so many good mathematicians.





**Yang, Lei**

Name: Lei Yang  
Year of Ph.D: 2014  
Institution of Ph.D.: The Ohio State University  
Dissertation title: HAUSDORFF DIMENSION OF DIVERGENT GEODESICS ON PRODUCT OF HYPERBOLIC SPACES  
Ph.D. advisor: Nimish Shah  
Mentor while at MSRI: Dmitry Kleinbock

Institution prior to obtaining the MSRI PD fellowship: Yale University  
Position at that institution: Postdoctoral associate  
Mentor (if applicable): Gregory Margulis

Institution (or company) where you are going after the MSRI PD fellowship: Hebrew University  
Position: Postdoctoral Fellow  
Anticipated length: 1 year  
Mentor (if applicable): Elon Lindentrauss

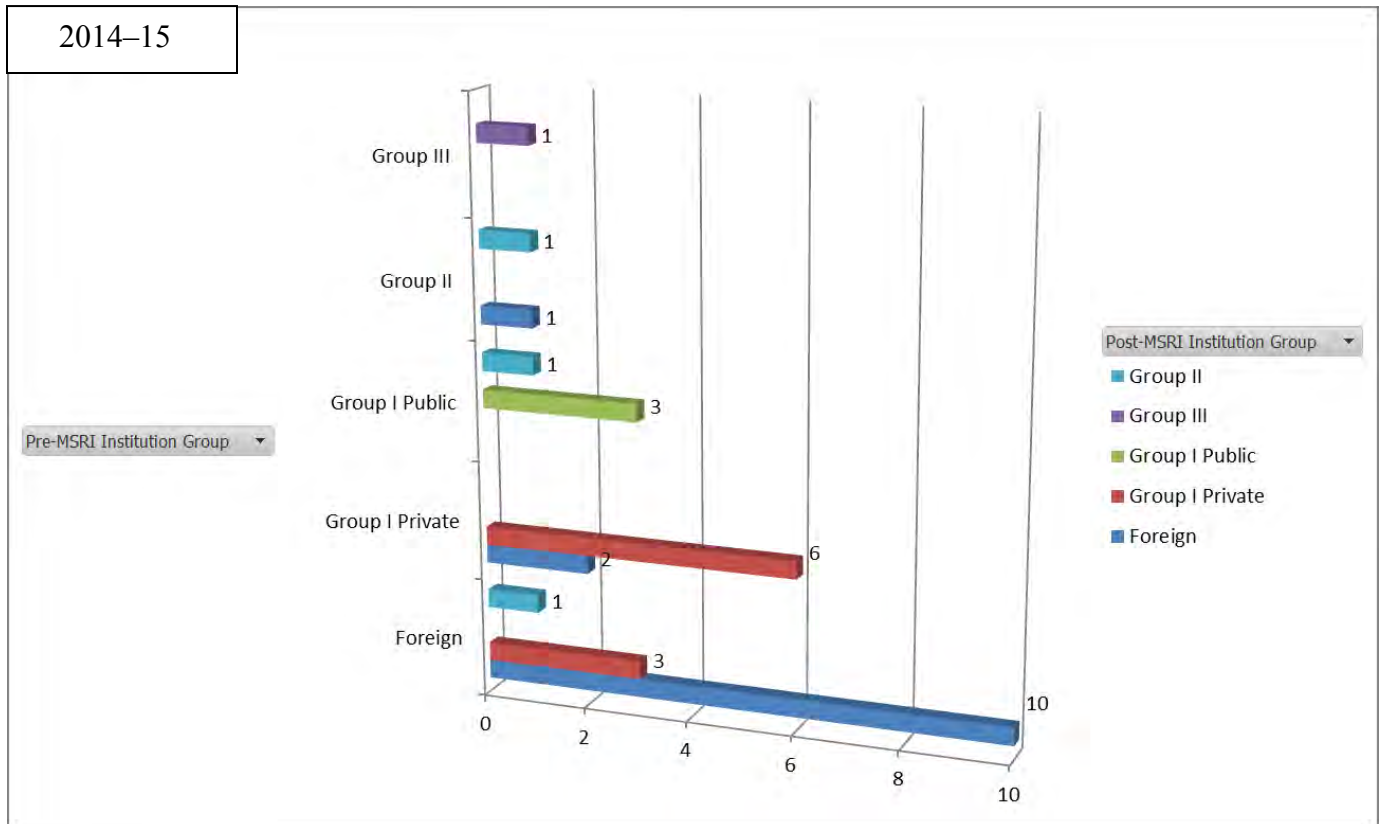
Postdoctoral fellow's comments:

I continue working with Nimish Shah on the equidistribution problem on expanding curves on homogeneous spaces and its applications to number theory. I also work with Ralf Spatzier on the problem of classification of higher rank expanding maps on compact manifolds. I am also talking to Yitwah Cheung and with Dmitry Kleinbock separately, about computing Hausdorff dimensions of points on homogeneous spaces, whose trajectories under particular diagonal flows satisfy particular conditions. I think my experience at MSRI is very beneficial, because during this semester, I have opportunities to talk to and work with many great mathematicians in my field. Moreover, at MSRI, I learned a lot from many talks by people working on different branches and problems in homogeneous dynamics and dynamics of moduli spaces. Most topics of these talks are new to me, so my knowledge was greatly broadened during this semester.

### 3.2 Postdoctoral Fellow Placement List

Family Name	First Name	Pre-MSRI Institution Group	Post-MSRI Institution Group	Pre-MSRI Institution Name	Placement Institution Name
Amir-Khosravi	Zavosh	Foreign	Group II	Fields Institute for Research in Mathematical Sciences	University of Pittsburgh
Ashley	Caleb	Group III	Group III	Howard University	Howard University
Baba	Shinpei	Foreign	Foreign	Universität Heidelberg	Universität Heidelberg
Bouthier	Alexis	Foreign	Foreign	Université de Paris XI	Hebrew University
Dancso	Zsuzsanna	Foreign	Foreign	University of Toronto	Australian National University
de Saxce	Nicolas	Foreign	Foreign	Hebrew University	Université de Paris XIII (Paris-Nord)
Diao	Hansheng	Group I Private	Group I Private	Harvard University	Princeton University
Disegni	Daniel	Foreign	Foreign	McGill University	McGill University
Dodd	Christopher	Foreign	Foreign	University of Toronto	University of Toronto
Dreyer	Guillaume	Group I Private	Group I Private	University of Notre Dame	University of Southern California
Fratila	Dragos	Foreign	Foreign	Université de Paris VII (Denis Diderot)	Max Planck Institute
Gunningham	Sam	Group I Public	Group I Public	University of Texas at Austin	University of Texas at Austin
Hamacher	Paul	Foreign	Group I Private	TU Munchen	Harvard University
Johansson	Christian	Foreign	Group I Private	University of Oxford	Princeton University
Kret	Arno	Group I Private	Foreign	Institute for Advanced Study	Max Planck Institute
Le Hung	Bao	Group I Private	Group I Private	Harvard University	University of Chicago
Le Masson	Etienne	Foreign	Foreign	Hebrew University	University of Bristol
Li	Qiongling	Group I Private	Group I Private	Rice University	Caltech
Li	Han	Group I Public	Group II	University of Texas at Austin	Wesleyan University
Lomeli	Luis	Group II	Foreign	University of Oklahoma	Max Planck
Maloni	Sara	Group I Private	Group I Private	Brown University	Brown University
Mann	Kathryn	Group I Public	Group I Public	University of California, Berkeley	University of California, Berkeley
Matz	Jasmin	Foreign	Group I Private	Rheinische Friedrich-Wilhelms-Universität Bonn	Princeton University
Pozzetti	Maria Beatrice	Foreign	Foreign	ETH Zurich	University of Warwick
Rostami	Sean	Group I Public	Group I Public	University of Wisconsin-Madison	University of Wisconsin-Madison
Rozenblyum	Nikita	Group I Private	Group I Private	Northwestern University	University of Chicago
Shi	Ronggang	Foreign	Foreign	Tel Aviv University	Xiamen University
Yang	Lei	Group I Private	Foreign	Yale University	Hebrew University
Yang	Yaping	Group II	Group II	Northeastern University	UMass, Amherst

**Postdoctoral Fellow Placement Institution**  
(based on AMS Groupings)



## Highlights

Of the nine postdocs who came from Group I Private Institutions, six are currently at Group I Private Institutions. The others are divided among Group II and Foreign Institutions.

Of the four postdocs who came from Group I Public Institutions, three are currently at Group I Public Institutions, and one is at Group II.

Of the 13 postdocs who came from Foreign Institutions, 10 returned to Foreign Institutions.

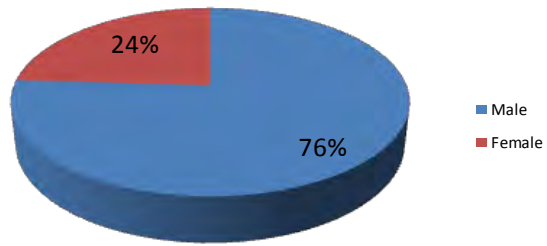
### 3.3 Postdoctoral Fellow Participant Summary

Programs	# of Members	# of Citizens & Perm. Res.	%	# of Female	%	# of Minorities <sup>1</sup>	%	US Home Institution	%
Dynamics on Moduli Spaces of Geometric Structures	7	3	42.9%	4	57.1%	1	100.0%	5	71.4%
Geometric and Arithmetic Aspects of Homogeneous Dynamics	5	1	20.0%	0	0.0%	0	0.0%	1	20.0%
Geometric Representation Theory	9	3	33.3%	2	22.2%	0	0.0%	5	55.6%
New Geometric Methods in Number Theory and Automorphic Forms	8	0	0.0%	1	12.5%	0	0.0%	4	50.0%
Complementary Program (2014-15)	0	0	0.0%	0	0.0%	0	0.0%	0	0.0%
<b>Total # of Distinct Postdocs</b>	<b>29</b>	<b>7</b>	<b>24.1%</b>	<b>7</b>	<b>24.1%</b>	<b>1</b>	<b>20.0%</b>	<b>15</b>	<b>51.7%</b>

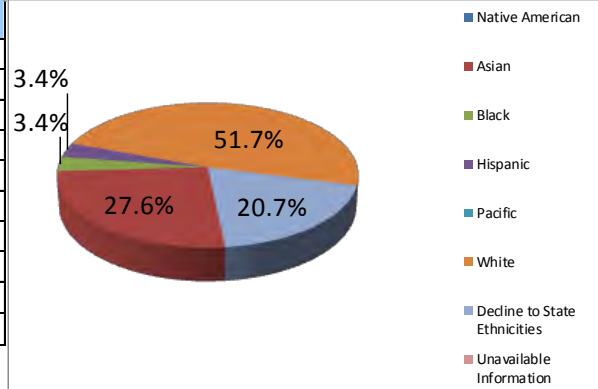
<sup>1</sup> Minorities are US citizen who declare themselves American Indian, Black, Hispanic, or Pacific Islander. Minority percentage is calculated by dividing the number of Minorities by the total number of US citizens.

### 3.4 Postdoctoral Fellow Demographic Data

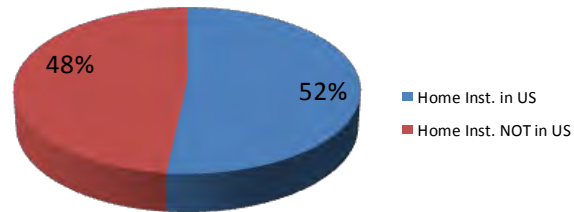
Gender	#	%(No Decl.)*	%
# of Distinct Postdocs	29		100.0%
Male	22	75.86%	75.9%
Female	7	24.14%	24.1%
Decline to State Gender	0		0.0%



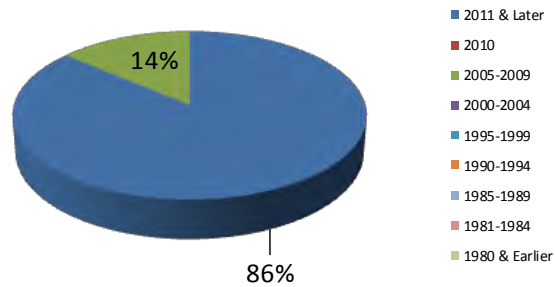
Ethnicities	#	%(No Decl.)*	%
Native American	0	0.00%	0.0%
Asian	8	32.00%	27.6%
Black	1	4.00%	3.4%
Hispanic	1	4.00%	3.4%
Pacific	0	0.00%	0.0%
White	15	60.00%	51.7%
Decline to State Ethnicities	6		20.7%
Unavailable Information	0		0.0%
Minorities	1		20.0%



Citizenships	#	%(No Decl.)*	%
US Citizen & Perm. Residents	7		24.1%
Foreign	22		75.9%
Unavailable information	0		0.0%
# of Distinct Members	29		100.0%
US Citizen	5		17.2%
Perm Residents	2		6.9%
Home Inst. in US	15		51.72%



Year of Ph.D	#	%(No Decl.)*	%
2011 & Later	25		86.2%
2010	0		0.0%
2005-2009	4		13.8%
2000-2004	0		0.0%
1995-1999	0		0.0%
1990-1994	0		0.0%
1985-1989	0		0.0%
1981-1984	0		0.0%
1980 & Earlier	0		0.0%
Unavailable Info.	0		0.0%
Total # of Distinct Postdocs	29		100.0%



\*Statistic Calculation based on all participants that did not decline.

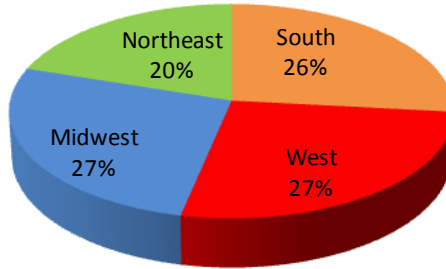
#### Programs

- Dynamics on Moduli Spaces of Geometric Structures
- Geometric and Arithmetic Aspects of Homogeneous Dynamics
- Geometric Representation Theory
- New Geometric Methods in Number Theory and Automorphic Forms
- Complementary Program (2014-15)

**2014–15 Postdoctoral Fellows Home Institution Classified by States**

*\*Regions based on US Census classification*

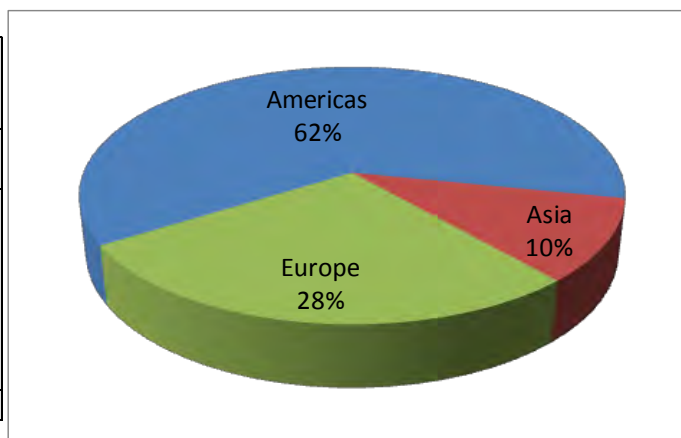
State	#	%	2007 Census Population
<b>South</b>	<b>4</b>	<b>26.7%</b>	<b>36.6%</b>
AL	-	0.0%	1.5%
AR	-	0.0%	0.9%
DE	-	0.0%	0.3%
DC	1	6.7%	0.2%
FL	-	0.0%	6.1%
GA	-	0.0%	3.2%
KY	-	0.0%	1.4%
LA	-	0.0%	1.4%
MD	-	0.0%	1.9%
MS	-	0.0%	1.0%
NC	-	0.0%	3.0%
OK	-	0.0%	1.2%
SC	-	0.0%	1.5%
TN	-	0.0%	2.0%
TX	3	20.0%	7.9%
VA	-	0.0%	2.6%
WV	-	0.0%	0.6%
<b>West</b>	<b>4</b>	<b>26.7%</b>	<b>23.2%</b>
AK	-	0.0%	0.2%
AZ	-	0.0%	2.1%
HI	-	0.0%	0.4%
ID	-	0.0%	0.5%
MT	-	0.0%	0.3%
CA	4	26.7%	12.1%
CO	-	0.0%	1.6%
NV	-	0.0%	0.9%
NM	-	0.0%	0.7%
OR	-	0.0%	1.2%
UT	-	0.0%	0.9%
WA	-	0.0%	2.1%
WY	-	0.0%	0.2%
<b>Midwest</b>	<b>4</b>	<b>26.7%</b>	<b>22.0%</b>
IL	2	13.3%	4.3%
IN	1	6.7%	2.1%
IA	-	0.0%	1.0%
KS	-	0.0%	0.9%
MI	-	0.0%	3.3%
MN	-	0.0%	1.7%
MO	-	0.0%	1.9%
ND	-	0.0%	0.2%
NE	-	0.0%	0.6%
OH	-	0.0%	3.8%
SD	-	0.0%	0.3%
WI	1	6.7%	1.9%
<b>Northeast</b>	<b>3</b>	<b>20.0%</b>	<b>18.1%</b>
CT	-	0.0%	1.2%
ME	-	0.0%	0.4%
MA	-	0.0%	2.1%
NH	-	0.0%	0.4%
NJ	2	13.3%	2.9%
NY	-	0.0%	6.4%
PA	-	0.0%	4.1%
RI	1	6.7%	0.4%
VT	-	0.0%	0.2%
Other	-	<b>0.0%</b>	<b>0%</b>
PR	-	0.0%	0%
Other	-	0.0%	0%
<b>Total</b>	<b>15</b>	<b>100%</b>	<b>100%</b>



## 2014–15 Postdoctoral Fellows Home Institution Classified by Countries

\*Regions based on United Nations classification

<b>Americas</b>		<b>18</b>
North America	Canada	3
	United States	15
<b>Asia</b>		<b>3</b>
Western Asia	Israel	3
<b>Europe</b>		<b>8</b>
Northern Europe	England	2
	France	3
	Germany	3
<b>Grand Total</b>		<b>29</b>



## 3.5 Postdoctoral Research Member Placement List

Family Name	First Name	Pre-MSRI Institution Group	Post-MSRI Institution Group	Pre-MSRI Institution Name	Placement Institution Name
Danciger	Jeffrey	Group I Public	Group I Public	University of Texas	University of Texas
Dowdall	Spencer	Group I Public	Group I Public	University of Illinois at Urbana-Champaign	University of Illinois at Urbana-Champaign
Caraiani	Ana	Group I Private	Group I Private	Princeton University	Princeton University
Larrain-Hubach	Andres	Group II	Group II	University of Arizona	University of Arizona
Sanders	Andrew	Group IV	Group IV	University of Illinois at Chicago	University of Illinois at Chicago
Dobrovolaska	Galyna	Group I Private	Group I Private	Columbia University	Columbia University
Raskin	Sam	Group I Private	Group I Private	Massachusetts Institute of Technology	Massachusetts Institute of Technology
Gekhtman	Ilya	Group I Private	Group I Private	Yale University	Yale University
Wright	Alexander	Group I Private	Group I Private	Stanford University	Stanford University

## 3.6 Postdoctoral Research Member Summary

Programs	# of PDRMs	# of Citizens & Perm. Res.	%	# of Female	%	# of Minorities <sup>1</sup>	%	US Home Institution	%
Dynamics on Moduli Spaces of Geometric Structures	4	4	100.0%	0	0.0%	1	25.0%	4	100.0%
Geometric and Arithmetic Aspects of Homogeneous Dynamics	2	1	50.0%	0	0.0%	0	0.0%	2	100.0%
Geometric Representation Theory	2	2	100.0%	1	50.0%	0	0.0%	2	100.0%
New Geometric Methods in Number Theory and Automorphic Forms	1	1	100.0%	1	100.0%	0	0.0%	1	100.0%
<b>Total # of Distinct PDRMs</b>	<b>9</b>	<b>8</b>	<b>88.9%</b>	<b>2</b>	<b>22.2%</b>	<b>1</b>	<b>16.7%</b>	<b>9</b>	<b>100.0%</b>

<sup>1</sup> Minorities are US citizen who declare themselves American Indian, Black, Hispanic, or Pacific Islander. Minority percentage is calculated by dividing the number of Minorities by the total number of US citizens.

# 4. Graduate Program

In 2014–15, 941 graduate students visited MSRI to participate in our workshops (486 graduate students), summer graduate schools (417 graduate students), and programs (38 graduate students). While the majority of the graduate students who visit MSRI had been invited to take part in one of our workshops or summer graduate schools, a smaller number of graduate students were invited as ‘Program Associates’ in our semester- and year-long scientific programs.

## 4.1 Summer Graduate Schools (SGS)

Every summer, MSRI organizes several summer graduate schools (usually two weeks each), most of which are held at MSRI. Attending one of these schools can be a very motivating and

exciting experience for a student; participants have often said that it was the first experience where they felt like real mathematicians, interacting with other students and mathematicians in their field.

Graduate students from MSRI Academic Sponsoring Institutions or from Department of Mathematics at U.S. Universities are eligible for summer schools. For each institution, MSRI provides support for two students per summer and for a third student if at least one of the students is female or from a group that is underrepresented in the mathematical sciences. MSRI covers travel and local expenses with the maximal allowance for travel reimbursement being \$550 for students from U.S. and Canadian universities (depending on the point of origin), and \$700 for students from other sponsoring institutions.

The application procedure is as follows: The summer graduate schools and the open enrollment period for the summer of year  $n+1$  are announced in October of year  $n$ . Graduate students must be nominated by their Director of Graduate Studies during the enrollment period. MSRI accepts nominees on a first-come first-served basis up to the limits of the capacity of each workshop, which is around 40-50 for workshops that are held at MSRI. If the chosen workshop is already full, the students are either kept on a waiting list or the nominating institution may make nominations to other workshops until its workshop quota is reached.

The following is a list of the 14 Summer Graduate Schools that took place during the 2014 and 2015 summers. Altogether 58 lecturers and 417 graduate students participated in these workshops. Of those graduate students, 28% were female. See the table in section 4.2 for detailed demographic data.

For a complete report on each SGS, please refer to the Appendix.

### **Summer 2014**

#### **SGS 1: Dispersive Partial Differential Equations**

June 16, 2014 - June 27, 2014

*Organizers: Natasa Pavlovic (University of Texas), Nikolaos Tzirakis (University of Illinois at Urbana-Champaign)*

#### **SGS 2: Seminaire de Mathematiques Superieures 2014: Counting Arithmetic Objects**

**Location: Montreal, Canada**

June 23, 2014 - July 04, 2014

*Organizers: Henri Darmon (McGill University), Andrew Granville (Université de Montréal), Benedict Gross (Harvard University)*

#### **SGS 3: IAS/PCMI 2014: Mathematics and Materials**

June 29, 2014 - July 19, 2014

**Location: Park City, Utah**

*Organizers: Mark Bowick (Syracuse University), David Kinderlehrer (Carnegie Mellon University), Govind Menon (Brown University), Charles Radin (University of Texas)*

**SGS 4: Algebraic Topology**

June 30, 2014 - July 11, 2014

*Organizers: \*Jose Cantarero-Lopez (Centro de Investigación en Matemáticas), Michael Hill (University of Virginia)*

**SGS 5: Stochastic Partial Differential Equations**

July 07, 2014 - July 18, 2014

*Organizers: Yuri Bakhtin (New York University, Courant Institute), Ivan Corwin (Columbia University), James Nolen (Duke University)*

**SGS 6: Geometry and Analysis**

July 28, 2014 - August 08, 2014

*Organizers: Hans-Joachim Hein (Imperial College, London), Aaron Naber (Massachusetts Institute of Technology)*

**Summer 2015****SGS 1: CRM-PIMS Summer School in Probability**

June 15, 2015 - July 11, 2015

**Location: Montreal, Canada**

*Organizers: Louigi Addario-Berry (McGill University), Louis-Pierre Arguin (Université de Montréal), Alexander Fribergh (Université de Montréal), Lea Popovic (Concordia University)*

**SGS 2: Geometric Group Theory**

June 15, 2015 - June 26, 2015

*Organizers: John Mackay (University of Bristol), Anne Thomas (University of Sydney), Kevin Wortman (University of Utah)*

**SGS 3: Seminaire de Mathematiques Superieures 2015: Geometric and Computational Spectral Theory**

June 15, 2015 - June 26, 2015

**Location: Montreal, Canada**

*Organizers: Alexandre Girouard (Laval University), Dmitry Jakobson (McGill University), Michael Levitin (University of Reading), Nilima Nigam (Simon Fraser University), Iosif Polterovich (Université de Montréal), Frederic Rochon (Université du Québec à Montréal)*

**SGS 4: NIMS Summer School on Random Matrix Theory**

June 29, 2015 - July 10, 2015

**Location: Daejeon, South Korea**

*Organizers: Jinho Baik (University of Michigan)*

**SGS 5: Mathematical Topics in Systems Biology**

June 29, 2015 - July 10, 2015

*Organizers: Steven Altschuler (University of California, San Francisco), Lani Wu (UCSF)*

**SGS 6: Berkeley summer course in mining and modeling of neuroscience data**

July 06, 2015 - July 17, 2015

**Location: UC Berkeley**



Organizers: Ingrid Daubechies (Duke University), Bruno Olshausen (University of California, Berkeley), Christos Papadimitriou (University of California, Berkeley), Fritz Sommer (University of California, Berkeley), Jeff Teeters (University of California, Berkeley)

### SGS 7: Gaps between Primes and Analytic Number Theory

July 13, 2015 - July 24, 2015

Organizers: Dimitris Koukoulopoulos (Université de Montréal), Emmanuel Kowalski (ETH Zuerich), James Maynard (University of Oxford), Kannan Soundararajan (Stanford University)

### SGS 8: Incompressible Fluid Flows at High Reynolds Number

July 27, 2015 - August 07, 2015

Organizers: Jacob Bedrossian (University of Maryland), Vlad Vicol (Princeton University)

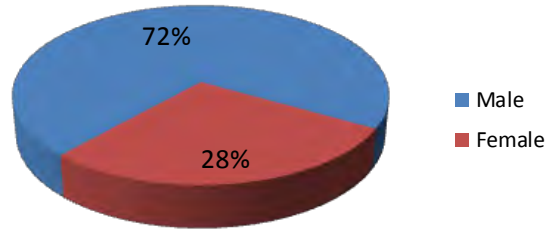
## 4.2 Summer Graduate Schools 2014 & 2015 Data

Summer Graduate Schools	# of Students	# of Citizens & Perm. Res.	%	# of Female	%	# of Minorities <sup>1</sup>	%	US Home Institution	%
Algebraic Topology	16	13	81.3%	5	31.3%	0	0.0%	15	93.8%
Dispersive Partial Differential Equations	46	20	43.5%	14	30.4%	1	5.0%	38	82.6%
Geometry and Analysis	48	20	41.7%	7	14.6%	1	5.0%	39	81.3%
IAS/PCMI 2014: Mathematics and Materials	11	5	45.5%	5	45.5%	0	0.0%	9	81.8%
Seminaire de Mathematiques Superieures 2014: Counting Arithmetic Objects	23	15	65.2%	9	39.1%	1	6.7%	22	95.7%
Stochastic Partial Differential Equations	53	17	32.1%	18	34.0%	3	17.6%	45	84.9%
Berkeley summer course in mining and modeling of neuroscience data	6	5	83.3%	2	33.3%	0	0.0%	6	100.0%
CRM-PIMS Summer School in Probability	18	7	38.9%	3	16.7%	0	0.0%	15	83.3%
Gaps between Primes and Analytic Number Theory	41	26	63.4%	12	29.3%	0	0.0%	36	87.8%
Geometric Group Theory	55	35	63.6%	15	27.3%	0	0.0%	46	83.6%
Incompressible Fluid Flows at High Reynolds Number	47	22	46.8%	14	29.8%	0	0.0%	40	85.1%
Mathematical Topics in Systems Biology	20	10	50.0%	10	50.0%	0	0.0%	15	75.0%
NIMS Summer School on Random Matrix Theory	14	7	50.0%	3	21.4%	0	0.0%	13	92.9%
Seminaire de Mathematiques Superieures 2015: Geometric and Computational Spectral Theory	19	7	36.8%	1	5.3%	0	0.0%	18	94.7%
<b>Total # of Students</b>	<b>417</b>	<b>209</b>	<b>50.1%</b>	<b>118</b>	<b>28.3%</b>	<b>6</b>	<b>6.1%</b>	<b>357</b>	<b>85.6%</b>

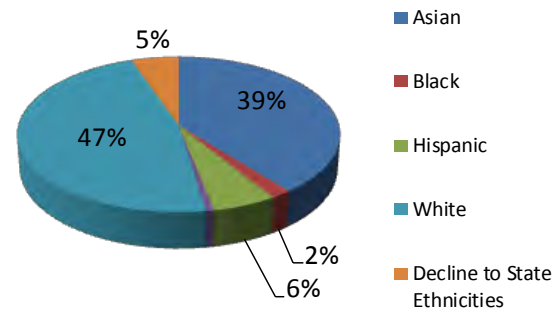
<sup>1</sup> Minorities are US citizens who declare themselves American Indian, Black, Hispanic, or Pacific Islander. Minority percentage is calculated by dividing the number of Minorities by the total number of US citizens.

## Summer Graduate School Demographic Data

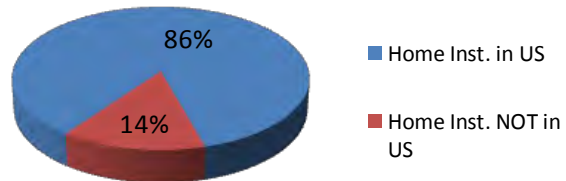
Gender	#	%(No Decl.)*	%
# of Students	417		100.0%
Male	297	71.57%	71.2%
Female	118	28.43%	28.3%
Decline to State Gender	2		0.5%



Ethnicities	#	%(No Decl.)*	%
Native American	1	0.24%	0.2%
Asian	170	41.36%	39.2%
Black	8	1.95%	1.8%
Hispanic	25	6.08%	5.8%
Pacific	3	0.73%	0.7%
White	204	49.64%	47.0%
Decline to State Ethnicities	23		5.3%
Unavailable Information	0		0.0%
Minorities	6		3.1%



Citizenships	#	%(No Decl.)*	%
US Citizen & Perm. Residents	209		50.1%
Foreign	208		49.9%
Unavailable information	0		0.0%
# of Students	417		100.0%
US Citizen	196		93.8%
Perm Residents	13		100.0%
Home Inst. in US	357		85.61%



\*Statistic Calculation based on all participants that did not decline.

### Summer Graduate Schools

*Algebraic Topology*

*Dispersive Partial Differential Equations*

*Geometry and Analysis*

*IAS/PCMI 2014: Mathematics and Materials*

*Seminaire de Mathematiques Superieures 2014: Counting Arithmetic Objects*

*Stochastic Partial Differential Equations*

*Berkeley summer course in mining and modeling of neuroscience data*

*CRM-PIMS Summer School in Probability*

*Gaps between Primes and Analytic Number Theory*

*Geometric Group Theory*

*Incompressible Fluid Flows at High Reynolds Number*

*Mathematical Topics in Systems Biology*

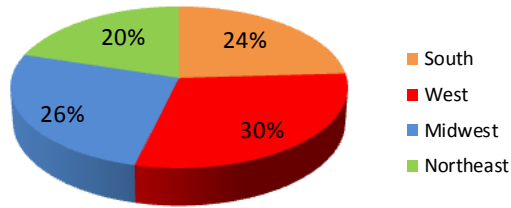
*NIMS Summer School on Random Matrix Theory*

*Seminaire de Mathematiques Superieures 2015: Geometric and Computational Spectral Theory*

**2014 & 2015 Summer Graduate Schools Home Institution Classified by States**

*\*Regions based on US Census classification*

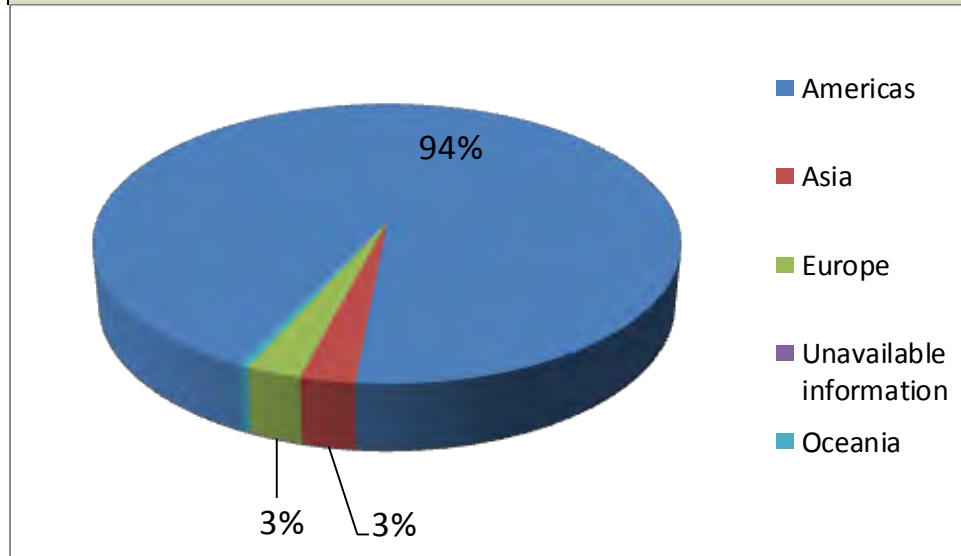
State	#	%	2007 Census Population
<b>South</b>	<b>86</b>	<b>24.1%</b>	<b>36.6%</b>
AL	1	0.3%	1.5%
AR	-	0.0%	0.9%
DE	5	1.4%	0.3%
DC	-	0.0%	0.2%
FL	2	0.6%	6.1%
GA	10	2.8%	3.2%
KY	3	0.8%	1.4%
LA	8	2.2%	1.4%
MD	12	3.4%	1.9%
MS	-	0.0%	1.0%
NC	11	3.1%	3.0%
OK	5	1.4%	1.2%
SC	-	0.0%	1.5%
TN	7	2.0%	2.0%
TX	17	4.8%	7.9%
VA	5	1.4%	2.6%
WV	-	0.0%	0.6%
<b>West</b>	<b>106</b>	<b>29.7%</b>	<b>23.2%</b>
AK	-	0.0%	0.2%
AZ	11	3.1%	2.1%
HI	-	0.0%	0.4%
ID	-	0.0%	0.5%
MT	-	0.0%	0.3%
CA	63	17.6%	12.1%
CO	8	2.2%	1.6%
NV	1	0.3%	0.9%
NM	-	0.0%	0.7%
OR	8	2.2%	1.2%
UT	7	2.0%	0.9%
WA	8	2.2%	2.1%
WY	-	0.0%	0.2%
<b>Midwest</b>	<b>93</b>	<b>26.1%</b>	<b>22.0%</b>
IL	17	4.8%	4.3%
IN	16	4.5%	2.1%
IA	6	1.7%	1.0%
KS	10	2.8%	0.9%
MI	12	3.4%	3.3%
MN	4	1.1%	1.7%
MO	5	1.4%	1.9%
ND	1	0.3%	0.2%
NE	5	1.4%	0.6%
OH	10	2.8%	3.8%
SD	-	0.0%	0.3%
WI	7	2.0%	1.9%
<b>Northeast</b>	<b>72</b>	<b>20.2%</b>	<b>18.1%</b>
CT	-	0.0%	1.2%
ME	-	0.0%	0.4%
MA	25	7.0%	2.1%
NH	3	0.8%	0.4%
NJ	13	3.6%	2.9%
NY	20	5.6%	6.4%
PA	9	2.5%	4.1%
RI	2	0.6%	0.4%
VT	-	0.0%	0.2%
<b>Other</b>	<b>-</b>	<b>0.0%</b>	<b>0%</b>
PR	-	0.0%	0%
Other	-	0.0%	0%
<b>Total</b>	<b>357</b>	<b>100%</b>	<b>100%</b>



## 2014 & 2015 Summer Graduate Schools Home Institution Classified by Countries

\*Regions based on United Nations classification

<b>Americas</b>		<b>393</b>
Central America	Mexico	5
North America	Canada	29
	United States	357
South America	Colombia	2
<b>Asia</b>		<b>11</b>
East Asia	China	4
	Korea, Republic of	7
<b>Europe</b>		<b>11</b>
Southern Europe	Italy	4
	Spain	1
Western Europe	Austria	2
	Germany	4
<b>Oceania</b>		<b>2</b>
Australia and New Zealand	Australia	2
<b>Unavailable information</b>		<b>0</b>
<b>Grand Total</b>		<b>417</b>



### 4.3 Program Associate

Program Associates benefit greatly from the opportunity to interact with leaders of a field and postdoctoral fellows, gaining intense exposure to current ideas and trends in their area of specialization. While MSRI does not have the financial resources to fund the Program Associates, they are closely supervised and essentially benefit from all members' privileges, including shared office space. They are provided with an access card to the building which

allows them to use the premises at any time. They receive a bus pass, and a library and sports facilities access pass. There were 38 graduate students who resided at MSRI for an extended period of time during the academic year 2014–15. See the table in section 4.4 for a detailed description of the demographic data.

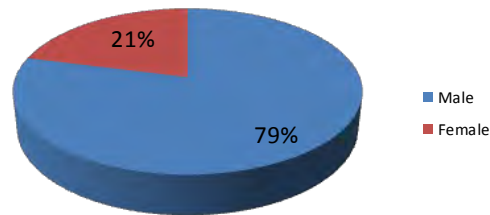
## 4.4 Program Associate Data

Programs	# of PAs	# of Citizens & Perm. Res.	%	# of Female	%	# of Minorities <sup>1</sup>	%	US Home Institution	%
Dynamics on Moduli Spaces of Geometric Structures	7	2	28.6%	1	14.3%	0	0.0%	4	57.1%
Geometric and Arithmetic Aspects of Homogeneous Dynamics	12	4	33.3%	3	25.0%	0	0.0%	7	58.3%
Geometric Representation Theory	10	5	50.0%	2	20.0%	0	0.0%	6	60.0%
New Geometric Methods in Number Theory and Automorphic Forms	9	0	0.0%	2	22.2%	0	0.0%	0	0.0%
<b>Total # of Distinct Program Associates</b>	<b>38</b>	<b>11</b>	<b>28.9%</b>	<b>8</b>	<b>21.1%</b>	<b>-</b>	<b>0.0%</b>	<b>17</b>	<b>44.7%</b>

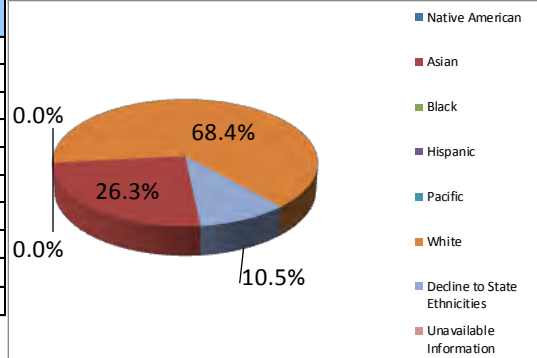
<sup>1</sup> Minorities are US citizen who declare themselves American Indian, Black, Hispanic, or Pacific Islander. Minority percentage is calculated by dividing the number of Minorities by the total number of US citizens.

## Program Associate Demographic Data

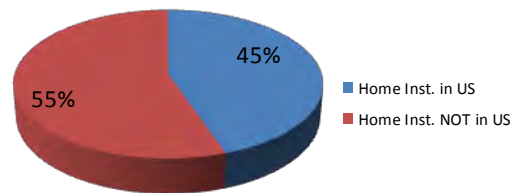
Gender	#	%(No Decl.)*	%
# of Distinct Members	38		100.0%
Male	30	78.95%	78.9%
Female	8	21.05%	21.1%
Decline to State Gender	0		0.0%



Ethnicities	#	%(No Decl.)*	%
Native American	0	0.00%	0.0%
Asian	10	27.78%	26.3%
Black	0	0.00%	0.0%
Hispanic	0	0.00%	0.0%
Pacific	0	0.00%	0.0%
White	26	72.22%	68.4%
Decline to State Ethnicities	4		10.5%
Unavailable Information	0		0.0%
Minorities	0		0.0%



Citizenships	#	%(No Decl.)*	%
US Citizen & Perm. Residents	11		28.9%
Foreign	27		71.1%
Unavailable information	0		0.0%
# of Distinct Members	38		100.0%
US Citizen	10		26.3%
Perm Residents	1		2.6%
Home Inst. in US	17		44.74%



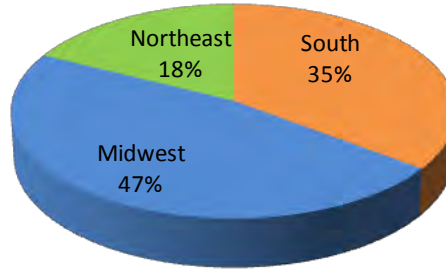
### Programs

*Dynamics on Moduli Spaces of Geometric Structures*  
*Geometric and Arithmetic Aspects of Homogeneous Dynamics*  
*Geometric Representation Theory*  
*New Geometric Methods in Number Theory and Automorphic Forms*  
*Complementary Program (2014-15)*

**2014–15 Program Associates Home Institution Classified by States**

*\*Regions based on US Census classification*

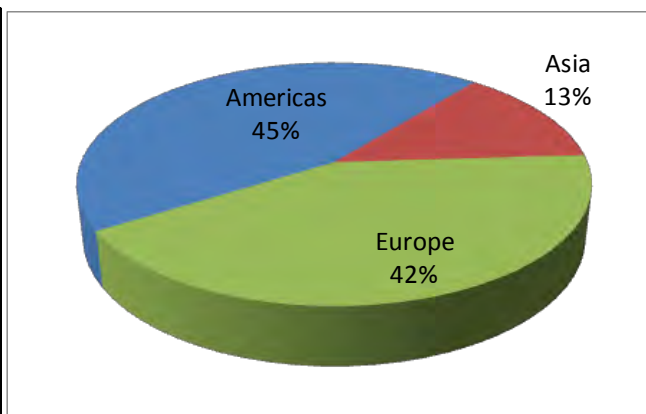
State	#	%	2007 Census Population
<b>South</b>	<b>6</b>	<b>35.3%</b>	<b>36.6%</b>
AL	-	0.0%	1.5%
AR	-	0.0%	0.9%
DE	-	0.0%	0.3%
DC	-	0.0%	0.2%
FL	-	0.0%	6.1%
GA	-	0.0%	3.2%
KY	-	0.0%	1.4%
LA	1	5.9%	1.4%
MD	2	11.8%	1.9%
MS	-	0.0%	1.0%
NC	-	0.0%	3.0%
OK	-	0.0%	1.2%
SC	-	0.0%	1.5%
TN	-	0.0%	2.0%
TX	3	17.6%	7.9%
VA	-	0.0%	2.6%
WV	-	0.0%	0.6%
<b>West</b>	<b>-</b>	<b>0.0%</b>	<b>23.2%</b>
AK	-	0.0%	0.2%
AZ	-	0.0%	2.1%
HI	-	0.0%	0.4%
ID	-	0.0%	0.5%
MT	-	0.0%	0.3%
CA	-	0.0%	12.1%
CO	-	0.0%	1.6%
NV	-	0.0%	0.9%
NM	-	0.0%	0.7%
OR	-	0.0%	1.2%
UT	-	0.0%	0.9%
WA	-	0.0%	2.1%
WY	-	0.0%	0.2%
<b>Midwest</b>	<b>8</b>	<b>47.1%</b>	<b>22.0%</b>
IL	3	17.6%	4.3%
IN	1	5.9%	2.1%
IA	-	0.0%	1.0%
KS	-	0.0%	0.9%
MI	2	11.8%	3.3%
MN	-	0.0%	1.7%
MO	-	0.0%	1.9%
ND	-	0.0%	0.2%
NE	-	0.0%	0.6%
OH	2	11.8%	3.8%
SD	-	0.0%	0.3%
WI	-	0.0%	1.9%
<b>Northeast</b>	<b>3</b>	<b>17.6%</b>	<b>18.1%</b>
CT	1	5.9%	1.2%
ME	-	0.0%	0.4%
MA	1	5.9%	2.1%
NH	-	0.0%	0.4%
NJ	-	0.0%	2.9%
NY	-	0.0%	6.4%
PA	-	0.0%	4.1%
RI	1	5.9%	0.4%
VT	-	0.0%	0.2%
<b>Other</b>	<b>-</b>	<b>0.0%</b>	<b>0%</b>
PR	-	0.0%	0%
Other	-	0.0%	0%
<b>Total</b>	<b>17</b>	<b>100%</b>	<b>100%</b>



## 2014–15 Program Associates Home Institution Classified by Countries

\*Regions based on United Nations classification

<b>Americas</b>			<b>17</b>
North America	United States		17
<b>Asia</b>			<b>5</b>
Western Asia	Israel		5
<b>Europe</b>			<b>16</b>
Northern Europe	France		3
Western Europe	France		8
	Germany		4
	Switzerland		1
<b>Grand Total</b>			<b>38</b>



## 4.5 Graduate Student List

(Participants who attended 2014–15 workshops, excluding Summer Graduate Schools)

(See e-mail attachment)

## 4.6 Graduate Student Data

(Participants who attended 2014–15 workshops, excluding Summer Graduate Schools)

Workshops	# of Participants	# of Citizens & Perm. Res.	%	# of Female	%	# of Minorities <sup>1</sup>	%	US Home Institution	%
<b>13 Scientific Workshops</b>									
Advances in Homogeneous Dynamics	30	15	50.0%	11	36.7%	1	7.7%	23	76.7%
Automorphic forms, Shimura varieties, Galois representations and L-functions	63	20	31.7%	11	17.5%	1	5.6%	39	61.9%
Categorical Structures in Harmonic Analysis	40	10	25.0%	6	15.0%	0	0.0%	26	65.0%
Connections for Women: Dynamics on Moduli Spaces of Geometric Structures	26	8	30.8%	11	42.3%	1	12.5%	13	50.0%
Connections for Women: Geometric and Arithmetic Aspects of Homogeneous Dynamics	26	7	26.9%	9	34.6%	0	0.0%	13	50.0%
Connections for Women: Geometric Representation Theory	22	7	31.8%	13	59.1%	1	16.7%	10	45.5%
Connections for Women: New Geometric Methods in Number Theory and Automorphic Forms	12	7	58.3%	5	41.7%	0	0.0%	8	66.7%
Dynamics on Moduli Spaces	34	15	44.1%	9	26.5%	1	7.1%	23	67.6%
Hot Topics: Kadison-Singer, Interlacing Polynomials, and Beyond	7	4	57.1%	0	0.0%	0	0.0%	6	85.7%
Introductory Workshop: Dynamics on Moduli Spaces of Geometric Structures	55	26	47.3%	14	25.5%	1	4.0%	38	69.1%
Introductory Workshop: Geometric and Arithmetic Aspects of Homogeneous Dynamics	50	13	26.0%	8	16.0%	0	0.0%	26	52.0%
Introductory Workshop: Geometric Representation Theory	67	27	40.3%	13	19.4%	0	0.0%	51	76.1%
Introductory Workshop: New Geometric Methods in Number Theory and Automorphic Forms	43	20	46.5%	8	18.6%	1	5.6%	35	81.4%
<b>All 13 Workshops Total</b>	<b>475</b>	<b>179</b>	<b>37.7%</b>	<b>118</b>	<b>24.8%</b>	<b>7</b>	<b>4.2%</b>	<b>311</b>	<b>65.5%</b>
<b>2 Education &amp; Outreach Workshops</b>									
Breaking the Neural Code	0	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Critical Issues in Mathematics Education 2015: Developmental Mathematics: For whom? Toward what ends?	11	11	100.0%	8	72.7%	3	30.0%	11	100.0%
<b>All 2 Workshops Total</b>	<b>11</b>	<b>11</b>	<b>100.0%</b>	<b>8</b>	<b>72.7%</b>	<b>3</b>	<b>30.0%</b>	<b>11</b>	<b>100.0%</b>
<b>All 15 Workshops Total</b>	<b>486</b>	<b>190</b>	<b>39.1%</b>	<b>126</b>	<b>25.9%</b>	<b>10</b>	<b>5.7%</b>	<b>322</b>	<b>66.3%</b>

<sup>1</sup> Minorities are US citizens who declare themselves American Indian, Black, Hispanic, or Pacific Islander. Minority percentage is calculated by dividing the number of Minorities by the total number of US citizens.

# 5. Undergraduate Program in 2014 & 2015 (MSRI-UP)

## 5.1 Description of Undergraduate Program

*Please note: MSRI-UP is funded by an independent NSF grant, DMS 1156499. The report was filed independently to the NSF in February annually, thus there is no report attached in Section 11. Appendix.*

The MSRI Undergraduate Program (MSRI-UP) is a comprehensive summer program designed for undergraduate students who have completed two years of university-level mathematics courses and would like to conduct research in the mathematical sciences. Due to funding restrictions, only U.S. citizens and permanent residents are eligible to apply and the program cannot accept foreign students regardless of funding.

The main objective of the MSRI-UP is to identify talented students, especially those from underrepresented groups, who are interested in mathematics and make available to them meaningful research opportunities, the necessary skills and knowledge to participate in successful collaborations, and a community of academic peers and mentors who can advise, encourage and support them through a successful graduate program.

This objective is designed to contribute significantly toward meeting the program goal of increasing the number of graduate degrees in the mathematical sciences, especially doctorates, earned by U.S. citizens and permanent residents by cultivating heretofore untapped mathematical talent within the U.S. Black, Hispanic/Latino and Native American communities.

During the summer, each of the 18 student participants will:

- participate in the mathematics research program under the direction faculty and graduate students mentors.
- complete a research project done in collaboration with other MSRI-UP students
- give a presentation and write a technical report on his/her research project
- attend a series of colloquium talks given by leading researches in their fields
- attend workshops aimed at developing skills and techniques needed for research careers in the mathematical sciences and
- learn techniques that will maximize a student's likelihood of admissions to graduate programs as well as the likelihood of winning fellowships
- receive a \$3100 stipend, lodging, meals and round trip travel to Berkeley, CA.

After the summer, each student will:

- have an opportunity to attend a national mathematics or science conference where students will present their research
- be part of a network of mentors that will provide continuous advice in the long term as the student makes progress in his/her studies
- be contacted regarding future research opportunities



## MSRI-UP 2014: Arithmetic Aspects of Elementary Functions

June 21, 2014 - August 03, 2014

The question of evaluation of finite sums with entries in a reasonable large class (of hypergeometric type) has been settled by the algorithms developed by H. Wilf, D. Zeilberger and collaborators. On the other hand, arithmetic properties of these sums offer interesting challenges. For instance, it is an elementary result that the central binomial coefficient is always even. This motivates the natural question: what is the exact power of 2 that divides these coefficients? Is there a closed-form formula for this?

The fact that binomial coefficients satisfy certain recurrences, for example in the formation of Pascal's triangle, has been used to analyze their arithmetic properties. What can be said about sequences generated by similar recurrences? For example, factorials  $n!$  satisfy  $xn = nxn-1$ . Is it possible to describe arithmetic properties for  $yn = P(n)yn-1$  with a polynomial  $P$ ? Very few results are known.

Graphical representations offer some indication of the complexity involved. For example, there is a marked difference between the power of two that divides  $n^2+1$  and  $n^2+7$ . What is the reason behind this? The second graph looks almost random compared to the first. Is there a way to quantify this phenomena?

Some sequences with surprising arithmetical properties include Stirling numbers, Catalan numbers that count legal typing words using parenthesis, the ASM numbers that count the number of matrices with entries from  $\{0, \pm 1\}$  satisfying an ordering condition and many other coming from Combinatorics. Recent symbolic experiments include sequences such as the harmonic numbers  $H_n = 1 + \frac{1}{2} + \dots + \frac{1}{n}$  and the sequence of formed by partial sums of the exponential function.

These type of problems are ideal for introduction to undergraduates: they can be explained with a minimal amount of background, data can be obtained by using symbolic languages and partial results are available in the literature. Thus, this REU is accessible to students who have had three semesters of calculus, linear algebra, and a course in which they have had to write proofs.

Announcement:

Three posters from 2014 MSRI-UP were selected as outstanding presentations in the undergraduate poster session at the JMM:

On the divisibility and valuations of the Franel numbers

Samantha VanSchalkwyk, Mount Holyoke College

Adela Yang, Bowdoin College

Abraham Schulte, Northwestern University

Infinite Products Arising in Paperfolding

Hadrian Quan, University of California, Santa Cruz

Fernando Roman, Kansas State University

Michole Washington, Georgia Institute of Technology

Sequences of p-adic valuations of polynomials: an analysis of aperiodic and non preregular behavior

Amber Yuan, The University of Chicago

Alyssa Brynes, Tulane University

Isabelle Nogues, Princeton University

## **MSRI-UP 2015: Geometric Combinatorics Motivated by the Social Sciences**

June 13, 2015 - July 26, 2015

The academic and research portion of the 2015 MSRI-UP will be led by Prof. Francis Su from Harvey Mudd College.

In only the last 75 years or so has mathematics enjoyed a symbiotic relationship with the social sciences. On one hand, mathematics can be used to model questions in the social sciences; on the other hand, the social sciences motivate new mathematical questions. Game theory was born out of a question to model human interaction and decision-making.

As an example, the space of preferences is often a geometric space whose combinatorial structure encodes player preferences in interesting ways. In many 'fair division' problems (e.g., how to divide a cake fairly among several people) the space of preferences is often a convex polytope, and in a voting theory the space of preferences (the political spectrum) is commonly modeled as a line but could be something else as well.

In this REU we will consider mathematical problems motivated by 'fair division' questions and voting theory, using a mix of techniques from combinatorics, convex geometry, and analysis. Students who have had a course in which they have had to write proofs and also linear algebra or discrete mathematics are eligible to apply. It can be helpful, though not necessary, to have some exposure to economics, game theory, or a course in programming.

## **5.2 MSRI-UP Data**

MSRI-UP 2014 Participant List

<b>Last Name</b>	<b>First Name</b>	<b>Home Institution</b>
Byrnes	Alyssa	Tulane University
Cervantes Nava	David	SUNY College at Potsdam
Chavoya	Joseph	California State University
Lucero	Alphonso	Iowa State University
Michel	Alexandra	Mills College
Miller	Andrew	University of Massachusetts, Amherst
Musgrave	Erica	Saint Mary's College of California
Nogues	Isabelle	Princeton University
Pane	Gianluca	Brown University
Quan	Hadrian	University of California, Santa Cruz
Rennie	Robert	Reed College
Reynolds	Sean	University of Chicago

Roman	Fernando	Kansas State University
Schulte	Abraham	Northwestern University
VanSchalkwyk	Samantha	Mount Holyoke College
Washington	Michole	Georgia Institute of Technology
Yang	Adela	Bowdoin College
Yuan	Amber	University of Chicago

#### MSRI-UP 2015 Participant List

<b>Last Name</b>	<b>First Name</b>	<b>Institution name</b>
Andrade	Gabriel	University of Massachusetts Amherst
Baeza	Edwin	Purdue University
Bugg	Caleb	Morehouse College
Bush	Ethan	University of Michigan, Flint
Duke	Kyle	James Madison University
Elvin	Gabriel	University of California, Los Angeles
Kuture	Beaattie	Pomona College
Leong	Oscar	Swarthmore College
Loa	Christopher	University of Tennessee
Rodriguez	Andres	Universidad de los Andes
Rosado	Michelle	University of Puerto Rico
Ruiz Sandoval	Alberto	University of Puerto Rico
Scruse	Ashley	Clark Atlanta University
Smith	Nikaya	University of North Carolina
Stevens	Miles	Morehouse College
Torre	Alexis Jane	University of Arizona
Yoseph	Sarah	Loyola Marymount University

## **11. Appendix – Final Reports of Activities in 2014–15**

**Geometric Representation Theory**  
August 18, 2014 to December 19, 2014  
MSRI, Berkeley, CA  
USA

**Organizers:**

LEAD David Ben-Zvi (University of Texas)  
Ngô Bảo Châu (University of Chicago)  
Thomas Haines (University of Maryland)  
Florian Herzig (University of Toronto)  
Kevin McGerty (University of Oxford)  
David Nadler (University of California, Berkeley)  
Catharina Stroppel (University of Bonn)  
Eva Viehmann (TU München)

## MSRI GEOMETRIC REPRESENTATION THEORY PROGRAM: FINAL REPORT

### **Organizers:**

*David Ben-Zvi (Texas)*

*Thomas Haines (Maryland)*

*Florian Herzig (Toronto)*

*Kevin McGerty (Oxford)*

*David Nadler (Berkeley)*

*Ngô Bao Châu (Chicago)*

*Catharina Stroppel (Universität Bonn)*

*Eva Viehmann (Technische Universität München)*

### 1. RESEARCH ACHIEVEMENTS: ORGANIZER SUMMARY

The MSRI program in Geometric Representation Theory (GRT) was an exciting and highly successful semester bringing together over fifty researchers, from the founders and superstars of the field to beginning graduate students. It encompassed three workshops, six regular seminars or organized working groups, many visitors and a constant whirl of activity from August to December. Programs such as this usually have an enormous impact in shaping the direction of the field, and we think this program will play such a role in the coming years. Sample exit survey reactions of participants include Postdoc Galyna Dobrovolska: “I love MSRI, this has been the greatest semester in my life,” and Simons Research Professor Ivan Mirkovic: “It was a perfect setting for working with the best people in my profession”.

A particularly successful aspect of the GRT program was its profound interaction with the parallel program, New Geometric Methods in Number Theory and Automorphic Forms (NGM). There was a large degree of shared interest among participants in the two programs, resulting in extensive cross-fertilization in discussions, collaborations and seminars. NGM member Peter Scholze’s historic Chancellor Lectures were heavily attended by members of both programs and formed the scientific highpoint of joint programs. In addition a weekly seminar and two weekly working groups were organized jointly for the two programs. One of the primary goals in the GRT program proposal was to explore the emerging direct connections between the geometric Langlands program and the classical (arithmetic) Langlands program, which were long connected mostly by suggestive analogies. It was extremely exciting and gratifying to see during this semester the emergence of a direct and precise link between the two worlds, thanks to the work of Scholze, NGM member Laurent Fargues and others, which is sure to play a central role in the future shape of both fields.

The setting of MSRI was extremely conducive to spurring countless informal discussions and exchanges of ideas, some of which lead to new projects and collaborations. A sampling of these new collaborations: some involve senior researchers (Research Professors David Nadler and Zhiwei Yun), some involve senior mentors and junior researchers (postdoc Alexis Bouthier, Clay Professor Ngô Bao Châu and NGM RP Yiannis Sakellaridis, Simons professor Mirkovic with postdocs Dobrovolska and Yaping Yang), and others involve junior researchers who met at the program (postdocs Dragos Fratila and Sam Gunningham with Berkeley graduate student Penghui Li, graduate assistants Jordan Ganev, Emmanuele Ghedin and Jacob Matherne). Some

new collaborations began with Berkeley faculty who actively participated in the program (in particular Vivek Shende began projects with Ngô and postdoc Zsuzsanna Dancso, and RP Edward Frenkel with postdoc Alexis Bouthier). In at least one case, discussions at MSRI led to an immediate result: RP Tom Haines and Xuhua He (arXiv.math:1411.5450) proved a conjecture of Pappas-Rapoport-Smithling on special fibers of Shimura varieties with parahoric level structure, completing a program of Kottwitz-Rapoport from 2000. In many other cases, discussions and work at MSRI laid the foundations for results and research programs for years to come.

**1.1. Research Directions and Highlights.** We give a (by no means exhaustive) sample of the research directions which we investigated at the program.

*1.1.1. Modular geometric representation theory.* The impact of geometric techniques in representation theory in positive characteristic (the “modular case”) was until about five or six years ago still in a nascent state, but recent developments, in particular the theory of parity sheaves (developed by members Daniel Juteau and Carl Mautner in collaboration with Geordie Williamson) has seen the vista of possibilities expand significantly. Moreover, Williamson’s recent counter-examples to the Lusztig conjecture make it clear that new conjectures and insights will be required in the subject. Indeed Lusztig spoke at MSRI and proposed a beautiful new picture of characters beyond the restricted range to which his original conjectures applied, with the thrilling suggestion of new representation theories interpolating quantum groups and modular representations. A working group at the program, lead by Pramod Achar, Daniel Juteau and Peter Fiebig, focused on the new geometric techniques, and exposed these new questions to graduate students ensuring a new generation can attach this newly-reopened field.

*1.1.2.  $p$ -adic and mod  $p$  Langlands program.* The program also witnessed concerted efforts by members of the GRT and NGM program to apply geometric and categorical techniques to a relatively recent topic in the arithmetic theory, the study of mod  $p$  and  $p$ -adic representations of  $p$ -adic groups. One aspect is the appearance of derived categorical structures and derived analogues of Hecke algebras, of the kind long at the center of the geometric theory, in the arithmetic theory, as was explored in a joint working group was organized by David Ben-Zvi, Michael Harris and Akshay Venkatesh and the focus of talks of Peter Schneider, Rachel Ollivier and Marie-France Vignéras. The Beilinson-Bernstein theory of representations as systems of differential equations, a staple of the geometric theory of Lie algebra and group representations, is also emerging as major tool in the  $p$ -adic theory and was the topic of talks of new collaborations and talks by Christine Huyghe, Matthias Strauch and Konstantin Ardakov.

*1.1.3. Wild ramification.* Another aspect of the similarity between the  $p$ -adic Langlands program and the geometric theory was investigated in a working group on irregular singularities organized by Kevin McGerty, David Treumann and NGM member Kedlaya. Irregular singularities have already played a fascinating role in the study of wall-crossing by Valerio Toledano Laredo and Tom Bridgeland, and David Treumann and Shende and collaborators have an exciting programme relating irregular singularities to knot theory. The studying of connections (for example their moduli) is a basic aspect of the geometric Langlands program, and in the case of irregular singularities there are many problems still to address (explored by program participants Tsao-Hsien Chen, Masoud Kamgarpour, Daniel Sage, Yun, Ngô and Xinwen Zhu) and interaction with the  $p$ -adic theory may well help shed light on these questions.

1.1.4. *The Vinberg semigroup comes of age.* Geometric representation theory of reductive groups has long focused on a core collection of geometric objects, including the flag variety and affine Grassmannian, the Springer resolution and adjoint quotient, etc., whose myriad realizations provide a remarkable unity to the subject. The GRT program marked the rise from relative obscurity to prominence of another geometric construction, the Vinberg semigroup (and its other guises, the asymptotic cone and wonderful compactification of a reductive group). This trend was highlighted by the unexpected ubiquity of the Vinberg semigroup around the GRT research conference, where it featured in work of Bouthier, Ngô, Sakellaridis, Alexander Braverman and Dennis Gaitsgory. The Vinberg semigroup captures the classical harmonic analytic concerns of asymptotics and scattering in a purely algebro-geometric fashion, and one now expects it to become part of the standard toolkit of practitioners in the field.

1.1.5. *The affine Grassmannian in new light.* On the other hand, one of the most studied objects in geometric representation theory and the geometric Langlands program, the affine Grassmannian, appeared in three strikingly new guises during the program. Mirkovic introduced a new theory of “local spaces”, a refinement of the Beilinson-Drinfeld theory of factorization algebras which has become ubiquitous in mathematical aspects of quantum field theory. Using this theory Mirkovic provided a remarkable new construction of the affine Grassmannian as an analogue of projective space in the world of local spaces, leading to new perspectives and many generalizations (explored in part with GRT postdocs Dobrovolska and Yang). The work of Zhu, discussed in seminars at MSRI and Berkeley and during the research workshop, defined a  $p$ -adic version of the affine Grassmannian (the “Witt Grassmannian”) using subtle results from the geometric theory, and showed its power as a tool to describe the geometry and arithmetic of Shimura varieties – perhaps the central geometric object behind the NGM program – including new cases of the Tate conjecture. Finally Scholze, in his Chancellor Lectures and talk in the research workshop, showed how to transport the deepest structures on the Grassmannian (chiefly factorization) to his brand new geometric theory of  $p$ -adic geometry, opening up the way to a completely geometric approach to the local Langlands program.

1.1.6. *The geometric arithmetic Langlands program.* The seminal work of Scholze and Fargues presented in the Chancellor’s Lectures and during the NGM research workshop set the foundations for an ultimate bridge between the topics of the two programs. In this story, a new curve, the Fargues-Fontaine curve, has emerged as the fundamental geometric object, for whose proper study the new machinery of Scholze is essential – the theory of perfectoid spaces and its elaboration, that of diamonds, allows one to effectively treat algebra over  $\mathbb{Q}_p$  as geometry over a curve. The vision of Scholze and Fargues embeds the local Langlands program into the (newly formulated) geometric Langlands program on this curve, bringing the key ideas underlying the GRT program into direct contact with number theory. This work was closely followed by many GRT participants and looks to frame the interactions of geometry and algebra for years to come.

## 2. ORGANIZATIONAL STRUCTURE

Aside from the workshops run in special weeks which framed the semester, the activities in the geometric representation theory program were organized around three strands. Firstly we had formal seminars: given the extent of overlap in the research interests of the parallel programs, it was deemed sensible to have a joint seminar (held on Wednesdays) and a separate program seminar (held on Tuesdays). Secondly, a number of more informal working groups (for example on modular representation theory or irregular singularities) were organised by various research professors, (especially in the case of graduate students) to give expositions of the latest

techniques used in the field. Many of these talks benefited graduate students from nearby institutions as well as the junior (and sometimes senior!) members of the program. The Five-Minute Talks was a very successful event to start the semester, in which every participant had an opportunity to give a snapshot of their research interests. The participation was extremely high, from graduate students to luminaries such as Clay Professor Bernstein, and helped foster conversations and engagement.

**2.1. GRT Research Seminar.** The seminar was run by Ivan Mirkovic and David Treumann. The seminar covered many topics, including Grothendieck’s  $p$ -curvature conjecture (Chris Dodd); Generalized Springer correspondence (Sam Gunningham); the depth of representations (Masoud Kamgarpour); Sign conjecture for Shimura varieties (Junecue Suh) and the proof of the Mirkovic-Vilonen conjecture (Carl Mautner). In particular, Tom Hales strengthened the celebrated results of Ngo on the fundamental lemma using nontraditional tools from logic. Edward Frenkel talked about a project with Langlands and Ngô on a geometrization of the trace formula which would be a very powerful refinement of this fundamental tool in automorphic representation theory. David Jordan explained a construction of a topological field theory out of representations of quantum groups, with close links to the Quantum Geometric Langlands Program. A long term effort in representation theory was to construct elliptic groups (the elliptic refinement of reductive groups) and Valerio Toledano-Laredo explained his approach to elliptic quantum groups.

**2.2. Joint Seminar.** This is a report on the joint seminar between the “New geometric methods...” and the “Geometric representation theory” program, organized by Florian Herzig and Akshay Venkatesh.

The speakers were: Y. Varshavsky, X. Zhu, B. Stroth, D. Ben-Zvi, M. Strauch, B-C. Ngô, G. Lusztig, M. Rapoport.

The speakers covered a range of topics: geometric Langlands and its interaction with the classical Langlands program, new geometric methods (e.g. arising from  $p$ -adic Hodge theory), and representation theory in characteristic  $p$  as well as average ranks of elliptic curves. The seminar was well attended by members of both programs.

**2.3. Working group on Irregular Singularities.** The classical Riemann-Hilbert correspondence shows that fundamental groups of smooth varieties can be studied via algebraic vector bundles equipped with connections with “regular singularities”. Via the covering space theory of Grothendieck this allows one to unify Galois theory and the theory of connections with regular singularities. More intriguing however, is that even when the connections no longer have regular singularities, and so are not completely captured by the topological data given by their space of holomorphic solutions, the analogy with the arithmetic of field extensions seems nevertheless to persist, where the irregularity of the connection is mirrored by wildly ramified extensions. This relationship is potentially very interesting, as for both the classical and geometric Langlands program, the issues of how to understand wild ramification and irregular singularities are of fundamental importance. Recently, there has been significant progress in our understanding of a third topic, connections in  $p$ -adic analysis, which provides in some sense a new meeting point of arithmetic and analysis, having both an arithmetic and analytic aspect. It plays an important role in the newly emerging  $p$ -adic Langlands theory.

Until relatively recently, the theory had been studied only on one-dimensional spaces, but the question of understanding connections with irregular singularities (or more generally holonomic  $\mathcal{D}$ -modules) in dimensions greater than one is now a very active topic, which has been informed in particular by some of the progress in the  $p$ -adic theory. These developments prompted Kevin McGerty and David Treumann from the GRT program and Kiran Kedlaya from the NGM



program to organise a working group with the goal of investigating the latest developments in this area. The working group drew participants from both programs, and over the semester discussed a wide range of topics, including a review of the classical one-dimensional theory of irregular connections and in particular Stokes phenomenon, the relations to wild ramification, the recent developments on good formal structure for connections in higher dimension (a beautiful result due in slightly different contexts to Saito and Kedlaya) and its application in the theory Ind-Sheaves and irregular Riemann-Hilbert. Moreover, relations of irregular singularities to other geometric topics were also discussed: the connection with wall-crossing phenomenon in DT theory was discussed by Valerio Toledano Laredo, Shende (Berkeley) and Treumann describe their on-going work relating irregular singularities to Legendrian knots, and Daniel Sage discussed his work on slopes and minimal  $K$ -types for flat connections on  $G$ -bundles inspired by ideas in the theory of  $p$ -adic representation theory of reductive groups.

#### 2.4. Working group on Geometric Aspects of Representations of $p$ -adic Groups.

This working group was organized by D. Ben-Zvi, M. Harris and A. Venkatesh. Its aim was to foster communication between the GRT and NGM programs around the focused setting of mod- $p$  representations of  $p$ -adic groups. In particular most of the talks touched on describing the derived categories of representations via modules for derived forms of Iwahori-Hecke algebras, a new phenomenon which suggests possible applications of the modern technology of the geometric Langlands program. The seminar concluded with Fargues presenting a new geometric construction of local class field theory in the spirit of the geometric Langlands program.

Speakers: P. Schneider, M. Harris, D. Ben-Zvi, R. Ollivier, M.-F. Vigneras, N. Rozenblyum, L. Fargues

**2.5. Working group on Modular Sheaves and Representation Theory.** In this working group (jointly organized by Pramod Achar, Peter Fiebig and Daniel Juteau) we discussed modern structures and results concerning the representation theory of reductive algebraic groups and Lie algebras in positive characteristics. It was mainly oriented towards graduate students and young postdocs, so in addition to introducing theoretical concepts we studied explicitly calculable examples.

The talks were mainly given by graduate students and postdocs. All the talks were well prepared and presented. The informal atmosphere of the working group led many students to ask specific questions, and oftentimes longer discussions arose during a presentation.

It might have been a problem that the theory needs input from many very different angles (among these: perverse and parity sheaves, moment graph combinatorics, Soergel bimodules, modular representation theory), and some of these aspects almost deserve a semester seminar on their own. It seemed, however, that the seminar helped to convey an overview on the subject and to deepen the understanding of some particular aspects. Some talks led to ongoing discussions among students, organizers and the speaker in the following days.

The working group was very well attended in the beginning, but as the theory progressed, it thinned out. We finished the last talks with maybe 10-15 attendees. A reason for this might be the more and more difficult specialized content of the talks.

Some of the students showed a very strong interest in the theory, and confirmed their intent to work on some aspect of the theory in the future. At least two graduate students projects were directly related to the topics of the working group, and the working group provided an introduction to senior mathematicians that leads to future scientific support or even collaboration.

The speakers were: D. Fratila, J. Matherne and G. Melvin (twice each), I. Ganev, J. Hilburn, P. Fiebig, S. Morgan and S. Makisumi.

### 3. WORKSHOPS AND CONFERENCES

The geometric representation theory program included three major workshops. We give a brief summary of them below, for more details see the individual workshop reports.

**3.1. Connections for Women.** This two-day workshop was organized by Monica Vazirani and Eva Viehmann. The workshop consisted of seven research talks (including two short series of talks), a poster session with 7 posters, a panel discussion on building and sustaining momentum in mathematical research, and a banquet. This workshop was held right before the introductory workshop to make it easier for participants to attend both.

**3.2. Introductory Workshop.** This workshop was organized by David Ben-Zvi and Kevin McGerty. It consisted of several series of introductory lectures by great expositors (Achar, Arinkin, Frenkel, Ginzburg, Hales, Proudfoot, Schiffmann), as well as a research talk by Baum. Topics covered all the broad themes of the semester program: the Langlands program, quiver varieties and Hall algebras, as well as geometric representation theory of finite and  $p$ -adic groups. The workshop was extremely well attended with 177 registered participants.

**3.3. Topical Workshop: Categorical Structures in Harmonic Analysis.** This workshop was organized by Thomas Haines, Florian Herzig, and David Nadler. Talks were presented by leading researchers in representation theory and related areas, with the main theme of categorical structures underlying geometric constructions. The workshop was very well attended, including a number of participants of the parallel number theory program.

### 4. POSTDOCTORAL FELLOWS

The postdoctoral program was one of the key components of the GRT program. Thanks to generous funding from MSRI as well as the NSF and NSA, the GRT program had eleven postdocs, an unusually high number, all of whom had stellar research records and participated very actively in the program. Many of them started new projects and collaborations at MSRI. Each postdoc was assigned a mentor (other than their former advisor in case the advisor was in residence), who was an established expert in a nearby field to provide guidance and break down potential barriers of seniority. In turn many of the postdocs played a vital role in mentoring graduate students. Many of the postdocs spoke in the various seminars and working groups, and in addition a weekly GRT Pizza Seminar was organized by Chris Dodd, in which each of the postdocs had an opportunity to present their work to a broad audience.

- Questions:
- a. Year of Ph.D.
  - b. Institution of Ph.D.
  - c. Institution and position(s) prior to MSRI's fellowship
  - d. Post MSRI institution and position
  - e. Mentor while at MSRI
  - f. Brief description of your work
  - g. Publications resulting from work done while at MSRI

**4.1. Alexis Bouthier.** a. 2014

- b. Université Paris-Sud Orsay
- c. Université Paris-Sud Orsay
- d. Post-doc Hebrew University of Jerusalem.
- e. Edward Frenkel
- f. My work concerned the geometrization of fundamental lemma for spherical Hecke algebra, initiated in my PhD and the study the intersection complex on the monoids introduced by

Ngô which should give a geometric interpretation of the test function of the Local-unramified L-factors.

g. No publications, but work in progress with Ngô and Sakellaridis, and the geometrization of the fundamental lemma for spherical Hecke algebra.

My mentorship with Edward was fine and we talk frequently. during this program, I started a collaboration with Ngô and Sakellaridis, also Varshavsky and Yun needed part of my work to be extended for their own purposes. I also made progress on my own work about finishing the fundamental lemma for spherical Hecke algebra, I hope to post it soon. The only thing I will complain about, is the electronic resources. We don't have any access through MSRI Wi-fi to the major journals (Duke Math or Inventiones, for example) and we can't borrow from the library, It makes things really difficult. Also, we can't print after 5pm and it is definitely too early. Otherwise, I really enjoyed the program, both mathematically and socially and you did a really good job.

4.2. **Zsuzsanna Dancso.** a. I got my PhD in 2011,

b. from the University of Toronto.

c. I was a member at the IAS in Fall 2011, a post-doc at the Fields Institute 2012-2013, a visitor at University of Toronto in Spring 2014.

d. My mentor is Monica Vazirani.

f. While at MSRI I was mainly working on two projects: one which I has started before arriving here, on the Kashiwara-Vergne conjecture and knot theory; and a new collaboration with Vivek Shende (at UCB) on a graphical analogue of the  $W=2P$  conjecture.

g. I expect that my collaboration with Vivek will result in a publication, but the paper (or the results) are not quite finished. I have made significant progress on another paper (on the Kashiwara-Vergne conjecture), which is close to finished. (I have also edited two papers for publication based on referee comments.)

What I enjoyed most: MSRI has been a very stimulating and supportive environment and I met many new people (both at MSRI and UCB). I have enjoyed the freedom to travel and the opportunity to give talks (Pizza seminar, Evans lecture, Oberwolfach, and seminar at UC Davis). I really appreciated Monica's mentorship and advice. I also enjoyed the outreach opportunities and led several sessions at the Berkeley and Stanford Math Circles and made two videos with Brady. My biggest professional gain from the term is the collaboration with Vivek (and potentially with some other people at UCB as well whom I have just started working with).

What I would have done differently: Before coming to MSRI I had little knowledge of the geometric Langlands program, and although the introductory workshop was helpful, it was too short a time to catch up on such a major topic. If I were to do it again I would do some more reading before coming to Berkeley. Maybe a good way of encouraging this would be to send a short reading list by email to all post-docs about a month before the intro workshop.

Overall I had a very enjoyable and productive term.

Random comments: MSRI needs more paper recycling bins. I would put two in each office, and at least one in the lunch room. With one income between the two of us and the incredible cost of housing, making ends meet was possible but not easy. I think this probably affects other post-docs as well if they are here with partners or family. I agree that the lunches are not great and a bit monotone after a while, but the popsicles were wonderful!

4.3. **Galyna Dobrovolska.**

4.4. **Chris Dodd.** a. Year of Ph.D: 2011

b. Institution of Ph.D.: Massachusetts Institute of Technology

c. Institution prior to obtaining the MSRI PD fellowship: University of Toronto Position at that institution: Postdoctoral Fellow Mentor (if applicable): Joel Kamnitzer

d. Institution (or company) where you are going after the MSRI PD fellowship: University of Toronto Position: Postdoctoral Fellow Anticipated length: 1 semester

e. Mentor while at MSRI: Kevin McGerty

f. At MSRI, I mostly worked on understand flat connections in two contexts: first of all, the theory of wild flat connections in characteristic zero and its analogues in positive characteristic, and secondly, the theory of connection with p-curvature zero. In both cases, I made substantial progress during the semester; in particular, conversations with other members allowed me to correct misconceptions, fix errors in my thinking, and prove several new theorems. I haven't published anything from this time, but I expect the ideas formulated there to be the basis of several publications in the future. So the whole semester was highly beneficial.

4.5. **Dragos Fratila.** a. Year of Ph.D. 2014 (July)

b. Institution of Ph.D. Universite Paris Diderot

c. Institution and position(s) prior to MSRI's fellowship PhD student Universite Paris Diderot

d. Post MSRI institution and position post-doc Max-Planck Institut, Bonn, Germany until June 2016

e. Mentor while at MSRI Pramod Achar

f. Brief description of your work I mostly worked on the classification of simple summands of spherical Eisenstein sheaves for an elliptic curve and a reductive group  $G$ . I had numerous discussions with Penghui Li and Sam Gunningham about the geometry of semistable bundles. In particular, thanks to Penghui Li, I realized that the stratification (according to some regularity conditions) of the stack of semistable  $G$ -bundles that I thought I've found was pretty wrong. That led me to learn much more about reductive subgroups of reductive groups as well as about nilpotent orbits. Eventually, even the stratification of the stack of semistable bundles seems to require a bit of work and might be interesting in itself so I decided to write it down as an independent (short) article.

Also, with Sam Gunningham we discussed a lot about the character sheaves for the group  $G$  and thought about extending his results to the elliptic case. We will try probably to work together on this thing in the future.

g. Publications resulting from work done while at MSRI Nothing finished but a (drafty)draft in progress "Stratification of the stack of semistable  $G$ -bundles over an elliptic curve".

Activities/Mentorship

Among the activities that I enjoyed the most while at MSRI was the GRT seminar, the postdoc seminar and the working group "Modular sheaves and modular representation theory". I really liked this working group and I feel I learned a lot of things (I also gave two talks). Most importantly I think is that it opened up new areas of research which I find very exciting and I'm considering pursuing in the future.

I have to express my gratitude for the idea of mentorship! My mentor was Pramod Achar (which I had met a few years ago) and he was great! We would meet officially almost weekly and discuss math, my progress, my future plans but also my (many) concerns about career, publications, choosing and handling (multiple) projects, managing stress and pressure. He was also very available so we could also meet almost anytime I wanted to ask him some math questions. He took the time to explain me (and open my mind) many math things, like Koszul duality and perverse coherent sheaves. He also suggested some possible project to work on regarding perverse coherent sheaves on nilpotent cones for real reductive groups which I find very exciting and hoping to work in the future. To sum up, my mentorship experience was

great and it came at a very timed moment in my career so I hope MSRI and future programs will continue to do this.

One other thing that I liked about MSRI is the big open space and the fact that the offices are easily accessible so one could go and talk to anyone almost all the time. Also the common kitchen and the lunch time were a great place to meet new people and discuss “leisure” math, learn about new things, etc.

Obviously I didn’t do nearly as much as I was hoping at the beginning of the semester but this might be a usual thing.

Thank you very much for organizing this program! I absolutely loved it and I’m sure it will prove very valuable to my career!

**4.6. Sam Gunningham.** Sam Tomas Powaga Gunningham, Viterbi Postdoc, MSRI, Fall 2014. Program: Geometric Representation Theory. PhD: 2013, Northwestern University, Advisor: David Nadler, Dissertation: “Categorified Harmonic Analysis on a Complex Reductive Group”. Mentor while at MSRI: Zhiwei Yun. Position prior to MSRI: University of Texas, Austin, Instructor (with R.H. Bing Postdoctoral Fellowship). Mentors: David Ben-Zvi, Dan Freed. Position post MSRI: University of Texas, Austin, Instructor (with R.H. Bing Postdoctoral Fellowship). I have 3 semesters more in this position.

My research is in the field of Geometric Representation Theory. Whilst at MSRI, I have been focusing in two directions, both concerning the categories of D-modules on certain stacks associated to a reductive group (for example the adjoint quotient stack).

The first direction is building on work from my thesis, to understand parabolic induction and restriction functors, and the resulting structure on categories of D-modules. I am currently writing a paper, “Generalized Springer Theory on a Reductive Lie Algebra”, in which I recover, extend, and present simpler proofs of results from Springer theory. A sequel to this paper is also in preparation. During the preparation of this work I have had many helpful conversations with fellow MSRI members, including Pramod Achar, David Ben-Zvi, Dragos, Fratila, Daniel Juteau, Carl Mautner, Kevin McGerty, David Nadler, Tom Nevins, and Zhiwei Yun. I hope to start a project extending this work to the stack of semistable bundles on an elliptic curve, joint with Dragos Fratila and (Berkeley graduate student) Penghui Li.

The second direction concerns a certain category associated to the group scheme of regular centralizers. This work is in its early stages, and is joint with (MSRI members) David Ben-Zvi and David Nadler. Helpful new perspectives were obtained from conversations with (MSRI member) Ivan Mirkovic.

Overall, my experience at MSRI was overwhelmingly beneficial. The seminars and workshops exposed me to new ideas as well as providing new perspectives on my research. Most notably, the abundance of researchers in my field coupled with a fantastic working environment lead to a very productive semester. The math I have learned and the connections I have made will have a strong and lasting effect on my career.

**4.7. Paul Hamacher.** a) 2014

b) Technische Universität München

c) PhD student/wissenschaftlicher Mitarbeiter at the Technische Universität München

d) Postdoc at Harvard under a DAAD scholarship.

e) Xinwen Zhu

f) I work on the geometry of the Newton strata on Shimura varieties. In my PhD thesis I determined their dimension and closure relations, at the moment I try to generalise it to Shimura varieties of Hodge type. The main issue here is that one has to generalise the “almost

product” decomposition of a Newton stratum given by Mantovan (in the case of PEL Shimura varieties) and Oort (in the Siegel case).

g) None so far.

#### 4.8. **Sam Raskin.**

4.9. **Sean Rostami.** a. Year of Ph.D. : May or June 2012

b. Institution of Ph.D. :University of Maryland, College Park

c. Institution and position(s) prior to MSRI’s fellowship : University of Wisconsin, Madison

d. Post MSRI institution and position : return to UW in Summer 2015 for final year of postdoc

e. Mentor while at MSRI : Matthias Strauch

f. Brief description of your work (I merged the bottommost section with part f.)

(1) For approximately the first month, I worked on a dessin d’enfants project that was started in the middle of Spring 2014, and I was able to state and prove a nice characterization theorem (I tried to do this in summer but was unsuccessful). This is an important first step, and a good time to pause the project and send a summary of the project to a professor I know who expressed interest. I will return to this project in the coming months.

(2) For approximately the next 2 months, I mainly did a mixture of three things. The first was to begin investigating an algebraic geometry question (in brief, moduli functor descriptions of reduced closures) with obvious value to geometric representation theory. Although I learned something and enjoyed thinking about it, no compelling progress was made and I was convinced to postpone the question. The second was to prepare my thesis for publication (for various reasons, it was not published at the time of graduation), which required both expositional and mathematical changes (correcting errors and filling gaps, which required me to read and understand some things that I did not know before). The third was to edit a paper submitted in January 2014, in response to a referee report that I received while at MSRI.

(3) For the past couple weeks, and probably for the next couple weeks and into 2015, I am working with a collaborator on a question concerning Gross-Reeder “simple” supercuspidal representations. It’s going well so far.

(4) Finally, there is another potential project that arose from conversations I had with another visitor to MSRI. We plan to talk soon and hopefully something will grow out of it.

g. Publications resulting from work done while at MSRI No recent work is ready to be published at this time (except for those things that required only editing), but I think that will change in the coming months.

4.10. **Nikita Rozenblyum.** a. Year of Ph.D: 2011

b. Institution of Ph.D.: MIT Dissertation title: Connections on conformal blocks Ph.D. advisor: Jacob Lurie

c. Institution prior to obtaining the MSRI PD fellowship: Northwestern University Position at that institution: Simons Postdoctoral Fellow

d. Institution (or company) where you are going after the MSRI PD fellowship: University of Chicago Position: Assistant Professor Anticipated length: 3 years

e. Mentor while at MSRI: David Treumann

f. Postdoctoral fellows comments: I have benefitted a great deal from the program. Particularly beneficial for me were discussions between the geometric representation theory program and the number theory program. During the semester many new connections were established, and it was a wonderful learning experience for me. I expect these ideas will play a significant role in my future work.

4.11. **Yaping Yang.** During the Fall of 2014 semester, I was fortunate to be a postdoctoral scholar in the Geometric Representation Theory (GRT) program at MSRI. I obtained my Ph.D. in Spring 2014 at Northeastern University in Boston under the supervision of Valerio Toledano Laredo. Right after my graduation, I attended the GRT program at MSRI. In January 2015, I will be moving to UMass, Amherst to take up a two and half year Visiting Assistant Professorship.

It was an enjoyable and productive semester at MSRI. I had the opportunity to talk to many experts and young researchers, especially Prof. Edward Frenkel, Prof. Ivan Mirkovic and Prof. Valerio Toledano Laredo. Prof. Edward Frenkel is my mentor. We had several official meetings. Frenkel is very kind and helpful. He explains things very well and clear. He gave useful suggestions and down to earth answers. He taught me the theory of conformal blocks for any Riemann surfaces. In particular, the twisted conformal blocks for the elliptic curve give rise to the Knizhnik-Zamolodhikov-Bernard (KZB) connection. It is closely related to the project I have been working on with Toledano Laredo.

I had a regular weekly meeting with Prof. Ivan Mirkovic and started a new project with him. We talked about the loop Grassmannians in the framework of local spaces over a curve. The local spaces is a simplified version of the notion of factorizable spaces introduced by Beilinson and Drinfeld. The point of view of local spaces produces a class of “loop Grassmannians” generalizing the loop Grassmannians of reductive groups. The procedure is as follows. There is a semi-infinite construction of loop Grassmannian using the certain pieces (Mirkovic and Vilonen cycles) of the loop Grassmannian. The MV cycles have a deformation space, the Zastava space. It is a local space with generic fiber the products  $\mathbb{P}^1 \times \mathbb{P}^1 \cdots \times \mathbb{P}^1$ . The general construction of the Zastava spaces produces the generalization of the loop Grassmannians.

I have been working with Prof. Toledano Laredo about the Universal KZB connections for arbitrary root systems and the elliptic Casimir connection. I have also been working with Prof. Nicolas Guay about the deformed double current algebras (DDCA) for semi-simple Lie algebras  $\mathfrak{g}$ . The DDCA is a deformation of the universal central extension of the double current algebra  $\mathfrak{g} \otimes \mathbb{C}[u, v]$  defined by Guay. These two projects go hand in hand. As the elliptic Casimir connections associated to the semisimple Lie algebra  $\mathfrak{g}$  take values in the DDCA of  $\mathfrak{g}$ . We have made new progress on both the two projects.

In a preprint with Guay, we found the double loop presentations of the DDCA for any  $\mathfrak{g}$ . The case for  $\mathfrak{g} = \mathfrak{sl}_2, \mathfrak{sl}_3$  needs a special treatment. It was worked out during my stay at MSRI. When  $\mathfrak{g} = \mathfrak{sl}_n$ , for special values of the deformation parameters, we proved a new theorem that the center of the DDCA contains two subrings isomorphic to the polynomial ring in infinitely many variables  $\mathbb{C}[s_1, s_2, s_3, \dots]$  and  $\mathbb{C}[t_1, t_2, t_3, \dots]$ . This is an analog theorem of the rational Cherednik algebra when the parameter  $t$  is zero.

During our stay at MSRI Toledano Laredo and I established a  $(\mathfrak{gl}_k, \mathfrak{gl}_n)$  duality between the KZB connection for  $\mathfrak{g} = \mathfrak{gl}_k$  and the elliptic Casimir connection for  $\mathfrak{g} = \mathfrak{gl}_n$ . This is an analog duality between the rational KZ-connection for  $\mathfrak{g} = \mathfrak{gl}_k$  and the rational Casimir connection for  $\mathfrak{g} = \mathfrak{gl}_n$  found by Toledano Laredo. Such a duality is a powerful tool to study the monodromy of the Casimir connection. The elliptic Casimir connection depends on the modular parameter  $\tau$ . We also extended the elliptic Casimir connection to the moduli space of elliptic curves with  $n$  marked points with values in the deformed double current algebra. Thanks to the extension, we would be able to compute the monodromy of the elliptic Casimir connection by letting  $\tau$  tend to  $i\infty$ . In this case, the elliptic Casimir connection degenerates to the trigonometric Casimir connection. The monodromy of the trigonometric Casimir connection is computable.

## 5. GRADUATE STUDENT ACTIVITIES AND MENTORING

The GRT program benefitted from the active participation of numerous Graduate Assistants as well as numerous local and visiting graduate students. These students partook of the many seminars and interacted with faculty and postdocs. The main component of the Graduate program consisted of the graduate student seminar.

**5.1. Graduate Student Seminar: Report by I. Ganev.** The grad student seminar this semester was joint between the GRT and NGM programs (and organized by Ana Caraiani, Jordan Ganev and Arno Kret), and we decided to learn about the geometric Satake equivalence; a topic relevant to both programs. One of the organizers, Ana Caraiani, wrote a syllabus (attached), and the participants volunteered to give talks. One of the first talks was an excellent overview (by Sam Raskin) that laid out the topics that would be covered in later talks. The next few talks were on the affine Grassmannian, and were meant to be basic and full of examples. However, they ended up quite technical and not very enlightening. Attendance was high at the beginning – perhaps 25 or so people – but declined significantly after a few weeks. I personally received complaints about the low quality of the talks.

This decline in quality could be expected – the speakers were not experts on the subject, as they had learned most of the material in preparation for the talk. It is not immediately clear how this decline could be prevented. One option would be for the organizers to take a more active role in helping speakers learn the material and prepare their talks. The danger would be that the organizers would exert too much control and prevent a participant from discovering what is interesting to him or her. Also, the organizers' time is somewhat limited during the semester.

Later talks improved somewhat in quality, but the attendance remained low. For me personally, the highlight of the seminar was my own talk. It was one of the last talks, and many things from previous talks came together.

There are a number of things that I would have done differently. Ideally, I would have met with the speakers regularly to help plan their talks and make sure they are accessible to the audience, and link well with the other talks. Another idea is to have one of the organizers start each week with a summary of what has been covered so far in the semester, what will occur in the current talk, and what will follow in later talks.

A very positive aspect of the seminar was that it was fairly focused on a topic relevant to both programs. In my opinion, this was preferable to the alternatives of having each person speak on his/her own research, or a series of mini-topics with just a few talks each.

One option for improvement is to compile informal summaries of the topics and organization of previous instances of the grad student seminar. In this way, the organizers each semester can learn what precedents there are for this seminar and can be warned about potential pitfalls.

## 6. DEMOGRAPHIC INFORMATION

### 7. SCIENTIFIC BREADTH

The GRT program represented the various aspects of geometric representation theory, including number theory, algebraic geometry, topology, logic, noncommutative geometry, harmonic analysis, operator algebras and category theory. Among younger participants there were eleven postdocs and twelve graduate assistants, together with very large numbers of graduate students from Berkeley. The broadest impact of the program was achieved through the Connections for Women workshop and Introductory workshop, which reached hundreds of young researchers and introduced them in an accessible and inviting fashion to exciting areas of current research. Careful attention was paid to the inclusion of underrepresented groups in all activities. In



particular the participation of women in all aspects of the program, from organizers to research members to postdocs to speakers to conference participants, far exceeded the unfortunately low levels of representation in the field, and we believe the GRT program will have a significant positive impact on changing the face of the subject.

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## Geometric Representation Theory



**Bouthier, Alexis**

Name: Alexis Bouthier

Year of Ph.D : 2014

Institution of Ph.D.: Université Paris-Sud Orsay

Dissertation title: Geometrization of the orbital side of the trace formula

Ph.D. advisor: Laumon, B.C. Ngo.

Mentor while at MSRI: Edward Frenkel

Institution (or company) where you are going after the MSRI PD fellowship: Post-doc Hebrew University of Jerusalem.

Postdoctoral fellow comments:

My work concerned the geometrisation of fundamental lemma of spherical Hecke algebra, initiated in my Phd and the study the intersection complex on the monoids introduced by Ngô which should give a geometric interpretation of the test function of the Local-unramified L-factors. Publication with Ngô & Sakellaridis, and work in progress on the geometrisation of the fundamental lemma for spherical Hecke algebra.



**Dancso, Zsuzsanna**

Name: Zsuzsanna Dancso  
Year of Ph.D: 2011  
Institution of Ph.D.: University of Toronto  
Dissertation title: Homomorphic expansions for knotted trivalent graphs  
Ph.D. advisor: Dror Bar-Natan

Mentor while at MSRI: Monica Vazirani

Institution prior to obtaining the MSRI PD fellowship: Fields Inst.  
Position at that institution: NSERC post-doc Mentor  
(I also spent a semester as a research visitor at the University of Toronto.)

Institution where you are going after the MSRI PD fellowship: Australian National University  
Position: Post-doctoral fellow  
Anticipated length: 2 years  
Mentor (if applicable): Anthony Licata and Scott Morrison

Postdoctoral fellow's comments:

While at MSRI I started a new project with a new collaborator, Vivek Shende at UC Berkeley, on the "graphical  $W=2P$ " conjecture. This work is still in progress, some preliminary result have been written up (working notes towards a paper). I have also made a significant progress on a joint paper with Dror Bar-Natan on the Kashiwara-Vergne conjecture and knotted objects in  $R^4$ , and edited two other papers according to referees' reports which are in the process of publication.

I have given several talks while based at MSRI (Evans lecture, post-doc seminar, UC Davis, Oberwolfach), and appreciated the freedom and opportunities to do so.

I benefited greatly from Monica's mentorship: she gave me feedback on talks, helped me with job applications, invited me to give a talk at Davis, and provided general career advice and support.

Overall I had a productive and enjoyable semester and formed many new professional contacts.



**Dodd, Christopher**

Name: Christopher Dodd

Year of Ph.D: 2011

Institution of Ph.D.: Massachusetts Institute of Technology

Dissertation title: Equivariant Coherent Sheaves, Soergel Bimodules, and Categorification of Affine Hecke Algebras

Ph.D. advisor: Roman Bezrukavnikov

Mentor while at MSRI: Kevin McGerty

Institution prior to obtaining the MSRI PD fellowship: University of Toronto

Position at that institution: Postdoctoral Fellow

Mentor (if applicable): Joel Kamnitzer

Institution (or company) where you are going after the MSRI PD fellowship: University of Toronto

Position: Postdoctoral Fellow

Anticipated length: 1 semester

At MSRI, I mostly worked on understand flat connections in two contexts: first of all, the theory of wild flat connections in characteristic zero and its analogues in positive characteristic, and secondly, the theory of connection with  $p$ -curvature zero. In both cases, I made substantial progress during the semester; in particular, conversations with other members allowed me to correct misconceptions, fix errors in my thinking, and prove several new theorems. I haven't published anything from this time, but I expect the ideas formulated there to be the basis of several publications in the future. So the whole semester was highly beneficial.



**Fratila, Dragos**

Name: Dragos Fratila

Year of Ph.D.: 2014

Institution of Ph.D.: Universite Paris Diderot

Dissertation title: Hall algebras, automorphisms forms and the geometry of principal bundles over an elliptic curve

Ph.D. advisor: Olivier Schiffmann

Mentor while at MSRI: Pramod Achar

Institution prior to obtaining the MSRI PD fellowship: Universite Paris Diderot

Position at that institution: Ph.D. student

Mentor (if applicable): Olivier Schiffmann

Institution where you are going after the MSRI PD fellowship: Max Planck, Bonn, Germany

Position: Post Doc

Anticipated length: (if it is a tenure track position just write tenure-track) 1.5 years

Mentor (if applicable): Geordie Williamson

Postdoctoral fellow's comments:

I mostly worked on the classification of simple summands of spherical Eisenstein sheaves for an elliptic curve and a reductive group  $G$ . I had numerous discussions with Penghui Li and Sam Gunningham about the geometry of semistable bundles. In particular, thanks to Penghui Li, I realized that the stratification (according to some regularity conditions) of the stack of semistable  $G$ -bundles that I thought I've found was pretty wrong. That led me to learn much more about reductive subgroups of reductive groups as well as about nilpotent orbits. Eventually, even the stratification of the stack of semistable bundles seems to require a bit of work and might be interesting in itself so in collaboration with P. Li and S. Gunningham we decided to write an article about this. We have an initial draft on this. We're also planning in a future work to use this stratification to study in more depth the category of perverse sheaves on this stack



**Gunningham, Sam**

Name: Sam Tomas Powaga Gunningham

Year of Ph.D.: 2013

Institution of Ph.D.: Northwestern University

Dissertation Title: "Categorified Harmonic Analysis on a Complex Reductive Group"

Ph.D. Advisor: David Nadler

Mentor while at MSRI: Zhiwei Yun

Position prior to MSRI: University of Texas, Austin, Instructor (with R.H. Bing Postdoctoral Fellowship). Mentors: David Ben-Zvi, Dan Freed.

Position post MSRI: University of Texas, Austin, Instructor (with R.H. Bing Postdoctoral Fellowship). I have 3 semesters more in this position.

Postdoctoral fellow's comments:

My research is in the field of Geometric Representation Theory. Whilst at MSRI, I have been focusing in two directions, both concerning the categories of D-modules on certain stacks associated to a reductive group (for example the adjoint quotient stack).

The first direction is building on work from my thesis, to understand parabolic induction and restriction functors, and the resulting structure on categories of D-modules. I am currently writing a paper, "Generalized Springer Theory on a Reductive Lie Algebra", in which I recover, extend, and present simpler proofs of results from Springer theory. A sequel to this paper is also in preparation. During the preparation of this work I have had many helpful conversations with fellow MSRI members, including Pramod Achar, David Ben-Zvi, Dragos, Fratila, Daniel Juteau, Carl Mautner, Kevin McGerty, David Nadler, Tom Nevins, and Zhiwei Yun. I hope to start a project extending this work to the stack of semistable bundles on an elliptic curve, joint with Dragos Fratila and (Berkeley graduate student) Penghui Li.

The second direction concerns a certain category associated to the group scheme of regular centralizers. This work is in its early stages, and is joint with (MSRI members) David Ben-Zvi and David Nadler. Helpful new perspectives were obtained from conversations with (MSRI member) Ivan Mirkovic.

Overall, my experience at MSRI was overwhelmingly beneficial. The seminars and workshops exposed me to new ideas as well as providing new perspectives on my research. Most notably, the abundance of researchers in my field coupled with a fantastic working environment lead to a very productive semester. The math I have learned and the connections I have made will have a strong and lasting effect on my career.



**Hamacher, Paul**

Name: Paul Hamacher

Year of Ph.D: 2014

Institution of Ph.D.: Technische Universität München

Dissertation title: The geometry of the Newton stratification in the reduction modulo  $p$  of Shimura varieties of PEL type

Ph.D. advisor: Eva Viehmann

Mentor while at MSRI: Xinwen Zhu

Institution prior to obtaining the MSRI PD fellowship:

Position at that institution:

Mentor (if applicable):

Institution (or company) where you are going after the MSRI PD fellowship:

Harvard University

Position: PostDoc on a DAAD scholarship

Anticipated length: 1 year

Mentor: Mark Kisin

Postdoctoral fellow's comments:

I continued my research on the Newton stratification and how it could be generalised to Shimura varieties of Hodge type. The aim is to generalise Mantovan's construction and describe the Newton strata as "almost product" of a central leaf and a subspace of a RZ space. Moreover, I tried to get a better description of a cellular decomposition of superbasic hyperspecial RZ spaces.

No publications were made yet.

During our time at the MSRI, Daniel Desegni, Andreas Mihatsch, Daniel Kirch and I held a reading course about Hilbert Blumenthal spaces.

Was your experience at MSRI beneficial? Yes



**Rostami, Sean**

Name: Sean Rostami

Year of Ph.D: 2012

Institution of Ph.D.: University of Maryland, College Park

Dissertation title: Kottwitz's nearby cycles conjecture for a class of unitary Shimura varieties

Ph.D. Advisor: Thomas Haines

Mentor while at MSRI: Matthias Strauch

Institution prior MSRI: University of Wisconsin, Madison

Position at that institution: Van Vleck Visiting Assistant Professor (postdoc)

Mentor (if applicable): Tonghai Yang

Institution (or company) where you are going after the MSRI PD fellowship: will return to UW for AY2015/2016

Position/Mentor: same as above

Anticipated length: (if it is a tenure track position just write tenure-track)  
1 year (continue and finish existing 3-year postdoc position)

Postdoctoral fellow's comments:

(1) For approximately the first month, I worked on a dessin d'enfants project that was started in the middle of Spring 2014, and I was able to state and prove a nice characterization theorem (I tried to do this in summer but was unsuccessful). This is an important first step in the bigger project, which I will return to in the coming months.

(2) For approximately the next 2 months, I mainly did a mixture of three things. The first was to begin an algebraic geometry question with obvious value to geometric representation theory. Although I learned something and enjoyed thinking about it, no compelling progress was made and I was eventually convinced to postpone the question. The second was to prepare my thesis for publication (for various reasons, it was not published at the time of graduation), which required both expositional and mathematical changes (correcting errors and filling gaps, which required me to read and understand some things that I did not know before). The third was to edit a paper submitted in January 2014, in response to a referee report that I received while at MSRI.

(3) For the past three weeks, and probably for the next couple weeks and into 2015, I am working with a collaborator on a question concerning Gross-Reeder "simple" supercuspidal representations. It's going very well so far.

(4) Finally, there is another potential project that arose from conversations I had with another visitor to MSRI, and we plan to work on this together in the next few months. I think I could have 2 preprints, based on material (1) and (3), ready by summer; I'm not totally sure if anything conclusive will ever come of (2), and I think (4) is a good project but may require more time. The time I spent here was extremely beneficial. Besides the great working conditions (people, environment, freedom from distractions), I feel like I have a lot of momentum and energy to carry into the next year. I suspect it will allow me to be much more successful in the future than I would have been otherwise.





**Rozenblyum, Nikita**

Your Name: Nikita Rozenblyum

Year of Ph.D: 2011

Institution of Ph.D.: MIT

Dissertation title: Connections on conformal blocks

Ph.D. advisor: Jacob Lurie

Mentor while at MSRI: David Treumann

Institution prior to obtaining the MSRI PD fellowship: Northwestern University

Position at that institution: Simons Postdoctoral Fellow

Mentor (if applicable):

Institution (or company) where you are going after the MSRI PD fellowship: University of Chicago

Position: Assistant Professor

Anticipated length: 3 years

Mentor (if applicable):

Postdoctoral fellow's comments:

I have benefitted a great deal from the program. Particularly beneficial for me were discussions between the geometric representation theory program and the number theory program. During the semester many new connections were established, and it was a wonderful learning experience for me. I expect these ideas will play a significant role in my future work.



**Yang, Yaping**

Name: Yaping Yang

Year of Ph.D.: 2014

Institution of Ph.D.: Northeastern University

Dissertation title: Three contributions to topology, algebraic geometry and representation theory: homological finiteness of abelian covers, algebraic elliptic cohomology theory and monodromy theorems in the elliptic setting

Ph.D. advisor: Valerio Toledano Laredo

Mentor while at MSRI: Edward Frenkel

Institution prior to obtaining the MSRI PD fellowship: Northeastern University

Position at that institution: PhD student

Mentor (if applicable): Valerio Toledano Laredo

Institution (or company) where you are going after the MSRI PD fellowship: UMass, Amherst

Position: Visiting assistant professor

Anticipated length: 2.5 years

Mentor (if applicable): Ivan Mirkovic

Postdoctoral fellow's comments:

It was an enjoyable and productive semester at MSRI. I had the opportunity to talk to many experts and young researchers, especially Prof. Edward Frenkel, Prof. Ivan Mirkovic and Prof. Valerio Toledano Laredo. Prof. Edward Frenkel is my mentor. We had several official meetings. Frenkel is very kind and helpful. He explains things very well and clear. He gave useful suggestions and down to earth answers. He taught me the theory of conformal blocks for any Riemann surfaces. In particular, the twisted conformal blocks for the elliptic curve give rise to the Knizhnik-Zamolodhikov-Bernard (KZB) connection. It is closely related to the project I have been working on with Toledano Laredo.

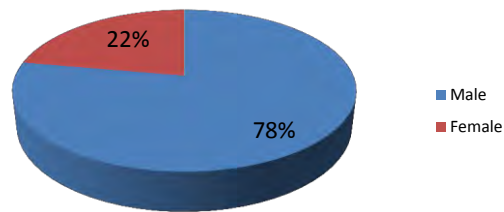
I had a regular weekly meeting with Prof. Ivan Mirkovic and started a new project with him.

Postdoc Pre/Post-MSRI Institution Group

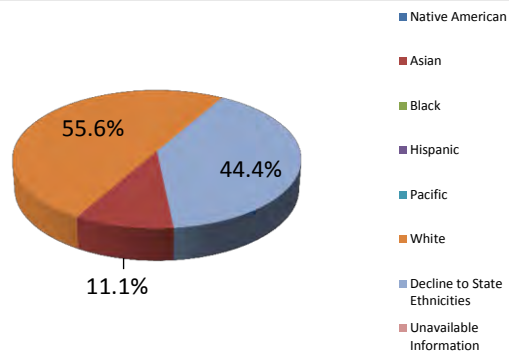
Family Name	First Name	Pre-MSRI Institution Group	Post-MSRI Institution Group	Pre-MSRI Institution Name	Placement Institution Name
Bouthier	Alexis	Foreign	Foreign	Universite de Paris XI	Hebrew University
Dancso	Zsuzsanna	Foreign	Foreign	University of Toronto	Australian National University
Dodd	Christopher	Foreign	Foreign	University of Toronto	University of Toronto
Fratila	Dragos	Foreign	Foreign	Universite de Paris VII (Denis Diderot)	Max Planck
Gunningham	Sam	Group I Public	Group I Public	University of Texas at Austin	University of Texas
Hamacher	Paul	Foreign	Group I Private	TU Munchen	Havard University
Rostami	Sean	Group I Public	Group I Public	University of Wisconsin-Madison	University of Wisconsin-Madison
Rozenblyum	Nikita	Group I Private	Group I Private	University of Chicago	University of Chicago
Yang	Yaping	Group II	Group II	Northeastern University	UMass, Amherst

2014–15 Postdoctoral Fellows Demographic Summary

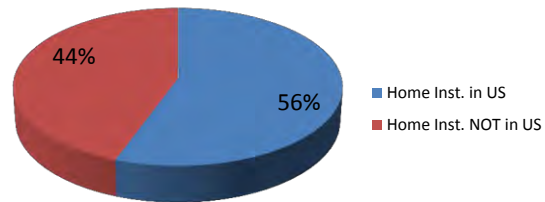
Gender	#	% (No Decl.)*	%
# of Distinct Postdocs	9		100.0%
Male	7	77.78%	77.8%
Female	2	22.22%	22.2%
Decline to State Gender	0		0.0%



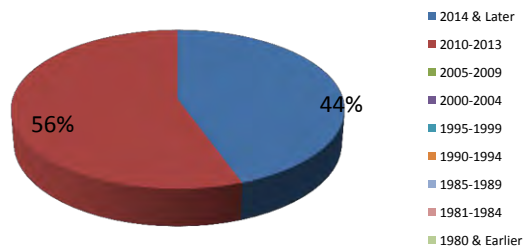
Ethnicities	#	% (No Decl.)*	%
Native American	0	0.00%	0.0%
Asian	1	16.67%	11.1%
Black	0	0.00%	0.0%
Hispanic	0	0.00%	0.0%
Pacific	0	0.00%	0.0%
White	5	83.33%	55.6%
Decline to State Ethnicities	4		44.4%
Unavailable Information	0		0.0%
Minorities	0		0.0%



Citizenships	#	%
US Citizen & Perm. Residents	3	33.3%
Foreign	6	66.7%
Unavailable information	0	0.0%
# of Distinct Members	9	100.0%
US Citizen	3	33.3%
Perm Residents	0	0.0%
Home Inst. in US	5	55.6%



Year of Ph.D	#	%
2014 & Later	4	44.4%
2010-2013	5	55.6%
2005-2009	0	0.0%
2000-2004	0	0.0%
1995-1999	0	0.0%
1990-1994	0	0.0%
1985-1989	0	0.0%
1981-1984	0	0.0%
1980 & Earlier	0	0.0%
Unavailable Info.	0	0.0%
Total # of Distinct Postdocs	9	100.0%



\*Statistic Calculation based on all participants that did not decline.

## Geometric Representation Theory Program Summary

Role	# of Distinct Members	%	# of Citizens & Perm. Res.	%	US Citizens	# of Female	%	# of Minorities <sup>1</sup>	%
Organizers	6	9.7%	4	66.7%	3	0	0.0%	0	0.0%
Research Professors	10	16.1%	6	60.0%	6	3	30.0%	0	0.0%
Postdoctoral Fellows MSRI	9	14.5%	3	33.3%	3	2	22.2%	0	0.0%
Postdoctoral Fellows NSF	2	3.2%	2	100.0%	1	1	50.0%	0	0.0%
Research Members	25	40.3%	15	60.0%	12	3	12.0%	0	0.0%
Program Associates	10	16.1%	5	50.0%	5	2	20.0%	0	0.0%
<b>Total # of Distinct Members</b>	<b>62</b>		<b>35</b>	<b>56.5%</b>	<b>30</b>	<b>11</b>	<b>17.7%</b>	<b>-</b>	<b>0.0%</b>

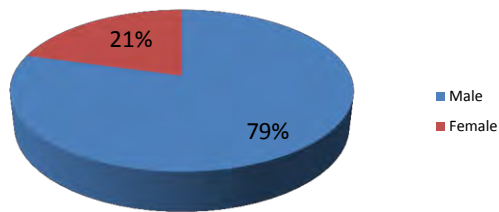
<sup>1</sup> Minorities are US citizen who declare themselves American Indian, Black, Hispanic, or Pacific Islander. Minority percentage is calculated by dividing the number of Minorities by the total number of US citizens.

### Home Institute Grouping

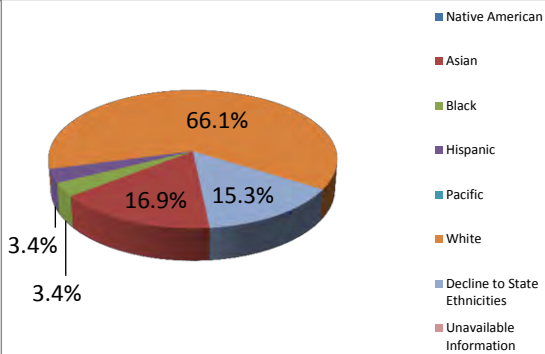
Role	US							Foreign	Total
	Group I Private	Group I Public	Group II	Group III	Group M	Group B	Non-Group		
Organizers	1	3	0	0	0	0	0	2	6
Research Professors	0	1	4	0	0	0	0	5	10
Postdoctoral Fellows MSRI	1	2	1	0	0	0	0	5	9
Postdoctoral Fellows NSF	2	0	0	0	0	0	0	0	2
Research Members	7	4	3	0	1	0	0	10	25
Program Associates	2	3	1	0	0	0	0	4	10
<b>Total</b>	<b>13</b>	<b>13</b>	<b>9</b>	<b>-</b>	<b>1</b>	<b>-</b>	<b>-</b>	<b>26</b>	<b>62</b>
<b>%</b>	<b>21.0%</b>	<b>21.0%</b>	<b>14.5%</b>	<b>0.0%</b>	<b>1.6%</b>	<b>0.0%</b>	<b>0.0%</b>	<b>41.9%</b>	

**2014-15 Program Members Demographic Summary**

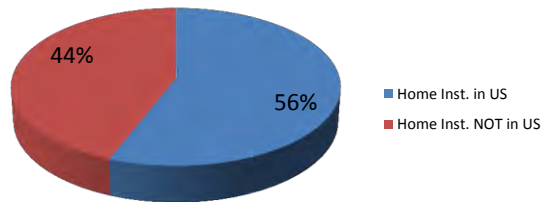
Gender	#	% (No Decl.)*	%
# of Distinct Members	59		100.0%
Male	46	79.31%	78.0%
Female	12	20.69%	20.3%
Decline to State Gender	1		1.7%



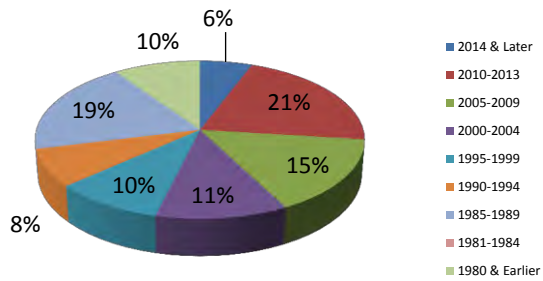
Ethnicities	#	% (No Decl.)*	%
Native American	0	0.00%	0.0%
Asian	10	18.87%	16.9%
Black	2	3.77%	3.4%
Hispanic	2	3.77%	3.4%
Pacific	0	0.00%	0.0%
White	39	73.58%	66.1%
Decline to State Ethnicities	9		15.3%
Unavailable Information	0		0.0%
Minorities	3		12.0%



Citizenships	#	%
US Citizen & Perm. Residents	30	50.8%
Foreign	29	49.2%
Unavailable information	0	0.0%
# of Distinct Members	59	100.0%
US Citizen	25	42.4%
Perm Residents	5	8.5%
Home Inst. in US	33	55.93%



Year of Ph.D	#	%
Program Associates (GS)	7	11.9%
2014 & Later	3	5.1%
2010-2013	11	18.6%
2005-2009	8	13.6%
2000-2004	6	10.2%
1995-1999	5	8.5%
1990-1994	4	6.8%
1985-1989	10	16.9%
1981-1984	0	0.0%
1980 & Earlier	5	8.5%
Unavailable Info.	0	0.0%
Total # of Distinct Members	59	100.0%



\*Statistic Calculation based on all participants that did not decline.

# **New Geometric Methods in Number Theory and Automorphic Forms**

August 11, 2014 to December 12, 2014

MSRI, Berkeley, CA

USA

## **Organizers:**

Pierre Colmez (Institut de Mathématiques de Jussieu)  
LEAD Wee Teck Gan (National University of Singapore)  
Michael Harris (Institut de Mathématiques de Jussieu)  
Elena Mantovan (California Institute of Technology)  
Ariane Mézard (Institut de Mathématiques de Jussieu)  
Akshay Venkatesh (Stanford University)

# NEW GEOMETRIC TECHNIQUES IN NUMBER THEORY AND AUTOMORPHIC FORMS

## Organizers

The organizers of this MSRI program were:

- (i) Pierre Colmez (Institut de Mathématiques de Jussieu, France).
- (ii) Wee Teck Gan (National University of Singapore, Singapore).
- (iii) Michael Harris (Institut de Mathématiques de Jussieu, France).
- (iv) Elena Mantovan (California Institute of Technology, USA).
- (v) Ariane Mézard (Institut de Mathématiques de Jussieu, France).
- (vi) Akshay Venkatesh (Stanford University, USA).

## Introduction

Some 4 years ago, during the special year on Galois representations and automorphic forms at the IAS, we were approached by Richard Taylor, a member of the scientific committee of the MSRI, who asked whether we would be interested in organizing a semester on the arithmetic Langlands program. He added that it could be at the same time as a program on the geometric Langlands program and that there may be some interesting interaction. We agreed and chose the title "New geometric methods in number theory and automorphic forms" for our program. We were inspired by what was happening at the time, such as the birth of the theory of perfectoid spaces, but we could not have foreseen how much to the point the title of the program would turn out to be! There were new geometric methods indeed, some of which are still waiting to be discovered to account for the plectic phenomena uncovered by Nekovar and Scholl, but the most spectacular being the interplay between the ideas of Fargues and Scholze-Weinstein for a geometrization (inspired by the works of Drinfeld, L. and V. Lafforgue in the geometric Langlands program) of the local Langlands correspondence (classical and hopefully  $p$ -adic). This involves the definition of a new class of geometric objects, that Scholze calls "diamonds" and to which he devoted his Chancellor's course (he was led to this definition when he realised, at the MSRI's Hot Topic workshop in February of this year, that the arithmetic affine Grassmanian of Fargues could not be a classical analytic space, but would be a diamond if such a notion was to make sense). Scholze's course was followed by many participants of the program and by many other mathematicians in the world, thanks to the recording and broadcasting on MSRI's website. It brought a sense of excitement that was matched by the final workshop where many striking results were presented, one of the highlights being Fargues' talk in which he proposed a beautiful conjectural geometric way to realise the local Langlands correspondence. Participants of the



program or the final workshop left with many new things to think about, and it can be said that the program was a big success.

### 1. Research developments

We would like to highlight some research developments achieved during the semester.

(1) One of the highlights of the program is undoubtedly the Chancellor lectures given by Peter Scholze. The course introduces an evolving theory of a new geometric structure, which Scholze has termed “Diamond” and which is a generalization of algebraic spaces (for the pro-stale topology) building upon Scholze’s theory of perfectoid spaces. The goal of introducing these new geometric objects is in developing a local theory of shtukas over  $\mathbb{Q}_p$ , generalizing Beilinson-Drinfeld’s Grassmannian, thus enabling the application of ideas from the Geometric Langlands program to the mixed characteristic setting, with the potential application of proving the local Langlands correspondence for general  $G$ . Thus, the lectures were of interest to participants of both NGM and GRT (our companion program).

In addition, Scholze explained the connections of his theory to the ongoing work of many other experts (who were in the audience), such as the sympathetic algebras and finite-dimensional Banach spaces of Colmez, the theory of Breuil-Kisin modules, the theory of Fargues-Fontaine curve, the work of Kedlaya-Liu on relative  $p$ -adic Hodge theory, Scholze’s work with Weinstein on  $p$ -divisible groups, as well as new developments on integral  $p$ -adic Hodge theory, such as the cohomological comparison theorem of Scholze-Bhatt-Morrow on integral  $p$ -adic Hodge theory and Colmez-Niziol. Scholze also initiated a new collaboration with Ana Caraiani (an NGM postdoc) on the construction of Hodge-Tate period map (reported in Caraiani’s lecture in final workshop).

(2) The technology introduced in the Chancellor lectures was nicely exploited by Laurent Fargues in his lecture during the final workshop of the program, in which he explained a compelling geometric framework for formulating the local Langlands correspondence, in the spirit of the Geometric Langlands correspondence and in the style of the work of Adams-Barbasch-Vogan for the archimedean case. More precisely, given a quasi-split reductive group  $G$  over the field of  $p$ -adic numbers, Fargues has proved that the points of the stack of  $G$ -bundles on the Fargues-Fontaine curve are in bijection with the Kottwitz set of  $\sigma$ -conjugacy classes in  $G$ . Fargues formulated a conjecture asserting the existence of a functor associating to a Langlands parameter with values in the Langlands dual group of  $G$  a perverse sheaf on the stack of  $G$ -bundle, together with a long list of natural properties. The work of Scholze and the conjectures of Fargues will surely serve as a roadmap for the future development of the local Langlands correspondence.

(3) There are many leading experts on the  $p$ -modular representation theory of  $p$ -adic groups who are members of the two programs, One of the highlights for this area is the completion of a joint paper of Abe-Henniart-Herzig-Vigneras on the classification of irreducible  $p$ -modular representations of an arbitrary reductive  $p$ -adic groups, in terms of supersingular ones. This completely resolves a question which was first investigated by Barthel-Livne for  $GL(2)$ , followed by the work of Herzig (for  $GL(n)$ ) and Abe (for split  $G$ ). This progress is reported in Vigneras’ lecture in the final workshop. In addition, the connection between the  $p$ -modular

representation theory of  $G$  and that of its pro- $p$ -Iwahori-Hecke algebra is a theme which was much discussed during the program, especially in view of possible analogies with approaches to the geometric Langlands program that were very much in view in the concurrent Geometric Representation Theory program.

Elmar Grosse-Klonne gave a talk explaining his construction of a bijection between irreducible  $n$ -dimensional mod  $p$  Galois representations and absolutely simple supersingular modules over the pro- $p$  Iwahori Hecke algebra (of dimension  $n$ ). Rachel Ollivier and Peter Schneider made progress on the connection between categories of (derived) mod  $p$  representations of  $p$ -adic groups and of (derived) Hecke modules, and described a relevant torsion pair in the category of Hecke modules.

(4) Christophe Breuil, Eugen Hellmann and Benjamin Schraen constructed a patched eigenvariety in their project to prove that Breuil's conjecture on the locally analytic socle of representations occurring in completed cohomology is equivalent to various modularity conjectures and a conjecture of Hellmann, namely that the eigenvariety of a unitary group is the union of irreducible components of the finite slope space.

(5) Luis Lomeli (an NGM postdoc) has continued his long-term project on extending the Langlands-Shahidi theory from the characteristic 0 setting to the case of function fields. One of the key missing results in the function fields case is to have a globalisation result for supercuspidal representations of local function fields, with control at all other places. In collaboration with Wee Teck Gan, such a strong globalisation result has now been shown, with the consequence that the Langlands-Shahidi theory for function fields can now be completed. Lomeli is writing up a paper on this, and Gan-Lomeli are preparing a short article on this globalisation result, with other applications.

(6) Wee Teck Gan and Dipendra Prasad are finishing up a paper (jointly with Benedict Gross) on the formulation of the Gross-Prasad conjecture for nontempered Arthur packets. A basic case is the problem for  $GL(n)$ , and in this setting, their work was greatly facilitated by the results of Erez Lapid (NGM RP), Arno Kret (NGM posdoc) and Alberto Minguéz, who computed the derivatives and Jacquet modules of the Speh representations. Building upon these results, they have been able to show the nontempered GP conjecture for  $GL(n)$ , and are preparing a paper for classical groups.

(7) In his seminar talk, Shin spoke about his recently released paper with Kaletha, Minguéz and White on the discrete spectrum of non-quasi-split unitary groups, extending the work of Mok for the quasi-split case. Colette Moeglin announced in her seminar talk that the long-awaited stabilization of the twisted trace formula (jointly with J.-L. Waldspurger) has finally been completed. Indeed, Moeglin and Waldspurger has just released the final paper on the arxiv; it is the 10th of the series. This essentially makes the work of Arthur, Mok and Kaletha-Minguéz-Shin-White on the discrete spectrum of classical groups unconditional.

(8) Akshay Venkatesh developed his ideas on derived deformations ring with powerful applications to integral structures in cohomology. Stefano Morra and Benjamin Schraen

computed a part of the modulo  $p$ -Galois representation associated by Breuil to supersingular representations of the group  $GL(2, F)$  for  $F$  an unramified extension of  $\mathbb{Q}_p$ . Ariane Mézard (jointly with Agnes David and Xavier Caruso) formulated a conjecture relating the Kisin variety (modulo  $p$ ) and the potentially Barsotti-Tate deformation ring. Laurent Berger proved that certain constructions of infinite Galois extensions of  $p$ -adic field are exactly the extension arising from relative Lubin-Tate groups.

(9) Jan Nekovar and Tony Scholl formulated the plectic conjecture: in the presence of real multiplication (if  $F$  is a totally real number field, say), motives have an additional canonical structure, the  $F$ -plectic structure. they give a cohomological  $\ell$ -adic version of the plectic conjecture in the case where  $G$  is a reductive group. Loeffler and Zerbes (jointly with Kings and Lei) constructed a new Euler system attached to the Rankin-Selberg convolution of two modular forms.

(10) Michael Harris, Kai-Wen Lan, Richard Taylor (jointly with Jack Thorne) constructed the compatible system of  $l$ -adic representations associated to a regular algebraic cuspidal automorphic representation of  $GL(n)$  over a CM field. They establish a higher Koecher's principle for any Shimura variety in mixed characteristic.

## 2. Organizational structure

Several seminar series ran throughout the semester during the program:

- Research seminar: this meets on Thursday afternoons, consisting of two 50 minute talks; it was organised by Ariane Mézard and Yiannis Sakellaridis.
- Joint seminar: this seminar presents research which is of interest to both members of NGM and GRT. Speakers come from both programs. The seminar was organised by Akshay Venkatesh.
- Working seminar: this seminar meets on Wednesday. It was organised by Michael Harris and Akshay Venkatesh.

The title of this working seminar is "Geometric aspects in the representation theory of  $p$ -adic groups".

- Pizza Seminar: this is a seminar where postdoctoral members present their work; it was run by NGM postdoc Luis Lomeli.
- Graduate Student Seminar: this seminar, run by Ana Caraiani and Arno Kret, is a learning seminar for graduate students of both NGM and GRT. The topic of the seminar is the geometric Satake isomorphism.

In general, the feeling is that it is too much for a single person to attend all the seminars. Some participants feel that it will be better if members have more say in the organisational aspects, such as what working seminars to run.

## 3. Workshops and conferences

(i) *Connections for Women Workshop*

Organizers: W. Li, E. Mantovan, S. Morel and R. Sujatha.

This intensive 2-day workshop, held on Aug 14-15, 2014, showcased the contributions of female mathematicians to the three main themes of the associated MSRI program: Shimura varieties, p-adic automorphic forms, periods and L-functions. It was also a wonderful opportunity to bring together women working in this area at all stages in their careers. In fact, many of the participants were graduate students and young postdocs. The workshop featured 8 research lectures reporting on recent progress in the field; it also included an informal panel discussion on career issues and a social dinner for the female participants. The speakers include: Ling Long, Julia Gordon, Ana Caraiani, Ila Varma, Sarah Zerbes, Ellen Eischen, Pei-Yu Tsai and Birgit Speh.

(ii) *Introductory Workshop: Geometric methods in number theory and automorphic forms*  
Organizers: L. Berger, A. Mézard, A. Venkatesh and Shou-Wu Zhang.

This workshop, held on August 18-22, 2014, gave a practical introduction to some of the main topics and techniques related to the NGM program. It is aimed at graduate students and interested researchers in number theory or related fields, and featured lectures by Frank Calegari (Northwestern University), Gabriel Dospinescu (École Normale Supérieure de Lyon), Payman Kassaei (McGill University), Kai-Wen Lan (University of Minnesota, Twin Cities), Rachel Ollivier (University of British Columbia), Birgit Speh (Cornell University), Jared Weinstein (Boston University) and Shou-Wu Zhang (Princeton University).

(iii) *Topical Workshop: Automorphic forms, Shimura varieties, Galois representations and L-functions.*  
Organizers: P. Colmez, W.-T. Gan, S. Kudla, E. Mantovan, A. Mézard, R. Taylor.

This 5-day conference was held on Dec 1-5 and is in honour of Michael Harris whose work has had huge influence on the main themes of this program. There were 17 speakers in all, many of whom are leaders of the fields, and the quality of the talks were very high, in terms of their content as well as presentation. Some talks were devoted to recent breakthroughs, such as the talks by Vigneras, Scholze, Skinner, Darmon, Zerbes, while others concerned newly created directions, such as the talks by Venkatesh, Prasad, Fargues, Clozel. One participant remarked that it was rare to attend a conference where there were surprises in every talk. All in all, it is a fitting end to an intensive and stimulating semester.

#### 4. Postdoctoral fellows

The program was fortunate to have a very strong group of 9 postdoctoral fellows: Zavosh Amir-Khosravi, Ana Caraiani (NSF), Daniel Disegni, Hansheng Diao, Christian Johansson, Arno Kret, Bao Viet Le Hung, Luis Lomeli and Jasmin Matz. Each of them are paired with an advisor who is senior member of the program. We leave it to the postdocs and their mentors to work out how often they want to meet. Most met up once a week or two, at least. Indeed, most of the postdocs are sufficiently independent and many arrived here with their own research projects and specific goals. Sometimes, a postdoc might require advice on career related issues, such as NSF grant applications, and the assigned mentor (who may not be based in the US) may not be an appropriate person to give such advice. In such cases, the organisers have needed to put the postdoc in question in touch with the appropriate advisor.

This happens, for example, with Ana Caraiani, who was advised on such matters by Kiran Kedlaya.

On the whole, we are pleased with the outcome of the postdoctoral program. The postdoctoral fellows added a lot of energy to the program and have impressed us with their creativity and maturity. Many of them formed new collaborations; for example, Ana Caraiani started a new work with Scholze on the Hodge-Tate period map, whereas Arno Kret worked with Sug Woo Shin on construction of Galois representations associated to cuspidal automorphic representations of  $GS\!p(2n)$  and Luis Lomeli collaborated with Wee Teck Gan on a globalisation result for supercuspidal representations over function fields. Some worked with each other, for example, Caraiani and Le Hung completed a paper “On the image of complex conjugation in certain Galois representations”.

Here is a more detailed account:

- (a) Disegni, Daniel: Disegni returned to his postdoctoral position at CRM with Henri Darmon after the semester at MSRI. While at MSRI, he submitted the paper “p-adic Heights of Heegner points on Shimura curves”, and mostly completed the manuscript “The p-adic Gross-Zagier formula on Shimura curves”. He also gave talks at UC Santa Cruz and UCLA.
- (b) Johansson, Christian: Johansson moved to the IAS after MSRI. While at MSRI, he made progress on a number of projects, on overconvergent automorphic forms and p-adic representation theory of p-adic groups. He also gave a talk at Stanford. He had a fruitful tie at MSRI and expect the semester to have “a lasting impact on his career”.
- (c) Kret, Arno: Kret moved on to a postdoctoral position at the Max Planck Institute at Bonn after MSRI. While at MSRI, he worked on the computation of the dimension of certain Newton strata on the special fiber of Shimura varieties. He also began a project with Sug Woo Shin (Berkeley) on associating Galois representations to cuspidal representations of  $GS\!p(2n)$ .
- (d) Le Hung, Bao: Le Hung began a 3-year postdoc position at University of Chicago after MSRI. While at MSRI, he began several projects and finished some. For example, he completed a paper with fellow MSRI postdoc Ana Caraiani (NSF postdoc).
- (e) Lomeli, Luis, Lomeli moved on to a postdoc position at the Max Planck Institute at Bonn after MSRI. For several years, Lomeli had been engaged in the development of the Langlands-Shahidi program over function fields. While at MSRI, he was able to make definitive progress and the various pieces of puzzle finally came together, so that the project could be completed. He also gave seminar talks at UCLA and Caltech.
- (f) Matz, Jasmin: Matz moved to the IAS for a semester after MSRI. She worked on two projects while at MSRI: one with Templier (Cornell) on the distribution of Hecke eigenvalues for automorphic forms and the other a problem on limit multiplicities suggested by her mentor Erez Lapid. She also pointed out that she benefitted greatly from the Geometric Representation Theory program as it gave her the chance to catch up with recent developments in constructing certain L-functions by Ngo,

Sakellaridis, and others (a topic she was interested in a while ago, and which she hope that she can return to it in the near future).

- (g) Amir-Khosravi, Zavosh: Amir-Khosravi moved to a postdoc position at University of Pittsburg after the semester at MSRI.
- (h) Diao, Hansheng: Diao moved to the IAS after the semester at MSRI.

One issue brought by some postdocs is the uneven distribution of the workload or speaking opportunities among them. For example, some were put in charge of the Pizza seminar or the Graduate student seminar, and some felt that it will be to have more time for research rather than having to attend these talks. As another example, Ana Caraiani had to give at least 4 talks throughout the semester: the Connections for Women workshop, the Evans lecture, the topical workshop and the Bay Area Number Theory and Arithmetic Geometry Day. A better coordination and more even distribution are certainly some areas which could be improved.

## 5. Graduate students

The program hosted nine program associates: Julien Hauseux, Valentin Hernandez, Pierre Jalinière, Lin Jie, Daniel Kirch, Marica Knezevic, Arthur-Cesar Le Bras, Lambros Mavrides and Andreas Mihatsch. All of them reported that they have made huge progress on their PhD thesis, benefitted from the exciting scientific atmosphere, conversations with their advisors and many experts in the field who gave them some new ideas and raised some questions for future works after their PhD. They were attentive participants to the seminars, Scholze's lecture and the workshops (of the two MSRI programs). They had the opportunity to present their own work to other participants in graduate students seminar or during the poster session of the final workshop. Andreas Mihatsch together with three other PhD students organized a reading course on Hilbert modular varieties, aiming to read several relevant papers to this topic. This was only possible because many PhD students shared similar interest.

Among the PhD-students achievements, Julien Hauseux determined the extensions between unitary continuous  $p$ -adic and smooth mod  $p$  principal series of  $G(F)$  (where  $G$  is a split connected reductive group over a finite extension  $F$  of  $\mathbf{Q}_p$ ) in the generic case. Lin Jie proved that critical value of the L-function for  $GL(n)$  over an arbitrary CM field can be interpreted as products of automorphic periods up to multiplication by an algebraic number.

## 6. Diversity

The program is well-represented by women mathematicians, including 5 RP's (Mézard, Mantovan, Niziol, Moeglin, Zerbes), 2 PD's (Caraiani, Matz) and 4 RM's (Gurevich, Ollivier, Rozenstajn, Speh). Almost all of them gave talks, and some gave multiple talks (Zerbes, Caraiani). We also have a PD who is a minority (Lomeli, Hispanic). There were also a number of female program associates (graduate students). There were however no African Americans among the members or associates.

## 7. Synergistic activities

- Opportunities were given to members of the program to visit the Berkeley Math Circles and to give classes there. This was taken up by Nadya Gurevich who taught

such a class. Nadya Gurevich had herself attended Math Circles in her native St. Petersburg when she was growing up, and was also involved in similar ventures in Israel, where she is now.

- The two programs NGM and GRT are very closely related and complement each other well. There are many cross-program collaboration between the members. For example, Herzig and Vigneras (both of GRT) worked with Abe and Henniart (invited as RM for NGM but declined); Sakellaridis began a new collaboration with Ngo; the work of Scholze and Fargues are inspired by ideas from the Geometric Langlands Program, Reznikov and Bernstein continued to collaborate.
- A group of members met regularly to play basketball on Sundays, though this became less frequent as the weather became colder.

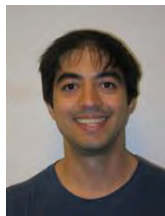
### 8. Nuggets and breakthrough

The Chancellor lectures given by Peter Scholze (on Tuesday and Thursday mornings) presented research breakthroughs of Scholze and his collaborators which one might call “fresh out of the oven”. The material itself was evolving as the semester went on. Each lecture was filled with anticipation by the audience who filled the room to its brim, with people sitting on the floor or standing for 90 minutes on many occasions. As a participant remarked: “the composition of the audience changes as the semester goes on (as there are many short-termed members of the program); the only constant is the full capacity of each lecture”. We can imagine that the video recordings of this course must surely be viewed and followed by many others elsewhere in the world.

The purpose of Scholze’s course is to introduce a new class of geometric objects which he called “Diamonds”. When questioned about the nomenclature, his answer was that they have so many symmetries that “they look beautiful from all angles, like a diamond”. Scholze had also introduced a potentially larger class of geometric objects which, for some technical reason, he initially called “faithful diamonds”. When someone questioned this nomenclature, he decided, in the middle of the course, that a more appropriate name would be “fake diamonds”. This gives a sense of the continuously evolving nature of the research material presented in this hugely successful and very exciting course.

The material presented was used by Laurent Fargues to formulate, a very compelling conjecture on a “geometric realisation of the local Langlands correspondence”, using (in his words) “more crazy objects”. Fargues’ lecture served as an appropriate reward to all those who followed Scholze’s lecture course faithfully. Together they charted a new course of development which will surely have much implications in the coming years.

**NEW GEOMETRIC METHODS IN NUMBER THEORY  
AND AUTOMORPHIC FORMS**



**Amir-Khosravi, Zavosh**

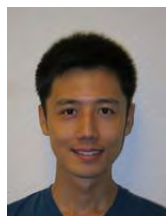
Name: Zavosh Amir-Khosravi  
Year of Ph.D: 2013  
Institution of Ph.D.: University of Toronto  
Dissertation title: Moduli of Abelian Schemes and Serre's Tensor Construction  
Ph.D. advisor: Stephen S. Kudla

Institution prior to obtaining the MSRI PD fellowship: Fields Institute of Mathematical Research  
Position at that institution: Visting Member

Institution (or company) where you are going after the MSRI PD fellowship: University of Pittsburgh  
Position: Post-Doctoral Associate

Postdoctoral fellow's comments:

None



**Diao, Hansheng**

Name: Hansheng Diao  
Year of Ph.D: 2014  
Institution of Ph.D.: Harvard University  
Dissertation title: The Eigencurve is Proper  
Ph.D. advisor: Mark Kisin

Institution prior to obtaining the MSRI PD fellowship: Harvard University  
Position at that institution: Ph.D Candidate  
Mentor (if applicable): Mark Kisin

Institution (or company) where you are going after the MSRI PD fellowship: Princeton University  
Position: Instructor

Postdoctoral fellow's comments:

None





**Disegni, Daniel**

Name: Daniel Disegni  
Year of Ph.D: 2013  
Institution of Ph.D.: Columbia  
Dissertation title: p-adic Heights of Heegner points on Shimura curves  
Ph.D. advisor: Shouwu Zhang  
Mentor while at MSRI: Stephen Kudla

Institution prior to obtaining the MSRI PD fellowship: CRM  
Position at that institution: Postdoc  
Mentor (if applicable): Henri Darmon

Institution (or company) where you are going after the MSRI PD fellowship: CRM  
Position: Postdoc  
Anticipated length: 2 years  
Mentor (if applicable): Henri Darmon

Postdoctoral fellow's comments:

I made final revisions to and submitted the paper "p-adic Heights of Heegner points on Shimura curves", and I mostly completed the manuscript "The p-adic Gross-Zagier formula on Shimura curves". Additionally I gave talks at UCSC and UCLA.

Was your experience at MSRI beneficial? Yes.



**Johansson, Christian**

Name: Christian Johansson

Year of Ph.D: 2013

Institution of Ph.D.: Imperial College London

Dissertation title: Classiciality for overconvergent automorphic forms

Ph.D. advisor: Prof. Kevin Buzzard and Prof. Toby Gee

Mentor while at MSRI: Prof. Pierre Colmez

Institution prior to obtaining the MSRI PD fellowship: University of Oxford

Position at that institution: Postdoctoral Research Fellow

Mentor (if applicable): N/A

Institution (or company) where you are going after the MSRI PD fellowship: Institute for Advanced Study, Princeton

Position: Member

Anticipated length: 20 months

Mentor (if applicable): N/A

Postdoctoral fellow's comments:

During my stay here at the MSRI I have worked on a few different projects; two of them started prior to my arrival (in the area of overconvergent automorphic forms) and three started whilst I was here, in collaboration with other MSRI visitors (in the area of p-adic representation theory of p-adic groups). None of these projects have been finalized during my time here, though three are getting close to completion. I have also been active in the rich mathematical life here at the MSRI and at UC Berkeley, attending numerous talk and giving two myself (one at MSRI and one at Stanford) and made many new connections that will be of great benefit to my future career as a mathematician.

Was your experience at MSRI beneficial?

Very much so. This semester has brought together a very large number of experts from the areas of mathematics most closely related to my research and it has been very valuable to meet and interact with them. I expect this semester will have a lasting impact on my career.



**Kret, Arno**

Name: Arno Kret  
Year of Ph.D.: 2013  
Institution of Ph.D.: Orsay  
Dissertation title: Stratification de Newton des varietes de Shimura et  
formule des traces d'Arthur-Selberg  
Ph.D. advisor: Clozel, Fargues  
Mentor while at MSRI: Rapoport

Institution prior to obtaining the MSRI PD fellowship: Institute for  
Advanced Study  
Position at that institution: Member  
Mentor (if applicable): Taylor

Institution (or company) where you are going after the MSRI PD  
fellowship: MPIM  
Position: Post-Doc  
Anticipated length: 1.5 years  
Mentor (if applicable):

Postdoctoral fellow's comments:

I worked on a paper on Langlands conjecture for the group  $GSp$ , also I  
tried to compute dimensions of Newton strata  
I published a paper on Equidistribution in supersingular locus of Shimura  
varieties  
I published a paper called "Combinatorics of the Basic Stratum".

Was your experience at MSRI beneficial? Yes. There were a lot of  
experts, and I had the chance to ask a lot of questions, which were very  
beneficial to my research. Also I worked on a collaboration with one of  
the mathematicians that followed the program as well



**Le Hung, Bao**

Name: Bao Le Hung

Year of Ph.D.: 2014

Institution of Ph.D.: Harvard University

Dissertation title: Modularity of some elliptic curves over totally real fields

Ph.D. advisor: Richard Taylor

Mentor while at MSRI: Ken Ribet

Institution before MSRI: Harvard University

Position: Graduate student

Institution after MSRI: University of Chicago

Position: Postdoc

Anticipated length: 2.5 years

Postdoctoral fellow's comments:

I finished writing up some on-going project, and started on a few new ones. Was your experience at MSRI beneficial? Yes.



**Lomeli, Luis**

Name: Luis Lomeli  
Year of Ph.D.: 2007  
Institution of Ph.D.: Purdue University  
Dissertation title: Functoriality for the classical groups over function fields  
Ph.D. advisor: Freydoon Shahidi  
Mentor while at MSRI: Dipendra Prasad

Institution prior to obtaining the MSRI PD fellowship: University of Oklahoma  
Position at that institution: Visiting Assistant Professor (Postdoc)  
Mentor (if applicable): Alan Roche

Institution (or company) where you are going after the MSRI PD fellowship: Max-Planck Institute for Mathematics  
Position: Postdoctoral fellow  
Anticipated length: (if it is a tenure track position just write tenure-track)  
Spring/Summer 2015  
Mentor (if applicable): Unknown

Postdoctoral fellow's comment:

I have completed a crucial step that makes the Langlands-Shahidi method available in complete generality in the case of function fields. The Langlands-Shahidi method over number fields, being due to Shahidi. I am currently working on writing the article and working on a couple of interesting applications which include a proof of the Ramanujan conjecture for the unitary groups over function fields. Unfortunately, I will probably finish writing the article in Max-Planck, yet much of the work was done here at MSRI and I am very thankful.

Was your experience at MSRI beneficial?

Extremely beneficial. In addition to solving the problem of completing the Langlands-Shahidi method over function fields, I was able to network properly and meet many great professors. My travels were professional. At my undergraduate institution in the neighboring state of Baja California, I was invited to give a general audience Number Theory talk, which went well and I linked it to a trip to LA. I gave seminar talks at UCLA and Caltech.



**Matz, Jasmin**

Name: Jasmin Matz

Year of Ph.D: 2011

Institution of Ph.D.: Heinrich-Heine Universitaet Duesseldorf

Dissertation title: Arthur's trace formula for  $GL(2)$  and  $GL(3)$  and non-compactly supported test functions

Ph.D. advisor: Tobias Finis

Mentor while at MSRI: Erez Lapid

Institution prior to obtaining the MSRI PD fellowship: Universitaet Bonn

Position at that institution: scientific assistant

Mentor (if applicable): Werner Mueller

Institution (or company) where you are going after the MSRI PD fellowship: IAS, Princeton

Position: Postdoctoral fellow

Anticipated length: one semester

Mentor (if applicable):

Postdoctoral fellow's comments:

I mainly worked on two different topics during my time at the MSRI: On the one hand, a joint project with Nicolas Templier about the distribution of Hecke eigenvalues for automorphic forms for  $GL(n)/\mathbb{Q}$  (extending my previous work for  $GL(n)$ /imaginary quadratic number fields), and, on the other hand, a project on limit multiplicities for the family of quotients  $SL_2(\mathcal{O}_F)\backslash SL_2(\mathbb{R}^r+\mathbb{C}^s)$  for  $F$  varying over number fields of fixed archimedean signature  $(r,s)$ .

In both cases detailed drafts exist but have not yet been submitted for publication.

I benefited from my stay at the MSRI in several ways. First of all, it was Erez Lapid who motivated me to look at the above mentioned limit multiplicity problem. I also benefited a lot from the other ongoing program on geometric representation theory as it gave me the chance to catch up with recent developments in constructing certain L-functions by Ngo, Sakellaridis, and others (a topic I was interested in a while ago, and I hope that I can return to it in the near future).

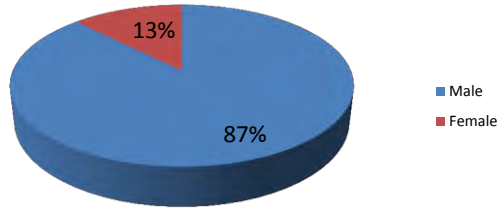
Finally, I had the chance to talk to many new people.

## Postdoc Pre/Post-MSRI Institution Group

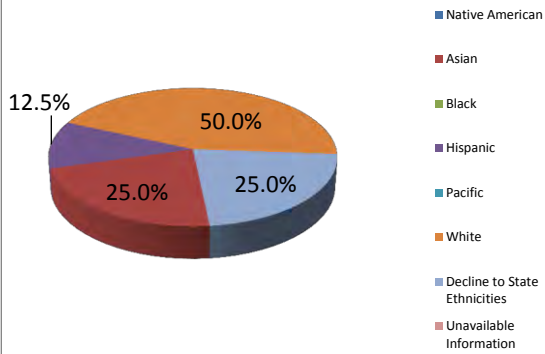
Family Name	First Name	Pre-MSRI Institution Group	Post-MSRI Institution Group	Pre-MSRI Institution Name	Placement Institution Name
Amir-Khosravi	Zavosh	Foreign	Group II	Fields Institute for Research in Mathematical Sciences	University of Pittsburgh
Diao	Hansheng	Group I Private	Group I Private	Institute for Advanced Study	Princeton
Disegni	Daniel	Foreign	Foreign	McGill University	McGill University
Johansson	Christian	Foreign	Group I Private	University of Oxford	Princeton
Kret	Arno	Group I Private	Foreign	Institute for Advanced Study	Max Planck
Le Hung	Bao	Group I Private	Group I Private	University of Chicago	University of Chicago
Lomeli	Luis	Group II	Foreign	University of Oklahoma	Max Planck
Matz	Jasmin	Foreign	Group I Private	Rheinische Friedrich-Wilhelms-Universitat Bonn	Princeton

2014–15 Postdoctoral Fellows Demographic Summary

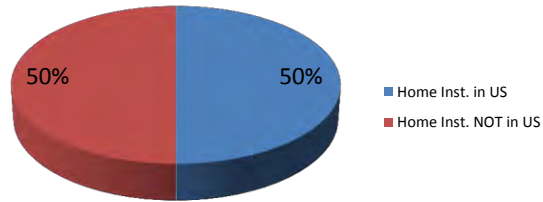
Gender	#	% (No Decl.)*	%
# of Distinct Postdocs	8		100.0%
Male	7	87.50%	87.5%
Female	1	12.50%	12.5%
Decline to State Gender	0		0.0%



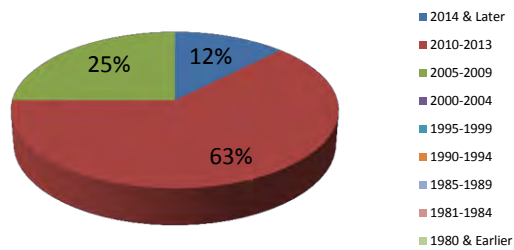
Ethnicities	#	% (No Decl.)*	%
Native American	0	0.00%	0.0%
Asian	2	28.57%	25.0%
Black	0	0.00%	0.0%
Hispanic	1	14.29%	12.5%
Pacific	0	0.00%	0.0%
White	4	57.14%	50.0%
Decline to State Ethnicities	2		25.0%
Unavailable Information	0		0.0%
Minorities	0		0.0%



Citizenships	#	%
US Citizen & Perm. Residents	0	0.0%
Foreign	8	100.0%
Unavailable information	0	0.0%
# of Distinct Postdocs	8	100.0%
US Citizen	0	0.0%
Perm Residents	0	0.0%
Home Inst. in US	4	50.00%



Year of Ph.D	#	%
2014 & Later	1	12.5%
2010-2013	5	62.5%
2005-2009	2	25.0%
2000-2004	0	0.0%
1995-1999	0	0.0%
1990-1994	0	0.0%
1985-1989	0	0.0%
1981-1984	0	0.0%
1980 & Earlier	0	0.0%
Unavailable Info.	0	0.0%
Total # of Distinct Postdocs	8	100.0%



\*Statistic Calculation based on all participants that did not decline.



## New Geometric Methods in Number Theory and Automorphic Forms Program Summary

Role	# of Distinct Members	%	# of Citizens & Perm. Res.	%	US Citizens	# of Female	%	# of Minorities <sup>1</sup>	%
Organizers	6	9.1%	3	50.0%	1	2	33.3%	0	0.0%
Research Professors	13	19.7%	5	38.5%	3	3	23.1%	0	0.0%
Postdoctoral Fellows MSRI	8	12.1%	0	0.0%	0	1	12.5%	0	0.0%
Postdoctoral Fellows NSF	1	1.5%	1	100.0%	0	1	100.0%	0	0.0%
Research Members	29	43.9%	7	24.1%	3	4	13.8%	0	0.0%
Program Associates	9	13.6%	0	0.0%	0	2	22.2%	0	0.0%
<b>Total # of Distinct Members</b>	<b>66</b>		<b>16</b>	<b>24.2%</b>	<b>7</b>	<b>13</b>	<b>19.7%</b>	<b>-</b>	<b>0.0%</b>

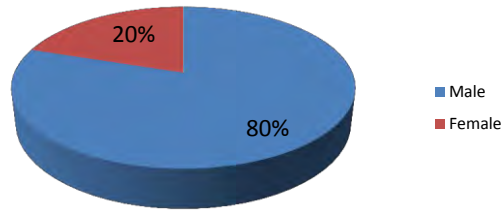
<sup>1</sup> Minorities are US citizen who declare themselves American Indian, Black, Hispanic, or Pacific Islander. Minority percentage is calculated by dividing the number of Minorities by the total number of US citizens.

### Home Institute Grouping

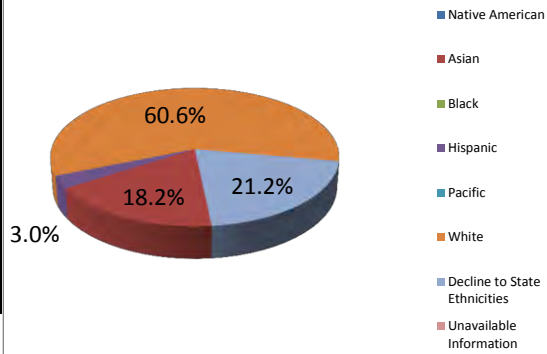
Role	US							Foreign	Total
	Group I Private	Group I Public	Group II	Group III	Group M	Group B	Non-Group		
Organizers	2	0	0	0	0	0	0	4	6
Research Professors	0	3	0	0	0	0	0	10	13
Postdoctoral Fellows MSRI	3	0	1	0	0	0	0	4	8
Postdoctoral Fellows NSF	1	0	0	0	0	0	0	0	1
Research Members	1	2	1	1	0	0	0	24	29
Program Associates	0	0	0	0	0	0	0	9	9
<b>Total</b>	<b>7</b>	<b>5</b>	<b>2</b>	<b>1</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>51</b>	<b>66</b>
<b>%</b>	<b>21.0%</b>	<b>21.0%</b>	<b>14.5%</b>	<b>0.0%</b>	<b>1.6%</b>	<b>0.0%</b>	<b>0.0%</b>	<b>41.9%</b>	<b>100.0%</b>

**2014-15 Program Members Demographic Summary**

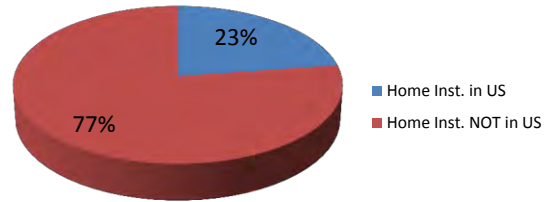
Gender	#	% (No Decl.)*	%
# of Distinct Members	66		100.0%
Male	52	80.00%	78.8%
Female	13	20.00%	19.7%
Decline to State Gender	1		1.5%



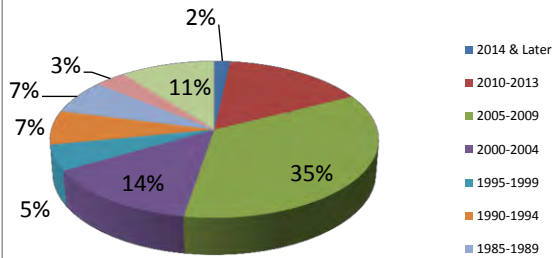
Ethnicities	#	% (No Decl.)*	%
Native American	0	0.00%	0.0%
Asian	12	22.22%	18.2%
Black	0	0.00%	0.0%
Hispanic	2	3.70%	3.0%
Pacific	0	0.00%	0.0%
White	40	74.07%	60.6%
Decline to State Ethnicities	14		21.2%
Unavailable Information	0		0.0%
Minorities	0		0.0%



Citizenships	#	%
US Citizen & Perm. Residents	16	24.2%
Foreign	50	75.8%
Unavailable information	0	0.0%
# of Distinct Members	66	100.0%
US Citizen	7	10.6%
Perm Residents	9	13.6%
Home Inst. in US	15	22.73%



Year of Ph.D	#	%
Program Associates (GS)	9	13.6%
2014 & Later	1	1.5%
2010-2013	9	13.6%
2005-2009	20	30.3%
2000-2004	8	12.1%
1995-1999	3	4.5%
1990-1994	4	6.1%
1985-1989	4	6.1%
1981-1984	2	3.0%
1980 & Earlier	6	9.1%
Unavailable Info.	0	0.0%
Total # of Distinct Members	66	100.0%



\*Statistic Calculation based on all participants that did not decline.

# **Dynamics on Moduli Spaces of Geometric Structures**

January 12, 2015 to May 22, 2015

MSRI, Berkeley, CA

USA

## **Organizers:**

Richard Canary (University of Michigan)

William Goldman (University of Maryland)

François Labourie (Université Nice Sophia-Antipolis)

LEAD Howard Masur (University of Chicago)

Anna Wienhard (Ruprecht-Karls-Universität Heidelberg)

**FINAL REPORT,  
“DYNAMICS ON MODULI SPACES OF GEOMETRIC  
STRUCTURES,”  
MSRI, SPRING 2015**

RICHARD CANARY, WILLIAM GOLDMAN, FRANÇOIS LABOURIE, HOWARD MASUR,  
AND ANNA WIENHARD

1. INTRODUCTION

The semester-long program was proposed and organized by Richard Canary (University of Michigan), William Goldman (University of Maryland), François Labourie (Université de Nice), Howard Masur (University of Chicago) and Anna Wienhard (Ruprecht-Karls-Universität Heidelberg). Each organizer assumed an active role in organizing the program. The program focused on a wide variety of topics in moduli spaces of geometric structures including higher Teichmüller theory, generalizations of Kleinian groups to other geometries, moduli spaces of analytic objects such as Higgs bundles and relationships to mathematical physics.

The program was very timely. The past fifteen years witnessed several important breakthroughs in these areas, leading to renewed interest in moduli of geometric structures. A key research theme of the program was to bring many of the deep techniques from classical Teichmüller theory and Kleinian groups to these more general settings. Several new fields emerged from these research developments. This research has been supported by several sponsors, including MSRI, the GEAR Research Network and others. MSRI played an crucial role in consolidating this growing research community. This and the intense scientific collaboration led to several new breakthroughs, the true impact of which we will only see in a few years from now.

We begin with a sample of some of the research accomplishments of the program.

2. RESEARCH DEVELOPMENTS

The program was a fertile breeding ground for the initiation of new research collaborations and the continuation and strengthening of existing collaborations.

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*Date:* July 31, 2015.

We highlight some research developments, to try to capture the productivity and intellectual excitement of the research atmosphere.

- Herbert Abels and Gregory Soifer presented their work on the Auslander Conjecture in dimensions  $< 7$  and discussed possible ways to construct a 7-dimensional counterexample using the exceptional group  $G_2$ .
- Ilesanmi Adeboye and Daryl Cooper completed a project which shows that the area of a properly convex real projective surface in its Hilbert metric is at least as large as the area of a homeomorphic hyperbolic surface. The key tool here is an estimate on the area of an ideal triangle in terms of its Fock-Goncharov parameter. This result is one of a family of intriguing recent results relating the geometry of projective surfaces and hyperbolic surfaces, including the collar lemma proved by Gye-Seon Lee and Tengren Zhang and the recent result by Nicolas Tholozan proving that the holonomy map of a strictly convex real projective surface is dominated by some Fuchsian representation.
- Daniele Alessandrini and Suhyoung Choi continued their investigation of the asymptotic properties of convex  $\mathbb{RP}^n$ -structures using trace functions associated to closed curves on surfaces.
- Daniele Alessandrini and Qiongling Li explored the relationship between Higgs bundles and geometric structures on 3-dimensional manifolds. They construct all closed Anti-de Sitter 3-manifolds using Higgs bundles and solutions of Hitchin's equations. They found a new method to compute the volume of those manifolds and prove volume rigidity.
- Sam Ballas, Jeff Danciger, and Gye-Seon Lee constructed many new convex  $\mathbb{RP}^3$ -structures on 3-manifolds with incompressible tori. Their examples arise by doubling finite volume hyperbolic 3-manifold and the proof involves a concrete study of the deformations of the holonomy of the hyperbolic 3-manifold within  $\mathrm{PSL}(4, \mathbb{R})$ .
- Martin Bridgeman and Dick Canary completed the proof of a simple length rigidity theorem for Kleinian surface groups. They use this result to characterize automorphism of quasifuchsian space which preserve the renormalized intersection number, which represents significant progress towards a classification of the isometries of the pressure metric on quasifuchsian space.
- Martin Bridgeman, Dick Canary, François Labourie and Andres Sambarino initiated a project to construct and investigate pressure metrics on the Hitchin component associated to simple roots. This project is motivated by work of Rafael Potrie and Andres Sambarino where they showed that the entropy associated to a simple root is constant.

- Jeff Brock, Ken Bromberg, Dick Canary and Yair Minsky finished proving a generalization of Thurston's bounded image theorem, providing information on the skinning map for freely indecomposable Kleinian groups. This result has potential applications to the topology of deformation spaces of Kleinian groups and to the construction of uniform bilipschitz models for hyperbolic 3-manifolds.
- Motivated in part by Tengren Zhang and Gye-Seon Lee's collar lemma for Hitchin representations, Marc Burger and Maria Beatrice Pozzetti proved a collar lemma for maximal representations. This collar lemma plays a key role in the study of limits of maximal representations.
- Virginie Charette and Bill Goldman completed their paper on McShane-type identities for affine deformations. Maryam Mirzakhani provided some key insights and is joining their collaboration.
- Suhyoung Choi and Bill Goldman substantially revised their paper establishing topological tameness of Margulis spacetimes without parabolics. They began working with Todd Drumm to extend this to the case with parabolics.
- Jeff Danciger, Fanny Kassel and François Guéritaud constructed new examples of proper affine actions of surface groups on  $\mathbb{R}^n$  arising from deformations of right angled Coxeter groups in  $O(p, q)$ . This on the one hand gives probably the first examples of proper affine actions of the fundamental group of a closed surface, and on the other hand suggests a more general approach of constructing geometrically interesting subgroups in higher rank Lie groups.
- David Dumas and Andy Sanders explored the complex manifolds obtained by deforming Hitchin representations in  $SL(n, \mathbb{C})$ . These new Anosov representations give new examples of compact complex (non-Kähler) manifolds with neither nonconstant holomorphic functions nor holomorphic differentials. These manifolds (which are deformations of examples due to Guichard-Wienhard) enjoy geometric structures modeled on parabolic homogeneous spaces, and are strikingly more bizarre than the ones arising from the classical Bers simultaneous uniformization theorem,
- François Guéritaud, Olivier Guichard, Fanny Kassel and Anna Wienhard completed a project on compactifications of quotient spaces associated to Anosov representations. In many cases, they obtain manifold compactifications which establish topological tameness of the quotient spaces. These questions were a major source of discussion during the semester, with various approaches.
- Jeremy Kahn, François Labourie and Shahar Mozes discussed the possibility of the existence of surface subgroups in higher rank lattices, making some

crucial progress concerning some part of the project. A result of this form would be an intriguing generalization of the surface subgroup conjecture for hyperbolic 3-manifolds recently established by Jeremy Kahn and Vlad Markovic.

- Misha Kapovich and Bernhard Leeb constructed compactifications of quotient manifolds associated to uniformly regular conical groups, which in particular include Anosov representations with respect to the minimal parabolic subgroup. Their approach is based on studying the horofunction compactification of a Finsler metric on the symmetric space, which realizes the maximal Satake compactification.
- Youngju Kim and Ser Peow Tan started an investigation into groups of isometries of hyperbolic 4-space generated by reflections in three hyperbolic planes.
- Francois Labourie and Richard Wentworth completed a paper in which they derive a formula for the pressure metric at points in the Fuchsian locus of a Hitchin component in terms of Hitchin’s parameterization of the Hitchin component by holomorphic differentials. Their variational formulas are analogues of classical results for Teichmüller space.
- Andres Larrain-Hubach and Richard Wentworth began a project to understand the moduli space of solutions to Bogomolny equations on a 3-manifold  $\Sigma \times \mathbb{R}$  where  $\Sigma$  is a closed Riemann surface, with certain asymptotic conditions at the ends.
- Sara Maloni and Frederic Palesi worked on the dynamics of the action of the mapping class group on the character variety of the twice-punctured projective plane. This nicely complemented the work of Bill Goldman, Greg McShane, George Stantchev and Ser Peow Tan, which was also in progress during the MSRI semester.
- Katie Mann and Maxime Wolff initiated a collaboration to study a conjecture concerning the rigidity of surface group actions on the circle. They made substantial progress, proving many cases of the conjecture.
- Adam Sikora proved that trace functions do not suffice to parametrize the “character variety” for  $\mathrm{SO}(2n, \mathbb{C})$ -representations. Unlike most known cases, this “character variety” is not really the “variety of characters” in this case.
- Mike Wolf and Richard Wentworth proved that for every nonelementary representation of a surface group into  $\mathrm{SL}(2, \mathbb{C})$  there is a Riemann surface structure such that the Higgs bundle associated to the representation lies outside the discriminant locus of the Hitchin fibration.

## 3. OUR POSTDOCS

**Caleb Ashley** received his Ph. D. in 2013 from Howard University. Before coming to MSRI, he was a postdoc at the University of Maryland. His mentors at MSRI were Virginie Charette, Bill Goldman, and Ilesamni Adeboye. He studies discreteness algorithms for 3-generator subgroups of  $SL(2, \mathbb{R})$ .

**Shinpei Baba** received his Ph.D. in 2009 from University of California, Davis. He was at University Heidelberg as a postdoc before MSRI and will return there after MSRI. His mentor at MSRI was David Dumas. He studies complex projective structures and Teichmüller geometry,

**Jeffrey Danciger** received his Ph.D. in 2010 from Stanford University. Before coming to MSRI, he was a postdoc at the University of Texas. He currently holds an assistant professorship at the University of Texas. His mentor at MSRI was François Labourie. He studies Lorentzian geometric structures and transitions of geometric structures.

**Guillaume Dreyer** received his Ph.D. in 2012 from University of Southern California. Before coming to MSRI, he was a postdoc at University of Notre Dame. His mentor at MSRI was Bill Goldman. He studies higher Teichmüller theory.

**Andres Larrain-Hubach** received his Ph.D. in 2012 from Boston University. Before coming to MSRI, he was a postdoc at University of Arizona, and will return there next year. His mentor at MSRI was Richard Wentworth. He studies K-theory and spectral theory of Riemannian manifolds.

**Qiongling Li** graduated from Rice University in 2014 and will assume a joint postdoctoral position at QGM(Aarhus) and Cal Tech after MSRI. Her mentor at MSRI was Dick Canary. She studies Higgs bundles and Anosov representations of surface groups.

**Sara Maloni** received her Ph. D. at Warwick University in 2013. She was a postdoc at Brown University before MSRI and will return there after MSRI. Her mentor at MSRI was Howard Masur. She studies Kleinian groups, dynamics on character varieties and anti-deSitter manifolds.

**Kathryn Mann** received her Ph.D. from University of Chicago in 2014. She was a postdoc at University of California, Berkeley before MSRI and will return there as a postdoc after the program. Her mentor at MSRI was Francis Bonahon. She studies group actions on manifolds.

**Maria Beatrice Pozzetti** received her Ph.D at ETH, Zurich in 2014. She is assuming a postdoctoral position at Warwick University after MSRI. Her mentor at



MSRI was Ursula Hamenstädt. She studies maximal representations and bounded cohomology.

**Andrew Sanders** received his Ph.D at University of Maryland in 2013. Since then he has been at a postdoc at the University of Illinois at Chicago, and will return there next year. His mentor at MSRI was Steve Kerckhoff. He studies harmonic maps, minimal surfaces and Higgs bundles and their applications to higher Teichmüller theory and hyperbolic 3-manifolds.

**3.1. Comments.** The MSRI program was tremendously beneficial for the post-docs. Several commented on the quality of the mentoring program. Here are a few excerpts:

**Shinpei Baba:** “My experience at MSRI was beneficial both to complete my on-going work and initiate new projects. It was unique experience to have so many experts in the area and spend time together. In particular the projects that I worked at MSRI includes the following:

- (1) I worked on writing a draft “Degeneration of  $\mathbb{C}P^1$ -structures by neck pinching” and I gave a talk on it in the postdoc seminar. Discussion with and feedback from people at MSRI were beneficial and also helped to me formulate the proof.
- (2) I worked on my project with Subhojoy Gupta on asymptotic Teichmüller rays. I gave a talk on this Geometry and Analysis of Surface group seminar at MSRI. As result of working at MSRI, I think that we are ready to start writing a paper in order to publish.
- (3) I and Subhojoy Gupta completed the final version of ‘Holonomy map fibers of  $\mathbb{C}P^1$ -structures moduli space,’ being published in *Journal of Topology*.”

**Andres Larrain-Hubach:** “ It was the best professional experience of my life. I learned like never before. I hope to be able to attend the main conferences of the program in spring 2016.”

**Qiongling Li:** “Yes, my experience at MSRI is [sic] very beneficial. I got the chance to talk to many people and learn a lot. I got to know more fields other than my phd work area. For example, the above work (2) and (3) are very different areas from what I’ve done in my phd. Also, I began to think about more problems in different subjects and I found them very interesting. This experience in MSRI is a very helpful process between my phd and new postdoc position”

**Sara Maloni:** “My experience as a Huneke Postdoctoral Fellow at the MSRI has been wonderful, and very fruitful. I have been able to participate in most of the activities, to organize a reading seminar (which I think was of interest to a large

group of other members), and above all it was great to be surrounded by colleagues and experts in the field which made my stay very productive.”

**Kathryn Mann:** (in response to “*Was your experience at MSRI beneficial? Why or why not?*”) “Yes! Here are just a few of the many reasons:

- I met many senior researchers in my field and related fields, and established relationships with them.
- Speaking at the workshops let me advertise my own work to others
- I gained a broad perspective on a large family of related problems and techniques
- I started a new collaboration which has already produced results (though not written down formally yet); I think it will be a productive, long-term working relationship
- I have collected many questions and new problems that I plan to work on over the next year
- The feedback and career advice from my mentor was immensely helpful.”

**Maria Beatrice Pozzetti:** “I have spent most of the time at MSRI working with Marc Burger on maximal representations. We studied geometric properties of the associated locally symmetric manifolds and degenerations of those. Apart from that I profited a lot from the abundance of interesting talks of both programs, and from the relaxed interaction with many people at the institute. I hope that in the future some of the discussions we had here will turn in new joint works. I also profited a lot from the mentoring program, it gave me the opportunity to interact a lot with Prof. Hamenstädt, discuss ideas with her and get useful feedback about many different issues related both to research and career-planning. All in all the experience at MSRI has been very beneficial.”

#### 4. WORKSHOPS

The program included three major workshops. The first was a *Connections for Women Workshop* organized by Virginie Charette, Fanny Kassel, Karin Melnick and Anna Wienhard. It was immediately followed by an *Introductory Workshop*, organized by Dick Canary, Bill Goldman, Ursula Hamenstädt, and Alessandra Iozzi. Near the end of the program was the *Research Workshop*, organized by Marc Burger, David Dumas, Olivier Guichard, François Labourie, and Anna Wienhard.

**Connections for Women.** This two-day workshop featured one-hour talks by outstanding women in the field:

- Alessandra Iozzi (Zurich);
- Kathryn Mann (UC Berkeley);

- Youngju Kim (Korea Institute for Advanced Study);
- Maria Beatrice Pozzetti (Warwick);
- Jing Tao (Oklahoma);
- Sara Maloni (Brown);
- Qionglin Li (Rice);
- Evelyn Lamb (Utah).

**Introductory Workshop.** This four-day workshop featured five series of lectures, each of which consisted of 3 one-hour talks. These introductory talks were given by leading experts in the subject of the program:

- Yves Benoist (University Paris XI), *Conformal dynamics*;
- Marc Burger (ETH Zürich), *Introduction to the study of Riemannian symmetric spaces*;
- Yair Minsky (Yale), *Dynamics on character varieties*;
- Anna Wienhard (Heidelberg), *Anosov representations*;
- Alex Wright (Stanford),  *$GL(2, R)$  action on moduli spaces of translation surfaces*.

**Research Workshop.** This five-day workshop featured one-hour lectures on a broad range of topics, given by prominent researchers in the areas of the program:

- Ian Agol (Berkeley)
- Daniele Alessandrini (Heidelberg)
- Francis Bonahon (University of Southern California)
- Dick Canary (Michigan)
- Bertrand Deroin (École Normale Supérieure, Paris)
- Ursula Hamenstädt (Bonn)
- Fanny Kassel (Lille)
- Qionglin Li (Rice)
- Kathryn Mann (Berkeley)
- Maryam Mirzakhani (Stanford)
- Pranav Pandit (Vienna)
- Anne Parreau (Grenoble)
- Maria Beatrice Pozzetti (Warwick)
- Alireza Salehi Golsefidy (University of California, San Diego)
- Andrés Sambarino (Universités de Paris VI et VII)
- Tengren Zhang (Michigan)
- Christian Zickert (Maryland)

## 5. SEMINARS

In addition to the three workshops, seminars met frequently during the semester. Three working seminars were organized by MSRI postdocs. Weekly seminars on *Lorentzian geometric structures* and *Geometry and analysis of surface group representations* continued during the entire semester. The third was an 18-hour mini-course by Bernhard Leeb and Michael Kapovich explaining their work with Joan Porti on *Geometric finiteness in higher rank symmetric spaces*.

The postdocs organized a weekly *Postdoc Seminar* which ran during the entire semester. Graduate students were strongly encouraged to attend. In addition, the *Research Seminar* met weekly. Each seminar typically consisted of two one-hour talks: the first hour was introductory, preparing the audience for the more specialized sequel.

## 6. INTERACTION WITH THE OTHER PROGRAM

The program substantially interacted with the companion program *Geometry and Arithmetic Aspects of Homogeneous Dynamics*. Areas of substantial overlap included Teichmüller dynamics and dynamics on Lie groups.

We give two examples of research collaborations involving members of both programs. First, Maryam Mirzakhani began a new project with Alex Wright, a postdoc from the companion program. Previously, together with Alex Eskin and Amir Mohammadi, members from the companion program, she had shown that all  $SL(2, \mathbb{R})$  orbit closures in moduli spaces of translation surfaces are affine submanifolds. In the project with Wright she investigated the boundary of these affine invariant manifolds in the Deligne Mumford compactification. A preprint of her paper with Wright has appeared. She also continued her collaboration with Eskin in studying the  $SL(2, \mathbb{R})$  action.

Secondly, Howard Masur finished a project with Eskin and Kasra Rafi, a visitor funded by GEAR, where they showed that Teichmüller space with the Teichmüller metric is quasi-isometrically rigid; further evidence for the analogy with symmetric spaces. He also began a new collaboration on the Siegel-Veech constants of translation surfaces with Jayadev Athreya and Yitwah Cheung, two research members from the companion program. The goal of this project is to obtain rates of convergence for various counting problems on translation surfaces.

Yves Benoist and Maryam Mirzakhani participated in both groups and spoke in activities of each. Marc Burger spoke in the *Homogeneous Dynamics Research Workshop* while Alireza Golesefidy (one of the organizers of the other program) spoke

in our Research Workshop. Alex Wright presented a minicourse in our Introductory Workshop.

## 7. INTERACTION WITH THE UC MATHEMATICS DEPARTMENT

The semester saw strong interaction between the Institute and the Department of Mathematics at the University of California Berkeley.

Several of our members gave colloquia or seminars at Evans Hall. Bill Goldman and Maryam Mirzakhani spoke in MSRI/Evans Lecture series to introduce department members (and particularly graduate students) to the activities in the program.

David Dumas and Yves Benoist spoke in the Department Colloquium. Michael Kapovich, François Labourie and Michael Wolf spoke in the Differential Geometry Seminar. Erica Flapan, Matthew Stover and Indira Chatterji spoke in the Topology Seminar. Ursula Hamenstädt spoke in the Analysis seminar. Ian Agol's *3-manifold topology seminar* at Evans Hall drew many MSRI participants.

At the end of the semester, the Berkeley department hosted the conference *Groups, geometry and 3-manifolds*, celebrating the sixtieth birthday of Daryl Cooper. One reason it was held in Berkeley was that so many people in the field were in residence at MSRI. Four of the ten invited speakers were members of our program.

Numerous mathematicians from UC attended our seminars and social events.

## 8. DIVERSITY

The organizers successfully recruited participants from under-represented groups. Four of the seven MSRI-supported postdocs are women: Qionglin Li, Sara Maloni, Kathryn Mann, and Maria Beatrice Pozzetti. Postdocs Caleb Ashley and Andres Lorrain-Hubach are African-American and Hispanic, respectively. Research Associate Claire Burrin is female. Senior participants Virginie Charette, Indira Chatterji, Erica Flapan, Ursula Hamenstädt, Dominique Hulin, Fanny Kassel, Evelyn Lamb, Alessandra Iozzi, Youngju Kim, Karin Melnick, Maryam Mirzakhani, Anne Parreau, Jing Tao and Anna Wienhard are women. Research member Ilesanmi Adeboye is African-American.

Seven of the seventeen speakers in the Research Workshop are female.

## 9. GRADUATE STUDENTS

Several graduate students attended the MSRI activity as *Research Associates*. Several received financial support through the NSF-funded GEAR Research Network.

**Jean-Philippe Burelle:** According to his thesis adviser, Bill Goldman: “Jean-Philippe’s experience at MSRI was valuable. He attended every workshop and many weekly seminars. He gained exposure to many new ideas and met many of the leading researchers in the subject. Although he already knew many of the members, he had the opportunity to get to know them better. His contacts with his officemates Nicolas Treib and Sourav Ghosh were especially fruitful, since their research interests complemented his. He made significant progress on his research with several collaborators, including myself, Virginie Charette, Todd Drumm, Caleb Ashley and Sean Lawton. It was a fantastic experience for him.”

**Claire Burrin:** According to her thesis adviser, Alessandra Iozzi: “Claire was in the rather fortunate position of working on problems that are at the crossroad of the two programs: she could draw inspiration for new questions from one and for new approaches from the other. She came in contact with an enormous amount of new mathematics through seminars and informal discussions mostly with postdocs and fellow graduate students, but also senior researchers. In addition she continued to meet with her advisor Alessandra Iozzi. While at MSRI she completed the main part of her thesis and found inspiration for new questions to tackle.”

**Sourav Ghosh:** According to his thesis adviser François Labourie: “Sourav Ghosh completed the writing up of his Ph.D. while being in MSRI for the first three months of the semester. He will next year be a postdoc in Heidelberg starting fall 2015 and his stay in MSRI also helped him connect with potential future post-doctoral advisors. Sourav participated actively (giving two talks) in the Lorentzian geometry seminar. He discussed mathematics with many young post-docs and senior researchers as well. This was a great experience for him, giving him the opportunity for the first time to give talks to a specialized and attentive audience.

**Robert Maschal:** According to his thesis adviser, Richard Wentworth: “Robert benefited mostly from meeting other graduate students and postdocs with similar interests but different expertise. This allowed him to expand his knowledge of the field and situate the context of his own research. With the other he also was exposed to the frontiers of research through the seminars and workshops. Finally, the opportunity also gave us the chance to continue our weekly meetings and make progress on Robert’s thesis problem.”

**David Renardy:** According to his thesis adviser Dick Canary, “David Renardy was a Program Associate for the first two months of the program. He made significant progress on his thesis project on deformation spaces of Kleinian groups while at MSRI. He also benefitted tremendously from the exposure to the wider research circle of Higher Teichmüller Theory.”

**Nicolas Treib:** According to his thesis adviser, Anna Wienhard: “Nicolas Treib benefitted a lot from the program and the environment at MSRI. He was especially involved in discussions with the program associates Jean-Philippe Burelle and Sourav Ghosh. He also took advantage to discuss with Fanny Kassel and Jeff Danziger and participated in the Lorentzian geometry seminar. He also benefitted from the exposure to a variety of topics in the companion program.”

**Tengren Zhang:** According to his thesis advisor Dick Canary: “Tengren Zhang completed his Ph.D. while at MSRI this semester and will begin a position as a Tausky-Todd Instructor at CalTech in Fall 2015. Tengren took full advantages of the many opportunities offered by MSRI. He initiated projects with Qiongling Li and with Gye-Seon Lee and also talked regularly with senior experts in the field, including Francois Labourie and Francis Bonahon. He spoke at the research conference in April and in the seminar on Geometry of Group Representations.”

## 10. SOCIAL LIFE

A lively social interaction integrated the young postdocs into the community, and broke the glass between young and senior researchers. The semester was indeed lively. This of course happened in the lunch room and frequently at the Jupiter, but it went beyond that. Each of the three US organizers threw large and well attended social events. These parties helped create a sense of community. Postdocs and senior members hiked at Tilden Park, Mount Tamalpais, Mount Diablo and Point Reyes. Even a few birthday parties (including those of toddlers) were celebrated.

## 11. NUGGETS

Here is an anecdote that celebrates the professionalism (and nerdiness) of our members. Francis Bonahon, most notably known (outside his mathematics) for his fierce southwestern French accent, was fearing a voice extinction during his talk. He prepared his talk using a synthetic voice on his computer and that was a lot of work. He finally went through his beautiful lecture without trouble, but could not resist showing off his geeky preparation. He launched the program, that started using the voice of a news anchor: “this is the first and last time that you will hear me speak with an American accent.”

Three of our participants worked with Brady Haran to create videos which were posted to his Numberphile channel on YouTube. Caleb Ashley’s video was entitled *Ditching the fifth axiom* with a sequel entitled *Fifth axiom* (extra footage). Francis Bonahon’s video was entitled *Funny fractions and Ford circles*. Dick Canary’s

video was entitled *Playing sports in hyperbolic space*, followed up by *More hyperbolic sports*, and *Hyperbolic sports* (extra footage). All together these videos have received over 700,000 views on YouTube.

## 12. RELATION WITH THE GEAR NETWORK

The mathematical activities were enhanced by the NSF-funded program *Research Networks in the Mathematical Sciences*. The *GEometric structures And Representation* Network enabled many more mathematicians to participate in the MSRI activity. In addition to funding graduate students, several mathematicians could participate in the program who were ineligible for support from MSRI. In particular more international participants could attend the workshops than usual, and short-term visitors (that is, visitors staying less than a month) could meet their collaborators who were long-term visitors to MSRI.

Several of these visitors spoke in the seminars, and all contributed to the intellectual and social community. The list includes such mathematicians as Jørgen Ellegaard Andersen, Sam Ballas, Steven Bradlow, Todd Drumm, François Guéritaud, Jeremy Kahn, Matthew Stover, Maxime Wolff and Scott Wolpert.



## DYNAMICS ON MODULI SPACES OF GEOMETRIC STRUCTURES



**Ashley, Caleb**

Name: Caleb Ashley

Year of Ph.D: 2013

Institution of Ph.D.: Howard University

Dissertation title: Towards A Discreteness Algorithm For Non-Elementary Rank 3 Subgroups Of  $PSL(2;R)$

Ph.D. advisor: Todd A. Drumm

Institution prior to obtaining the MSRI PD fellowship: Howard

Position at that institution: Math Instructor

Institution (or company) where you are going after the MSRI PD fellowship: Howard University

Position: Faculty

Postdoctoral fellow's comments:

None



**Baba, Shinpei**

Name: Shinpei Baba

Year of Ph.D: 2009

Institution of Ph.D.: University of California, Davis

Dissertation title: Decomposition theorems for complex projective structures

Ph.D. advisor: Michael Kapovich

Mentor while at MSRI: David Dumas

Institution prior to obtaining the MSRI PD fellowship: Universität Heidelberg

Position at that institution: Postdoctoral Researcher

Mentor (if applicable): Anna Wienhhard

Institution (or company) where you are going after the MSRI PD fellowship: Universität Heidelberg

Position: Postdoctoral Researcher

Anticipated length: 1 year and 3 months

Mentor (if applicable): Anna Wienhard

Postdoctoral fellow's comments:

My experience at MSRI was beneficial both to complete my on-going work and initiate new projects. It was unique experience to have so many experts in the area and spend time together. In particular the projects that I worked at MSRI includes the following:

1. I worked on writing a draft "degeneration of  $CP^1$ -structures by neck pinching" and I gave a talk on it in the postdoc seminar. Discussion with and feed back from people at MSRI were beneficial and also helped to me formulate the proof.
2. I worked on my project with Subhojy Gupta on asymptotic Teichmüller rays. I gave a talk on this Geometry and Analysis of Surface group seminar at MSRI. As result of working at MSRI, I think that we are ready to start writing a paper in order to publish.
3. I and Subhjoy Gupta completed the finial version of "Holonomy map fibers of  $CP^1$ -structures in moduli space" being published in Journal of Topology.



**Dreyer, Guillaume**

Name: Guillaume, Dreyer

Year of Ph.D: 2012

Institution of Ph.D.: University of Southern California

Dissertation title: Geometric properties of Anosov representations

Ph.D. advisor: Francis Bonahon

Mentor while at MSRI:

Institution prior to obtaining the MSRI PD fellowship: University of Norte Dame

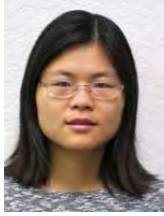
Position at that institution: Visiting Assitant Professor

Institution (or company) where you are going after the MSRI PD fellowship: University of Southern California

Position: Lecturer

Postdoctoral fellow's comments:

None



**Li, Qionglng**

Name: Qionglng Li  
Year of Ph.D: Dec 2014  
Institution of Ph.D.: Rice University  
Dissertation title: Hitchin components, Riemannian metrics and Asymptotics  
Ph.D. advisor: Mike Wolf  
Mentor while at MSRI: Richard Canary

Institution prior to obtaining the MSRI PD fellowship: Rice University  
Position at that institution: Graduate student  
Mentor (if applicable): Mike Wolf

Institution (or company) where you are going after the MSRI PD fellowship: QGM(Aarhus)  
Position: Joint Caltech-QGM postdoc position  
Anticipated length: 3 years  
Mentor (if applicable): Jorgen Anderson and Vladimir Markovic

Postdoctoral fellow's comments:

I mainly worked on three projects during my time at MSRI:

(1) (working with Brain Collier) continuing asymptotics of Higgs bundles in Hitchin components, we start to consider asymptotics of Higgs bundles for maximal representations. Moreover, we even generalize to consider asymptotics of quiver bundles; This work is partially finished and still working in progress.

(2) (working with Tengren Zhang) we consider the Anosov property of tensor products of Anosov representations. In particular, we find a rigidity of the Anosov property. This work is finished and is in preparation.

(3) (working with Daniele Alessandrini) we consider the relation between Higgs bundles and AdS geometry. In particular, we recover many results by the viewpoint of Higgs bundles, like, the AdS geometry, the property of circle fiber, and the volume. This work is finished and is in preparation.

Was your experience at MSRI beneficial? Why or why not?

Yes, my experience at MSRI is very beneficial. I got the chance to talk to many people and learn a lot. I got to know more fields other than my phd work area. For example, the above work (2) and (3) are very different areas from what I've done in my phd. Also, I began to think about more problems in different subjects and I found them very interesting. This experience in MSRI is a very helpful process between my phd and new postdoc position.



**Maloni, Sara**

Name: Sara Maloni

Year of Ph.D: 2013

Institution of Ph.D.: University of Warwick, UK

Dissertation title:

Ph.D. advisor: Caroline Series

Mentor while at MSRI: Howie Masur

Institution prior to obtaining the MSRI PD fellowship: Brown University

Position at that institution: Tamarkin Assistant Professor

Mentor (if applicable): Jeff Brock

Institution (or company) where you are going after the MSRI PD fellowship: Brown University

Anticipated length: 1 year

Mentor (if applicable): Jeff Brock

Postdoctoral fellow's comments:

See next page

## REPORT OF MY EXPERIENCE AT MSRI (SPRING 2015)

My experience as a Huneke Postdoctoral Fellow at the MSRI has been wonderful, and very fruitful. I have been able to participate in most of the activities, to organize a reading seminar (which I think was of interest to a large group of other members), and above all it was great to be surrounded by colleagues and experts in the field which made my stay very productive.

As a postdoc, I was assigned to a mentor, Howie Masur. Our frequent discussions spanned mathematical and professional development topics. I think this was a good tool to help me keep track of the improvements over time, and to overcome some fears mathematicians often have at an early stage of their career.

These are the activities in which I participated weekly:

- (1) Lorentzian seminar;
- (2) Research Seminar for the program “Dynamics on the moduli space of geometric structures”;
- (3) Analysis and Geometry Seminar;
- (4) Mini-course “Geometric finiteness in higher rank symmetric spaces” by Prof. Michael Kapovich and Prof. Bernhard Leeb;
- (5) Postdoc Seminar.

I tried not to attend too many seminars, so that I could dedicate enough time to research and discussions with colleagues. After discussing with my mentor, I tried to choose two or three events each week to attend, so that I could reserve some time to think about my research projects. Of course, many weeks I ended up attending more seminars, but, in general, I succeeded in my plan.

These are the seminars I gave:

- (1) Connection for women, January 16: ‘Introduction to quasi-Fuchsian groups’.
- (2) Postdoc Seminar, March 2: ‘Mapping class group actions on character varieties’.
- (3) Sponsor Day, March 6: ‘Polyhedra inscribed in quadrics and their geometries’.
- (4) Research Seminar, April 9: ‘Mapping class group actions on character varieties’.

People were interested in my work, and, thanks to the discussions, I certainly have now a much more deep understanding of my results, and of their relationship with similar other results in the field. In addition, when I was preparing the talk for the Sponsor Day, Prof. Francis Bonahon, who was also speaking, gave me lots of advices for giving a good ‘colloquium style’ talk.

I also organised a dinner at my house with the women at MSRI and the women grad students at Berkeley. I think it was a successful idea, so it might be worth thinking about some event of this kind in the future semesters as well.

These are the projects I discussed with people while I was a postdoc at MSRI:

- (1) *Exotic Delaunay triangulation*, joint with Jeff Danciger (also at MSRI) and Jean-Marc Schlenker: We develop an analog of the classical Delaunay decomposition with hyperbolas and parabolas, instead of spheres. We then characterize this exotic Delaunay triangulations as the ones satisfying some optimization results.
- (2) *On the character variety of the three holed projective plane*, joint with Frederic Palesi (also at MSRI): We study the (relative)  $SL(2, \mathbb{C})$ -character varieties of the three-holed projective plane and the action of the mapping class group on it. We describe a domain of discontinuity for this action, and we consider the relationship with the previous work of the authors and S. P. Tan on the character variety of the four-holed sphere.
- (3) *The  $SL(2)$ -geometry of the space of Lagrangians*, joint with Daniele Alessandrini and Anna Wienhard (both also at MSRI): We study Anosov representations in  $Sp(4, \mathbb{C})$  and their action on the Lagrangian space  $Lag(\mathbb{C}^4)$ . Using a nice geometrical interpretation of  $Lag(\mathbb{C}^4)$  as the space of regular ideal hyperbolic tetrahedra and their degenerations, we are able to define a natural projection of the domain of discontinuity in  $\mathbb{H}^2$  and study their fiber.
- (4) *Dynamics on  $PSL(2, \mathbb{C})$ -character varieties of manifolds with compressible boundary*, joint with Cyril Lecuire (also at MSRI) and Michelle Lee: We study the  $PSL(2, \mathbb{C})$ -character variety of a general hyperbolizable 3-manifold  $M$  with compressible boundary. In particular, we examine the dynamics of the action of the outer automorphism group, and, we find an open set, on which the action is properly discontinuous, that is strictly larger

than the interior of the deformation space of marked hyperbolic 3-manifolds homotopy equivalent to  $M$ .

- (5) *Interesting examples of primitive stable representations in higher rank groups*, joint with Fanny Kassel (also at MSRI) and Michelle Lee: Using the recent characterization of Anosov representation studied independently by Kapovich–Leeb–Porti and Kassel–Gueritaud–Guichard–Wienghard, there is a natural definition of primitive stable representations in higher rank Lie groups. Kim–Kim studied it in some cases. We want to have a deep understanding of these representations.

The first two papers are almost finished, while the third and the fourth need more work to be terminated. The last project needs a lot more of work, and we want to advance it by developing a more general theory about limits of Anosov representations. In addition to the first project, in joint work with Danciger and Schlenker, we plan to apply one of our earlier result to some conjectures for the universal Teichmüller space. I also interacted a lot with other members or visitors: Ian Agol, Marc Burger, Dick Canary, Bill Goldman, Steve Kerckhoff, Maryam Mirzakhani, Maxime Wolff, and many others.

In addition to these activities I found particularly useful the environment. For example, the schedule during the conference wasn't too busy, so there was lots of time to discuss with colleagues, which I think it is very important. In addition, just to underline the general nice atmosphere, I want to underline that we often organised hikes or gathering during the weekend, with junior and senior members. I found that quite emblematic as well.

Finally, I want to underline how efficient, friendly, and useful was all the staff at MSRI. A big part of this success is certainly due to their effort to make our semester going smoothly every day. Thanks a lot!





**Mann, Kathryn**

Name: Kathryn Mann  
Year of Ph.D: 2014  
Institution of Ph.D.: University of Chicago  
Dissertation title: Components of spaces of surface group representations  
Ph.D. advisor: Benson Farb  
Mentor while at MSRI: Francis Bonahon

Institution prior to obtaining the MSRI PD fellowship: UC Berkeley  
Position at that institution: Postdoc  
Mentor (if applicable): Ian Agol

Institution (or company) where you are going after the MSRI PD fellowship: UC Berkeley  
Position: Postdoc  
Anticipated length: 2 years  
Mentor (if applicable): Ian Agol

Postdoctoral fellow's comments:

- I have a new collaboration with Maxime Wolff, which is solving a conjecture of mine, and should (hopefully) become a major paper
- I have also been finishing a paper that I started before arriving at MSRI and I spoke about this work at the postdoc seminar.
- I was asked to write a survey paper based on one of my talks, this I have also started to work on
- I learned an immense amount of new material, thanks especially to our program seminar and the minicourse taught by Kapovich and Leeb.
- I was made aware of new techniques (markov maps and symbolic dynamics, work of Bowen) applicable to my research that might help solve a question I raised in my talk, I have just began working on learning this material.

Was your experience at MSRI beneficial? Why or why not?

Yes! Here are just a few of the many reasons:

- I met many senior researchers in my field and related fields, and established relationships with them.
- Speaking at the workshops let me advertise my own work to others
- I gained a broad perspective on a large family of related problems and techniques
- I started a new collaboration which has already produced results (though not written down formally yet); I think it will be a productive, long-term working relationship
- I have collected many questions and new problems that I plan to work on over the next year
- The feedback and career advice from my mentor was immensely helpful.



**Pozzetti, Maria  
Beatrice**

Name: Maria Beatrice Pozzetti  
Year of Ph.D: 2014  
Institution of Ph.D.: ETH Zurich  
Dissertation title: Boundary maps and maximal representations of complex hyperbolic lattices  
Ph.D. advisor: Alessandra Iozzi  
Mentor while at MSRI: Prof. Ursula Hamenstädt

Institution prior to obtaining the MSRI PD fellowship: ETH Zurich  
Position at that institution: PhD Student  
Mentor (if applicable): Prof. Alessandra Iozzi

Institution (or company) where you are going after the MSRI PD fellowship: Warwick University  
Position: Postdoctoral Position  
Anticipated length: 2 years  
Mentor (if applicable): Prof. Karen Vogtmann

Postdoctoral fellow's comments:

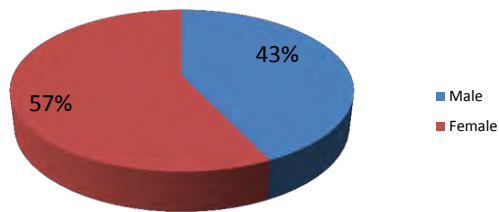
I have spent most of the time at MSRI working with Marc Burger on maximal representations. We studied geometric properties of the associated locally symmetric manifolds and degenerations of those. Apart from that I profited a lot from the abundance of interesting talks of both programs, and from the relaxed interaction with many people at the institute. I hope that in the future some of the discussions we had here will turn in new joint works. I also profited a lot from the mentoring program, it gave me the opportunity to interact a lot with Prof. Hamenstädt, discuss ideas with her and get useful feedback about many different issues related both to research and career-planning. All in all the experience at MSRI has been very beneficial.

## Postdoc Pre/Post-MSRI Institution Group

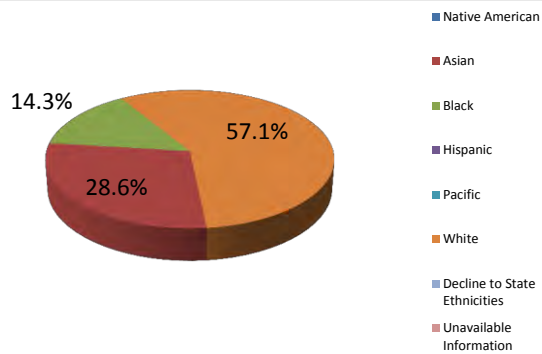
Family Name	First Name	Pre-MSRI Institution Group	Post-MSRI Institution Group	Pre-MSRI Institution Name	Placement Institution Name
Ashley	Caleb	Group III	Group III	Howard University	Howard University
Baba	Shinpei	Foreign	Foreign	Ruprecht-Karls-Universität Heidelberg	Universität Heidelberg
Dreyer	Guillaume	Group I Private	Industry	University of Notre Dame	n/a
Li	Qionglng	Group I Private	Group I Private	Rice University	Caltech
Maloni	Sara	Group I Private	Group I Private	Brown University	Brown University
Mann	Kathryn	Group I Public	Group I Public	University of California, Berkeley	University of California, Berkeley
Pozzetti	Maria Beatrice	Foreign	Foreign	University of Warwick	University of Warwick

2014–15 Postdoctoral Fellows Demographic Summary

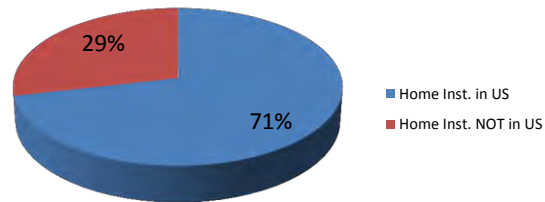
Gender	#	% (No Decl.)*	%
# of Distinct Postdocs	7		100.0%
Male	3	42.86%	42.9%
Female	4	57.14%	57.1%
Decline to State Gender	0		0.0%



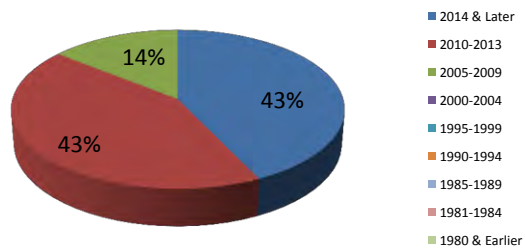
Ethnicities	#	% (No Decl.)*	%
Native American	0	0.00%	0.0%
Asian	2	28.57%	28.6%
Black	1	14.29%	14.3%
Hispanic	0	0.00%	0.0%
Pacific	0	0.00%	0.0%
White	4	57.14%	57.1%
Decline to State Ethnicities	0		0.0%
Unavailable Information	0		0.0%
Minorities	1		100.0%



Citizenships	#	%
US Citizen & Perm. Residents	3	42.9%
Foreign	4	57.1%
Unavailable information	0	0.0%
# of Distinct Postdocs	7	100.0%
US Citizen	1	14.3%
Perm Residents	2	28.6%
Home Inst. in US	5	71.43%



Year of Ph.D	#	%
2014 & Later	3	42.9%
2010-2013	3	42.9%
2005-2009	1	14.3%
2000-2004	0	0.0%
1995-1999	0	0.0%
1990-1994	0	0.0%
1985-1989	0	0.0%
1981-1984	0	0.0%
1980 & Earlier	0	0.0%
Unavailable Info.	0	0.0%
Total # of Distinct Postdocs	7	100.0%



\*Statistic Calculation based on all participants that did not decline.

## Dynamics on Moduli Spaces of Geometric Structures Program Summary

Role	# of Distinct Members	%	# of Citizens & Perm. Res.	%	US Citizens	# of Female	%	# of Minorities <sup>1</sup>	%
Organizers	5	8.5%	4	80.0%	3	1	20.0%	0	0.0%
Research Professors	12	20.3%	7	58.3%	5	3	25.0%	0	0.0%
Postdoctoral Fellows MSRI	7	11.9%	3	42.9%	1	4	57.1%	1	100.0%
Postdoctoral Fellows NSF	3	5.1%	3	100.0%	3	0	0.0%	1	33.3%
Research Members	24	40.7%	10	41.7%	10	3	12.5%	1	10.0%
Program Associates	7	11.9%	2	28.6%	2	1	14.3%	0	0.0%
Postdoctoral Research Members	1	1.7%	1	100.0%	1	0	0.0%	0	0.0%
<b>Total # of Distinct Members</b>	<b>59</b>		<b>30</b>	<b>50.8%</b>	<b>25</b>	<b>12</b>	<b>20.3%</b>	<b>3</b>	<b>12.0%</b>

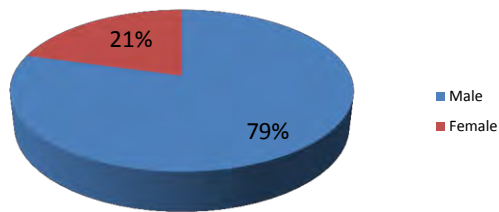
<sup>1</sup> Minorities are US citizen who declare themselves American Indian, Black, Hispanic, or Pacific Islander. Minority percentage is calculated by dividing the number of Minorities by the total number of US citizens.

### Home Institute Grouping

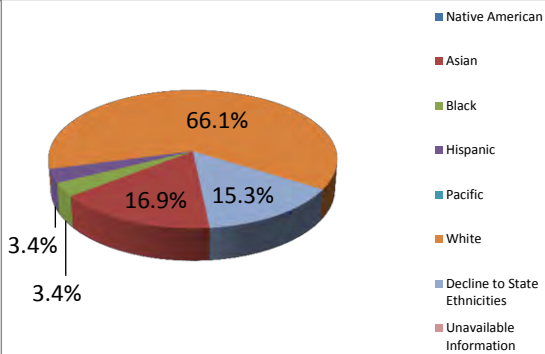
Role	US							Foreign	Total
	Group I Private	Group I Public	Group II	Group III	Group M	Group B	Group IV		
Organizers	1	2	0	0	0	0	0	2	5
Research Professors	2	2	1	0	0	0	1	6	12
Postdoctoral Fellows MSRI	3	1	0	1	0	0	0	2	7
Postdoctoral Fellows NSF	0	1	1	0	0	0	1	0	3
Research Members	4	3	2	0	2	0	0	13	24
Program Associates	0	4	0	0	0	0	0	3	7
Postdoctoral Research Members	0	1	0	0	0	0	0	0	1
<b>Total</b>	<b>10</b>	<b>14</b>	<b>4</b>	<b>1</b>	<b>2</b>	<b>-</b>	<b>2</b>	<b>26</b>	<b>59</b>
<b>%</b>	<b>16.9%</b>	<b>23.7%</b>	<b>6.8%</b>	<b>1.7%</b>	<b>3.4%</b>	<b>0.0%</b>	<b>3.4%</b>	<b>44.1%</b>	

2014-15 Program Members Demographic Summary

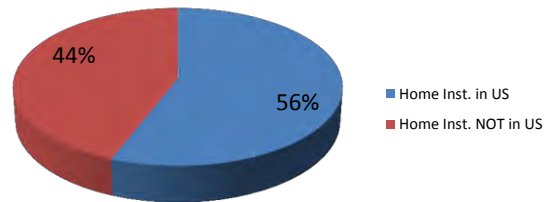
Gender	#	% (No Decl.)*	%
# of Distinct Members	59		100.0%
Male	46	79.31%	78.0%
Female	12	20.69%	20.3%
Decline to State Gender	1		1.7%



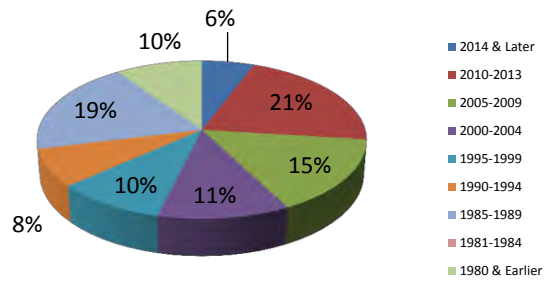
Ethnicities	#	% (No Decl.)*	%
Native American	0	0.00%	0.0%
Asian	10	18.87%	16.9%
Black	2	3.77%	3.4%
Hispanic	2	3.77%	3.4%
Pacific	0	0.00%	0.0%
White	39	73.58%	66.1%
Decline to State Ethnicities	9		15.3%
Unavailable Information	0		0.0%
Minorities	3		12.0%



Citizenships	#	%
US Citizen & Perm. Residents	30	50.8%
Foreign	29	49.2%
Unavailable information	0	0.0%
# of Distinct Members	59	100.0%
US Citizen	25	42.4%
Perm Residents	5	8.5%
Home Inst. in US	33	55.93%



Year of Ph.D	#	%
Program Associates (GS)	7	11.9%
2014 & Later	3	5.1%
2010-2013	11	18.6%
2005-2009	8	13.6%
2000-2004	6	10.2%
1995-1999	5	8.5%
1990-1994	4	6.8%
1985-1989	10	16.9%
1981-1984	0	0.0%
1980 & Earlier	5	8.5%
Unavailable Info.	0	0.0%
Total # of Distinct Members	59	100.0%



\*Statistic Calculation based on all participants that did not decline.

**Geometric and Arithmetic Aspects of  
Homogeneous Dynamics**  
January 19, 2015 to May 29, 2015  
MSRI, Berkeley, CA  
USA

**Organizers:**

LEAD Dmitry Kleinbock (Brandeis University)

Elon Lindenstrauss (Hebrew University)

Hee Oh (Yale University)

Jean-François Quint (Université de Bordeaux I)

Alireza Salehi Golsefidy (University of California, San Diego)

# REPORT ON THE MSRI PROGRAM: GEOMETRIC AND ARITHMETIC ASPECTS OF HOMOGENEOUS DYNAMICS

SPRING 2015

DMITRY KLEINBOCK, ELON LINDENSTRAUSS, HEE OH,  
JEAN-FRANÇOIS QUINT AND ALIREZA SALEHI GOLSEFIDY

## 1. INTRODUCTION

Homogeneous dynamics is the study of actions of subgroups  $H$  of locally compact groups  $G$  on locally compact spaces  $X$  on which  $G$  (but typically not  $H$ ) acts transitively, the most interesting cases being when  $G$  is either a Lie group or a product of algebraic groups over local fields. This includes many classical examples of dynamical systems, such as actions on tori by integer matrices, geodesic flows on manifolds with constant negative curvature etc. This topic is related to many branches of mathematics, in particular, number theory and geometry. Among the most active directions in this field are: measure rigidity of multidimensional diagonal groups; effectivization; sparse equidistribution and sieving; random walks, stationary measures and stiff actions; ergodic theory of thin groups and dynamics on infinite volume quotients.

The semester-long research program in Geometric and Arithmetic Aspects of Homogeneous Dynamics (GAAHD) was held at MSRI during the spring of 2015 (January 19 – May 31). The semester was proposed and organized by Dmitry Kleinbock (Brandeis University), Elon Lindenstrauss (Hebrew University), Hee Oh (Yale University), Jean-François Quint (Université Paris-Nord) and Alireza Salehi Golsefidy (University of California at San Diego). The program focused on several topics in dynamics on homogeneous spaces, including very rich interactions between homogeneous dynamics and other areas, in particular several branches of number theory, combinatorics, geometry, moduli spaces etc.

In the sections below we report on the MSRI postdoctoral fellows and program associates, the workshops and conferences held, other activities organized during the semester, and our interactions with the companion program on Dynamics on Moduli Spaces of Geometric Structures (DMSGs).



## 2. RESEARCH DEVELOPMENTS

The semester occurred at an exciting time for the field. For lack of space the description below is to be seen more as a sample of some of the developments than an exhaustive survey.

One particular area where there has been much progress recently is the study of thin groups, which e.g. can be defined as discrete subgroups  $\Lambda$  of a Lie group (or some other locally compact group) of infinite covolume. Such groups may occur in (at least) two different roles that are dual to each other: one can consider actions of a single  $\Lambda$  on a homogeneous quotient  $G/\Gamma$ , or one can consider the action of some group, perhaps a closed connected subgroup  $H < G$  on the infinite volume quotient space  $G/\Lambda$ .

Prior advances in the first direction were given by an important series of papers by Benoist and Quint and is closely connected to the work of Eskin and Mirzakhani on classification of invariant measures and invariant sets on moduli spaces of abelian and quadratic differentials (results that were mentioned in the citation to Mirzakhani's Fields medal). Because the dynamics on these moduli spaces form a bridge between homogeneous dynamics and the topic of the companion program on moduli spaces of geometric structures, these advances were part of the reasons these two programs meshed so well together.

Regarding the second direction: here again there were some pertinent recent advances, both using purely dynamical methods (e.g. Mohammadi and Oh's ergodicity theorem) and using the powerful tools of arithmetic combinatorics that relates these dynamical questions to spectral questions, in particular to important papers by Bourgain, Gamburd, Sarnak and others.

These directions are related – for instance, the quantitative stiffness result of Bourgain-Furman-Lindenstrauss-Mozes can be thought of as in either one.

During the semester (as well as immediately preceding it) there was much activity (and further advances) in these directions: several researchers (Weiss, Shi, Eskin-Lindenstrauss, . . . ) independently worked on extending the Benoist-Quint results, for instance to groups  $\Lambda$  whose Zariski closure is not semisimple; Mirzakhani and Wright gave several lectures explaining the rather remarkable consequences of the Eskin-Mirzakhani classification results. Incidentally, the scope of these ideas is not limited to homogeneous dynamics and the “homogeneous-flavored” dynamics of moduli spaces: in the May workshop, Rodrigues Hertz presented work with Brown showing how these ideas can be applied even for fairly arbitrary collections of diffeomorphisms.

In the other direction we mention the results of Oh and Winter giving a new *uniform* resonance free strip for congruence towers of quotients by thin groups, and the work of Mohammadi-Oh-McMullen on orbit closures of one-parameter unipotent flows on certain geometrically finite infinite volume quotients of

$SL(2, \mathbb{C})$ . In closely connected vein, Salehi Golsefidy presented new results on expander graphs on quotients of perfect groups modulo powers of primes.

Other areas where there has been exciting progress includes the area of Diophantine approximation. In particular new emphasis in recent months has been on the subject of intrinsic Diophantine approximations: approximating points on subvarieties by rational points *on the same subvariety* – including recent works of Gorodnik-Gosh-Nevo and Kleinbock-Merrill. The program gave a wonderful opportunity to compare different approaches to the study of singular vectors and matrices, where the geometry of numbers approach of Cheung developed further with other collaborators could be contrasted with the approach of Kadyrov-Kleinbock-Lindenstrauss-Margulis based on estimating certain integrals and using systems of inequalities. Quantitative density and equidistribution results have also been an important theme, and in particular a fairly general quantitative density theorem for unipotent orbits on arithmetic quotients was announced by Lindenstrauss-Margulis-Mohammadi-Shah for the first time in the May conference.

Motivated by the connections to homogenous dynamics, during the program there has been advances in the study of quantum ergodicity, particularly on graphs.

### 3. WORKSHOPS

The GAAHD program included three major workshops. The first was a “Connections for Women Workshop” run by Elon Lindenstrauss and Hee Oh (January 29–30, 2015). This workshop was immediately followed by an “Introductory Workshop” (February 2–6) organized by Manfred Einsiedler, Jean-François Quint and Barbara Schapira. The program culminated on May 11–15 with the final workshop “Advances in homogeneous dynamics”, which focused on more recent advances in the field and was organized by Dmitry Kleinbock, Hee Oh, Alireza Salehi Golsefidy and Ralf Spatzier.

**3.1. Connections for Women workshop.** The two-day event aimed to connect female graduate students and beginning researchers with established female researchers who work in the broad area of homogeneous dynamics and can serve as professional contacts and potential role-models. The workshop consisted of several mini-courses by established female mathematicians:

- Svetlana Katok (Penn State University)
- Tamar Ziegler (Hebrew University),
- Ursula Hamenstadt (Bonn University)
- Barbara Schapira (Universit de Picardie).

These lectures were interspersed with networking and social events over the course of the two days such as a panel discussion and a workshop dinner. Participants were encouraged to stay for the Introductory Workshop the following week. The mini-courses were intended for graduate students, postdocs, and researchers in areas related to the program. This workshop was open to all mathematicians.

**3.2. Introductory workshop.** This five-day workshop consisted of several introductory lectures on the recent trends in the field, given by experts. The lecture series were presented by:

- Yves Benoist (Université de Paris XI): 2 talks
- Jens Marklof (University of Bristol): 3 talks and one informal talk afterwards
- Amir Mohammadi (University of Texas): 2 talks
- Dave Morris (University of Lethbridge): 3 talks
- Hee Oh (Yale University): 2 talks
- Akshay Venkatesh (Stanford University): 2 talks

In addition, there were several one-hour talks describing main themes in homogeneous dynamics not covered by the lectures: Francesco Cellarosi (University of Illinois at Urbana-Champaign), Manfred Einsiedler (ETH), Elena Fuchs (University of Illinois at Urbana-Champaign), Anish Ghosh (TIFR), Dmitry Kleinbock (Brandeis University), Han Li (University of Texas), Seon-hee Lim (Seoul National University), Uri Shapira (Technion).

**3.3. Final workshop.** The “Advances in Homogeneous Dynamics” workshop was the final event of the MSRI semester on Geometric and Arithmetic Aspects of Homogeneous Dynamics. The five-day conference aimed to summarize recent progress and bring together established researchers who work in the broad area of homogeneous dynamics as well as graduate students and recent PhDs. There were 26 lectures, out of which 6 were short talks by younger mathematicians. The workshop was open to all mathematicians and was well attended, not just by program members but also by people from the companion program. The main speakers were:

- Nalini Anantharaman (Universit de Strasbourg)
- Emmanuel Breuillard (Universit de Paris XI)
- Marc Burger (Eidgenössische TH Zrich-Hnggerberg)
- Alex Eskin (University of Chicago)
- Hillel Furstenberg (Hebrew University)
- Alexander Gorodnik (University of Bristol)
- Francois Ledrappier (University of Notre Dame)
- Elon Lindenstrauss (Hebrew University)
- Gregory Margulis (Yale University)

- Maryam Mirzakhani (Stanford University)
- Amir Mohammadi (University of Texas)
- Hee Oh (Yale University)
- Jean-Francois Quint (Universit de Bordeaux I)
- Federico Rodriguez Hertz (Pennsylvania State University)
- Alireza Salehi Golsefidy (University of California, San Diego)
- Uri Shapira (Technion—Israel Institute of Technology)
- Andreas Strombergsson (Uppsala University)
- Corinna Ulcigrai (University of Bristol)
- Peter Varju (University of Cambridge)
- Zhiren Wang (Pennsylvania State University)

Short talks were given by Ilya Gekhtman, Shirali Kadyrov, Han Li, Michael Magee, Nicolas de Saxce and Lei Yang.

#### 4. ORGANIZATIONAL STRUCTURE

In addition to the three workshops, certain arrangements were made to help structure the time of the members in residence. Many of these were designed with the MSRI Postdoctoral fellows and other younger mathematicians in mind.

**4.1. Lectures and seminars.** These included a weekly research seminar (Tuesdays in the morning), a more advanced “Open-ended seminar” (Tuesday afternoons) and a weekly postdoc seminar (Friday at lunch time). The research seminars, organized by Seonhee Lim and Uri Shapira, gave an opportunity for the more established members to present their current research. The postdoc seminar was run and organized by two post-docs, one from each program: Kathryn Mann (DMSGs) and Nicolas de Saxce (GAAHD). It featured short lectures by post-docs from both programs and was followed by a pizza lunch.

In addition to regularly scheduled seminars there were many informal study groups and working seminars, where people discussed new papers and shared ideas for further collaboration. Just to name a few, there was a study group reading recent papers by Schmidt and Summerer (Jayadev Athreya, Yitwah Cheung, Anish Ghosh, Dmitry Kleinbock) and an informal talk by Anton Lukyanenko and Joseph Vandehey (participants of the final workshop) about continued fractions on the Heisenberg group.

Another interesting and useful event happened in February: a series of 5-minute talks where everyone could introduce his/her research using just two slides. This was organized by MSRI and many people from both programs participated.

Evans Lectures, although designed primarily for the UCB mathematical community, also proved to be a valuable resource for our program. Two talks by Elon Lindenstrauss and by Hee Oh were an excellent introduction to the area and were attended by many MSRI members, including graduate students and postdocs. The same goes for the two talks, by William Goldman and Maryam Mirzakhani, which were held within the framework of the companion program.

**4.2. Diversity.** In the selection of members and scholars, as well as in the selection of speakers to the workshops, special attention was paid to try to ensure diversity of participants. This involved some non-trivial tradeoffs: for instance, the “Connections for Women” workshop featured prominent female mathematicians who gave inspiring talks to an audience consisting of both female and male mathematicians, but travel constraints made it harder for us to get the same senior mathematicians to participate in the program later. MSRI assistance, in particular MSRI’s energetic family services coordinator, was helpful to participants with children, and in particular to many of the long-term female participants.

We were less successful with regards to the participation of under-represented minorities; perhaps efforts geared towards earlier stages in career development (e.g. at the graduate student level) have a better chance to be effective.

## 5. INTERACTIONS WITH THE OTHER PROGRAM

As should be clear from our descriptions above, one of the factors that we believe led to the success of the GAAHD program this past fall was the overlap with the parallel DMSGGS program at MSRI. The common denominator of both programs is the role of dynamics in understanding various phenomena. Thus, while the objects of study in the two groups are different, there is much overlap in techniques and there is a common language, which includes such notions as group actions, symmetric spaces, discrete subgroups of Lie groups etc.

The introductory events for the companion program were well attended by the members of the GAAHD program. The DMSGGS program held their seminars on Monday and Thursday; those were also well attended by our program members, and many of them (including Herbert Abels, Ilya Gekhtman, Gregory Soifer, Alex Wright and others) gave talks there. A mini-course taught by Misha Kapovich and Bernhard Leeb (both from the DMSGGS program) was particularly popular among GAAHD members. Similarly, the GAAHD seminars were open to and well attended by mathematicians from the companion program. One of the members, Yves Benoist, was in fact funded by both programs, and gave two series of talks, one at each introductory workshop. For more examples of interactions between the two programs – Alireza Salehi

Golsefidy (GAAHD) gave talks at both final workshops, and Marc Burger (DMSGs) was an invited speaker for the GAAHD workshop.

## 6. POSTDOCTORAL FELLOWS

There were seven official MSRI postdoctoral fellows in the GAAHD program. Here they are in alphabetical order, together with a brief description of their activities, mentors at MSRI and academic affiliation.

- Nicolas de Saxce graduated from Université Paris-Sud in 2012. His PhD advisor was Emmanuel Breuillard. He held a postdoctoral fellowship at the Hebrew University in Jerusalem before joining the program. At MSRI he was mentored by Yves Benoist. During the semester Nicolas managed to achieve a long term goal of his — understanding dense subgroups of simple Lie groups with positive Hausdorff dimension. Saxce has made significant progress on this problem before the special program, but the final step was done during the program in collaboration with his mentor. He also started new collaborations, in particular with Étienne Le Masson. He also was an organizer of the postdoc seminar, and quite a successful one. He gave several talks at the seminars during the semester, and also a short talk at the final workshop.
- Ilya Gekhtman graduated from the University of Chicago and is currently an NSF postdoctoral fellow at Yale University. He was mentored by Jean-Francois Quint. He gave two talks at the seminars during the semester and a short talk at the final workshop. In addition to continuing his existing projects, he started a new collaboration with Seonhee Lim.
- Etienne Le Masson graduated from Université Paris-Sud in 2013 under the direction of Nalini Anantharaman. He held a postdoctoral fellowship at the Hebrew University in Jerusalem before joining the program. His mentor at MSRI was Elon Lindenstrauss. During the semester Etienne completed a project with S. Brooks and Lindenstrauss, and started a new collaboration with Nicholas de Saxce. He also interacted often with Anantharaman.
- Han Li defended his PhD at Yale University in 2014 under the direction of Gregory Margulis. He was a postdoc at the University of Texas at Austin before coming to MSRI, and next year will move to Wesleyan University to become an Assistant Professor there. At MSRI he was mentored by Shahar Mozes. During the program he continued his joint work with Margulis and started a project with Dave Morris. Han gave a lecture at the introductory workshop, a talk at the postdoc seminar, and a short talk at the final workshop.

- Ronggang Shi was a student of Manfred Einsiedler at the the Ohio State University, graduating in 2009. He held positions at Xiamen University (China) and Tel Aviv University before coming to MSRI. His mentor at MSRI was Nimish Shah. Ronggang was able to finish a paper, joint with Dmitry Kleinbock and Barak Weiss, and start several new projects. He will return to Xiamen University next fall.
- Lei Yang was a student of Nimish Shah at the the Ohio State University. He graduated in 2014 and was a postdoctoral fellow at Yale University before coming to MSRI. He will be a postdoc at the Hebrew University next year – a position that was arranged at the semester. Lei gave a talk at the postdoc seminar, and a short talk at the final workshop. During the semester he was able to finish and submit three papers, and work on a new project with Nimish Shah. He was also discussing possible new projects with Yitwah Cheung and with Dmitry Kleinbock.
- Alexander Wright graduated from the University of Chicago in 2014 under the direction of Alex Eskin. He is currently a Clay Research Fellow and a postdoctoral fellow at Stanford University. His mentor at MSRI was Maryam Mirzakhani who is also his mentor at Stanford. Alex functioned as a senior (and highly visible) participant in the program, and interacted with the participants of both progrmas. In particular Alex gave a series of three talks at the introductory workshop of the companion program, several seminar talks, and a short presentation for academic sponsors of MSRI. He collaborated with Alex Eskin, Simion Filip and Maryam Mirzakhani, and wrote a paper with Erwan Lanneau and Duc-Manh Nguyen.

## 7. PROGRAM ASSOCIATES

We were happy to use the opportunity, offered to us by MSRI, to invited a selected group of graduate students to stay at MSRI and work with their advisors. Here is the list of associates supported by our program, with their advisers and duration of stay indicated:

- Caroline Arvis (Yves Benoist, 1 month)
- Carl Davis Buenger (Nimish Shah, 3 months)
- Tom Gilat (Elon Lindenstrauss, 1 month)
- Lien-Yung Kao (François Ledrappier, 3 months)
- Asaf Katz (Elon Lindenstrauss, 2 months)
- Ilya Khayutin (Elon Lindenstrauss, 3 months)
- Tue Ly (Dmitry Kleinbock, 2 months)
- Sebastien Miquel (Yves Benoist, 1 month)
- Wenyu Pan (Hee Oh, 1 month)

- Dale Winter (Hee Oh, 1 month)
- Grace Work (Jayadev Athreya, 4 months)
- Cheng Zheng (Nimish Shah, 3 months)

The program associates were an integral part of our program and significantly contributed to its success, in particular through stimulating talks given at the postdoc seminar on their work that led to interaction between themselves and between them and other more established researchers.

#### 8. THANKS!

The program organizers are grateful to NSF and Simons Foundation for their generous support, and to MSRI staff for creating a productive atmosphere and being extremely helpful in all the organizational matters, as well as in all aspects of the daily life of the program members. We all hope to be back to MSRI soon!



## GEOMETRIC AND ARITHMETIC ASPECTS OF HOMOGENEOUS DYNAMICS



de Saxce, Nicolas

Name: Nicolas de Saxce  
Year of Ph.D: 2012  
Institution of Ph.D.: Université Paris-Sud (11)  
Dissertation title: Borelian subgroups of Lie groups  
Ph.D. advisor: Emmanuel Breuillard  
Mentor while at MSRI: Yves Benoist

Institution prior to obtaining the MSRI PD fellowship: Hebrew University in Jerusalem

Position at that institution: Postdoc  
Mentor (if applicable): Elon Lindenstrauss

Institution (or company) where you are going after the MSRI PD fellowship: CNRS - Université Paris-Nord (13)  
Position: Chargé de recherches  
Anticipated length: permanent position

Postdoctoral fellow's comments:

Work while in MSRI:

- Convolution in perfect groups, with Yves Benoist (notes).

The purpose of this work is to show that in a connected perfect Lie group, any compactly supported continuous function has a convolution power that is  $k$ -times differentiable, for  $k$  an arbitrary integer. This is in sharp contrast with the abelian case, where there exist compactly supported continuous functions such that all of their convolution powers are nowhere differentiable. As an application, we show that if  $A$  is a borelian subset of a connected perfect Lie group with sufficiently large Hausdorff dimension, then some product set of  $A$  contains a non-empty open set.

- Quantum ergodicity in compact simple Lie groups, with Étienne Le Masson (draft).

I was introduced to the study of eigenfunctions of the Laplacian by Étienne Le Masson, and we plan to generalize his work with Elon Lindenstrauss and Shimon Brooks "Quantum Ergodicity and Averaging Operators on the Sphere" (arXiv:1505.03887v1) to the setting of arbitrary homogeneous spaces of compact semi-simple Lie groups. We have a sketch of proof when the homogeneous space is the compact semi-simple Lie group itself.

My experience at MSRI was beneficial, it allowed me to learn about the quantum ergodicity statements and the unique quantum ergodicity conjectures.

Organizing the postdoc seminar was also a great experience, this allowed me to meet the other postdocs from both programs and to discuss math with them.



**Le Masson, Etienne**

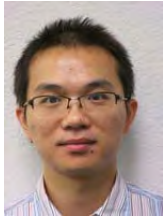
Name: Etienne Le Masson  
Year of Ph.D: 2013  
Institution of Ph.D.: Université Paris-Sud (Orsay)  
Dissertation title: Ergodicity and eigenfunctions of the Laplacian on large regular graphs  
Ph.D. advisor: Nalini Anantharaman  
Mentor while at MSRI: Elon Lindenstrauss

Institution prior to obtaining the MSRI PD fellowship: The Hebrew University of Jerusalem  
Position at that institution: Postdoctoral fellow  
Mentor (if applicable): Elon Lindenstrauss

Institution (or company) where you are going after the MSRI PD fellowship: University of Bristol  
Position: Postdoctoral research assistant  
Anticipated length: 1,5 years  
Mentor (if applicable): Jens Marklof

Postdoctoral fellow's comments:

I finished working on a paper in collaboration with Elon Lindenstrauss that was submitted during my stay at the MSRI. I learned more about homogeneous dynamics thanks in particular to the introductory workshop and have now a better understanding of the domain in general. Although the short time spent here made it difficult to start and finish a project, I had the opportunity to meet new people and start new projects that will hopefully lead to publications in the future. My experience at MSRI was thus very beneficial.



**Li, Han**

Name: Han Li

Year of Ph.D: 2008-2014

Institution of Ph.D.: Yale University

Dissertation title: Some effective results in homogeneous dynamics and number theory

Ph.D. advisor: Professor Gregory A. Margulis

Mentor while at MSRI: Professor Shahar Mozes

Institution prior to obtaining the MSRI PD fellowship: University of Texas at Austin

Position at that institution: Bing Instructor (Postdoc)

Mentor (if applicable): Professor Amir Mohammadi

Institution (or company) where you are going after the MSRI PD fellowship: Wesleyan University

Position: Assistant Professor of Mathematics

Anticipated length: tenure-track

Mentor (if applicable): N.A.

Postdoctoral fellow's comments:

With Dave Witte Morris I have been working on a project about the small generators of arithmetic groups. MSRI had also kindly funded me traveling to Yale University so that I was able to continue my work with Gregory A. Margulis on reduction theory of integral quadratic forms. I have also learned some geometric ideas from my academic mentor, Shahar Mozes, who I met regularly throughout the semester and who have been very responsible and supportive. These experiences have helped me better present my work in the introductory workshop, the advanced workshop, and the postdoc seminar of our program. I want to take this opportunity to express my sincere gratitude to the support from MSRI.



**Shi, Ronggang**

Name: Ronggang Shi

Year of Ph.D: 2009

Institution of Ph.D.: the Ohio State University

Dissertation title:

EQUIDISTRIBUTION OF EXPANDING MEASURES WITH  
LOCAL MAXIMAL DIMENSION AND DIOPHANTINE  
APPROXIMATION

Ph.D. advisor: Manfred Einsiedler

Mentor while at MSRI: Nimish Shah

Institution prior to obtaining the MSRI PD fellowship: Tel Aviv University

Position at that institution: Postdoc

Mentor (if applicable): Barak Weiss

Institution (or company) where you are going after the MSRI PD  
fellowship: Xiamen University

Position: Assistant Professor

Anticipated length: tenure-track

Mentor (if applicable): N/A

Postdoctoral fellow's comments:

My experience at MSRI is very beneficial.

I almost completed a paper joint with Barak Weiss and Dimitry Kleinbock:  
Pointwise equidistribution with an error rate and with respect to unbounded  
functions. Talking with experts here help me understand many things which  
otherwise may take me longer time.



**Wright, Alexander**  
**Clay postdoc**

Name: Alexander Wright

Year of Ph.D: 2014

Institution of Ph.D.: University of Chicago

Dissertation title: Affine invariant submanifolds in the moduli space of Abelian differentials

Ph.D. advisor: Alex Eskin

Mentor while at MSRI: Maryam Mirzakhani

Institution prior to obtaining the MSRI PD fellowship: Stanford University, and Clay Math Institute

Position at that institution: Clay Research Fellow

Mentor (if applicable): Maryam Mirzakhani

Institution (or company) where you are going after the MSRI PD fellowship: Stanford University, and Clay Math Institute

Position: Clay Research Fellow

Anticipated length: (if it is a tenure track position just write tenure-track): 3-5 years

Mentor (if applicable): Maryam Mirzakhani

Please give a brief description of your work while you were at MSRI as well as any publications made.

I collaborated with Alex Eskin (present at MSRI) and Simion Filip on a project about finiteness of Teichmuller curves and the algebraic hull of the Kontsevich-Zorich cocycle.

I collaborated with Maryam Mirzakhani (my MSRI mentor) on a project "The boundary of an affine invariant submanifold".

I wrote a paper "Finiteness of Teichmuller curves in non-arithmetic rank 1 orbit closures" with Erwan Lanneau and Duc-Manh Nguyen, who both visited MSRI.

Was your experience at MSRI beneficial? Why or why not?

Yes, it was beneficial to get to talk to so many good mathematicians.



**Yang, Lei**

Name: Lei Yang

Year of Ph.D: 2014

Institution of Ph.D.: The Ohio State University

Dissertation title: HAUSDORFF DIMENSION OF DIVERGENT GEODESICS ON PRODUCT OF HYPERBOLIC SPACES

Ph.D. advisor: Nimish Shah

Mentor while at MSRI: Dmitry Kleinbock

Institution prior to obtaining the MSRI PD fellowship: Yale University

Position at that institution: Postdoctoral associate

Mentor (if applicable): Gregory Margulis

Institution (or company) where you are going after the MSRI PD fellowship: Hebrew University

Position: Postdoctoral Fellow

Anticipated length: 1 year

Mentor (if applicable): Elon Lindentrauss

Postdoctoral fellow's comments:

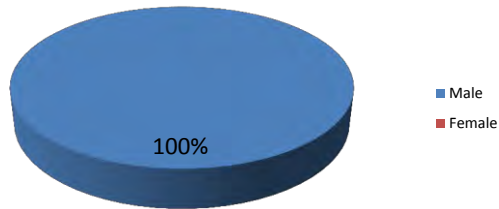
I continue working with Nimish Shah on the equidistribution problem on expanding curves on homogeneous spaces and its applications to number theory. I also work with Ralf Spatzier on the problem of classification of higher rank expanding maps on compact manifolds. I am also talking to Yitwah Cheung and with Dmitry Kleinbock separately, about computing Hausdorff dimensions of points on homogeneous spaces, whose trajectories under particular diagonal flows satisfy particular conditions. I think my experience at MSRI is very beneficial, because during this semester, I have opportunities to talk to and work with many great mathematicians in my field. Moreover, at MSRI, I learned a lot from many talks by people working on different branches and problems in homogeneous dynamics and dynamics of moduli spaces. Most topics of these talks are new to me, so my knowledge was greatly broadened during this semester.

## Postdoc Pre/Post-MSRI Institution Group

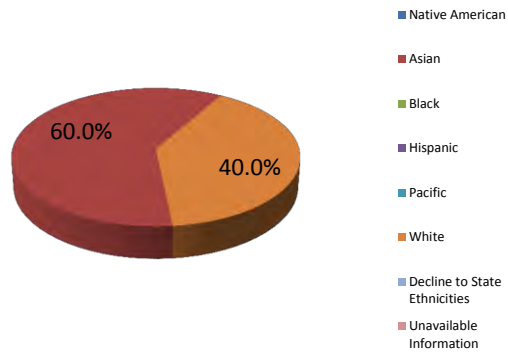
Family Name	First Name	Pre-MSRI Institution Group	Post-MSRI Institution Group	Pre-MSRI Institution Name	Placement Institution Name
de Saxce	Nicolas	Foreign	Foreign	Universite de Paris XIII (Paris-Nord)	Universite de Paris XIII (Paris-Nord)
Le Masson	Etienne	Foreign	Foreign	Hebrew University	University of Bristol
Li	Han	Group I Public	Group II	University of Texas at Austin	Wesleyan University
Shi	Ronggang	Foreign	Foreign	Tel Aviv University	Xiamen University
Yang	Lei	Foreign	Foreign	Hebrew University	Hebrew University

2014–15 Postdoctoral Fellows Demographic Summary

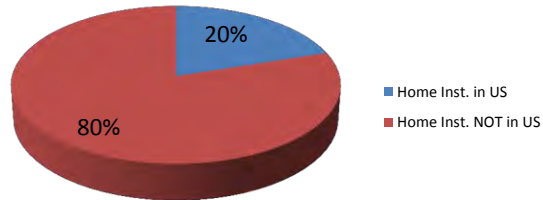
Gender	#	% (No Decl.)*	%
# of Distinct Postdocs	5		100.0%
Male	5	100.00%	100.0%
Female	0	0.00%	0.0%
Decline to State Gender	0		0.0%



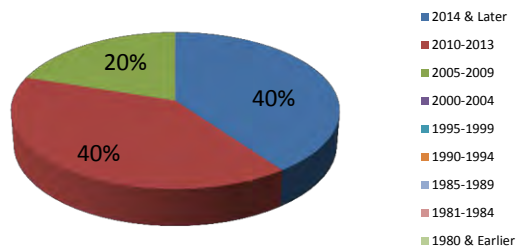
Ethnicities	#	% (No Decl.)*	%
Native American	0	0.00%	0.0%
Asian	3	60.00%	60.0%
Black	0	0.00%	0.0%
Hispanic	0	0.00%	0.0%
Pacific	0	0.00%	0.0%
White	2	40.00%	40.0%
Decline to State Ethnicities	0		0.0%
Unavailable Information	0		0.0%
Minorities	0		0.0%



Citizenships	#	%
US Citizen & Perm. Residents	1	20.0%
Foreign	4	80.0%
Unavailable information	0	0.0%
# of Distinct Postdocs	5	100.0%
US Citizen	1	20.0%
Perm Residents	0	0.0%
Home Inst. in US	1	20.00%



Year of Ph.D	#	%
2014 & Later	2	40.0%
2010-2013	2	40.0%
2005-2009	1	20.0%
2000-2004	0	0.0%
1995-1999	0	0.0%
1990-1994	0	0.0%
1985-1989	0	0.0%
1981-1984	0	0.0%
1980 & Earlier	0	0.0%
Unavailable Info.	0	0.0%
Total # of Distinct Postdocs	5	100.0%



\*Statistic Calculation based on all participants that did not decline.



## Geometric and Arithmetic Aspects of Homogeneous Dynamics Program Summary

Role	# of Distinct Members	%	# of Citizens & Perm. Res.	%	US Citizens	# of Female	%	# of Minorities <sup>1</sup>	%
Organizers	5	7.8%	3	60.0%	1	1	20.0%	0	0.0%
Research Professors	9	14.1%	4	44.4%	2	1	11.1%	0	0.0%
Postdoctoral Fellows MSRI	5	7.8%	1	20.0%	1	0	0.0%	0	0.0%
Postdoctoral Fellows NSF	1	1.6%	1	100.0%	1	0	0.0%	0	0.0%
Postdoctoral Fellows Clay	1	1.6%	0	0.0%	0	0	0.0%	0	0.0%
Research Members	31	48.4%	11	35.5%	7	6	19.4%	0	0.0%
Program Associates	12	18.8%	4	33.3%	3	3	25.0%	0	0.0%
<b>Total # of Distinct Members</b>	<b>64</b>		<b>24</b>	<b>37.5%</b>	<b>15</b>	<b>11</b>	<b>17.2%</b>	<b>-</b>	<b>0.0%</b>

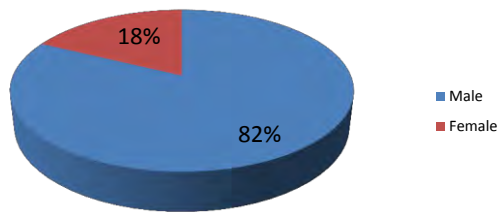
<sup>1</sup> Minorities are US citizen who declare themselves American Indian, Black, Hispanic, or Pacific Islander. Minority percentage is calculated by dividing the number of Minorities by the total number of US citizens.

### Home Institute Grouping

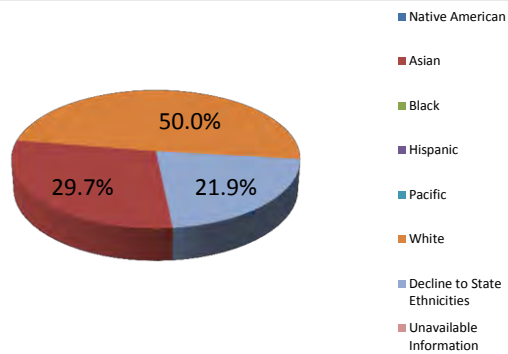
Role	US							Foreign	Total
	Group I Private	Group I Public	Group II	Group III	Group M	Group B	Non-Group		
Organizers	2	1	0	0	0	0	0	2	5
Research Professors	1	2	0	0	0	0	0	6	9
Postdoctoral Fellows MSRI	0	1	0	0	0	0	0	4	5
Postdoctoral Fellows NSF	1	0	0	0	0	0	0	0	1
Postdoctoral Fellows Clay	1	0	0	0	0	0	0	0	1
Research Members	2	6	0	0	1	0	0	22	31
Program Associates	4	3	0	0	0	0	0	5	12
<b>Total</b>	<b>11</b>	<b>13</b>	<b>-</b>	<b>-</b>	<b>1</b>	<b>-</b>	<b>-</b>	<b>39</b>	<b>64</b>
<b>%</b>	<b>17.2%</b>	<b>20.3%</b>	<b>0.0%</b>	<b>0.0%</b>	<b>1.6%</b>	<b>0.0%</b>	<b>0.0%</b>	<b>60.9%</b>	

**2014–15 Program Members Demographic Summary**

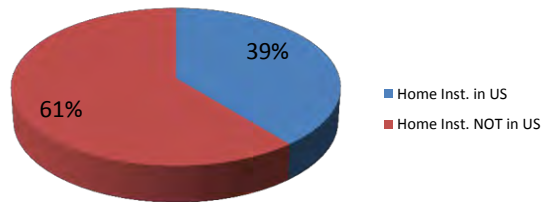
Gender	#	% (No Decl.)*	%
# of Distinct Members	64		100.0%
Male	51	82.26%	79.7%
Female	11	17.74%	17.2%
Decline to State Gender	2		3.1%



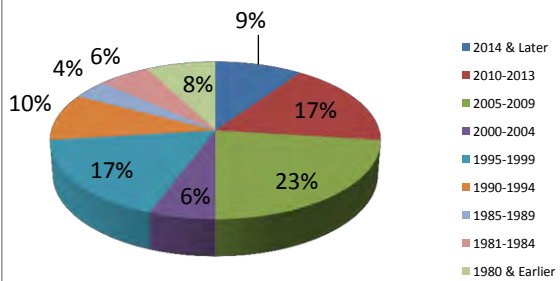
Ethnicities	#	% (No Decl.)*	%
Native American	0	0.00%	0.0%
Asian	19	37.25%	29.7%
Black	0	0.00%	0.0%
Hispanic	0	0.00%	0.0%
Pacific	0	0.00%	0.0%
White	32	62.75%	50.0%
Decline to State Ethnicities	14		21.9%
Unavailable Information	0		0.0%
Minorities	0		0.0%



Citizenships	#	%
US Citizen & Perm. Residents	24	37.5%
Foreign	40	62.5%
Unavailable information	0	0.0%
# of Distinct Members	64	100.0%
US Citizen	15	23.4%
Perm Residents	9	14.1%
Home Inst. in US	25	39.06%



Year of Ph.D	#	%
Program Associates (GS)	12	18.8%
2014 & Later	5	7.8%
2010-2013	9	14.1%
2005-2009	12	18.8%
2000-2004	3	4.7%
1995-1999	9	14.1%
1990-1994	5	7.8%
1985-1989	2	3.1%
1981-1984	3	4.7%
1980 & Earlier	4	6.3%
Unavailable Info.	0	0.0%
Total # of Distinct Members	64	100.0%



\*Statistic Calculation based on all participants that did not decline.

**Complementary Program 2014-15**

August 11, 2014 to May 29, 2015

MSRI

Berkeley, CA

USA

## **Complementary Program (2014–15)**

August 11, 2014 to May 29, 2015

The Complementary Program has a limited number of memberships that are open to mathematicians whose interests are not closely related to the core programs; special consideration is given to mathematicians who are partners of an invited member of a core program.

MSRI had a small Complementary Program comprised of ten researchers, Valerio Capraro (University of Southampton), Indira Chatterji (Universite d'Orleans), Hailong Dao (University of Kansas), Christopher Douglas (University of Oxford), Eric Flapan (Pomona College), Elon Lindenstrauss (Hebrew University of Jerusalem), Ariane Mezard (Institut de Mathématiques de Jussieu), Grigory Mikhalkin (University of Geneva), Stephen Morgan (University of Toronto), Frank Schreyer (Universität des Saarlandes), Volkmar Welker (Universitaet Marburg) and Gufang Zhao (Northeastern University).

### **Capraro Valerio**

Center for Mathematics and Computer Science (CWI)  
Amsterdam

Research Member of Complementary Program 2014–15

No comment from member

### **Chatterji Indira**

Universite de Nice Sophia Antipolis  
Nice

Research Member of Complementary Program 2014–15

At MSRI, Chatterji mainly collaborated with Alessandra Iozzi. She produced a paper titled The Median Class and Superrigidity of Actions on  $CAT(0)$  Cube Complexes. She commented that she had a very productive time while at MSRI.

### **Dao Hailong**

University of Kansas  
Lawrence, KS

Research Member of Complementary Program 2014–15

Dao mainly collaborated with David Eisenbud, MSRI's Director and Volkmar Welker. He wrote a paper titled Shape and boundary of Cohen-Macaulay cone and started on two other papers. Dao found "the sheer number of excellent people around, including the Complementary program" most beneficial.

### **Douglas Christopher**

University of Oxford  
Oxford, GB

Research Member of Complementary Program 2014–15  
No comment from member

**Flapan Erica**  
Pomona College  
Claremont, CA  
United States

Research Member of Complementary Program 2014–15

At MSRI, Flapan mainly collaborated with Kenji Kozai. She started on two papers and commented, “It was a great experience. I would definitely come back if I were given the opportunity.”

**Mikhalkin Grigory**  
Universite de Geneve  
Geneva

Research Member of Complementary Program 2014–15

Mikhalkin mainly collaborated with Yakov Eliashberg (Stanford) and Michael Kapovich (UC Davis). He started on a paper titled Rational quintics in the real plane.

**Morgan Stephen**  
University of Toronto

Research Member of Complementary Program 2014–15

At MSRI, Morgan mainly collaborated with Valerio Toledano Laredo, Chris Dodd, Sam Gunningham, Justin Hilburn. He started on a paper titled Quantum Hamiltonian reduction of  $W$ -algebras and Category  $O$ . He commented, “The high concentration of fellow mathematicians working in related areas was most useful.”

**Schreyer Frank-Olaf**  
Universitat des Saarlandes  
Saarbrücken, DE

Research Member of Complementary Program 2014–15

At MSRI, Morgan mainly collaborated with David Eisenbud, MSRI’s Director and Irena Peeva. He wrote on a paper titled Tate resolution on Products of projective spaces and started on another.

**Welker Volkmar**

Philipps-Universität Marburg  
Marburg, DE

Research Member of Complementary Program 2014–15

At MSRI, Morgan mainly collaborated with MSRI's Director David Eisenbud, MSRI's Deputy Director Helene Barcelo and Hai Long Dao. Welker submitted four papers and worked on five others. He comments, "The easy access to your colleagues during their stay facilitates collaborations. The atmosphere created by MSRI is very inspiring."

**Zhao Gufang**

Institut de Mathematiques de Jussieu  
Paris, FR

Research Member of Complementary Program 2014–15

No comment from member

## Complementary Program 2014–15 Program Summary

Role	# of Distinct Members	%	# of Citizens & Perm. Res.	%	US Citizens	# of Female	%	# of Minorities <sup>1</sup>	%
Organizers	0	0.0%	0	0.0%	0	0	0.0%	0	0.0%
Research Professors	0	0.0%	0	0.0%	0	0	0.0%	0	0.0%
Postdoctoral Fellows MSRI	0	0.0%	0	0.0%	0	0	0.0%	0	0.0%
Postdoctoral Fellows RM	0	0.0%	0	0.0%	0	0	0.0%	0	0.0%
Research Members	10	100.0%	4	40.0%	3	2	20.0%	0	0.0%
Program Associates	0	0.0%	0	0.0%	0	0	0.0%	0	0.0%
<b>Total # of Distinct Members</b>	<b>10</b>		<b>4</b>	<b>40.0%</b>	<b>3</b>	<b>2</b>	<b>20.0%</b>	<b>-</b>	<b>0.0%</b>

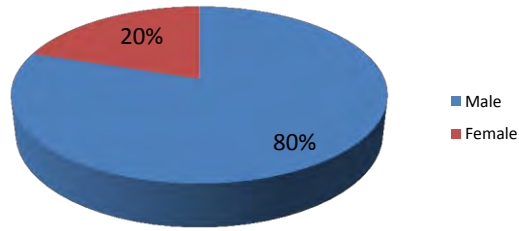
<sup>1</sup> Minorities are US citizen who declare themselves American Indian, Black, Hispanic, or Pacific Islander. Minority percentage is calculated by dividing the number of Minorities by the total number of US citizens.

### Home Institute Grouping

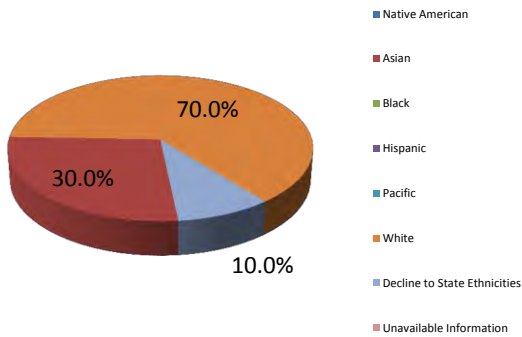
Role	US							Foreign	Total
	Group I Private	Group I Public	Group II	Group III	Group IV	Group M	Group B		
Organizers	0	0	0	0	0	0	0	0	0
Research Professors	0	0	0	0	0	0	0	0	0
Postdoctoral Fellows MSRI	0	0	0	0	0	0	0	0	0
Postdoctoral Fellows RM	0	0	0	0	0	0	0	0	0
Research Members	0	0	0	1	0	0	1	8	10
Program Associates	0	0	0	0	0	0	0	0	0
<b>Total</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>1</b>	<b>-</b>	<b>-</b>	<b>1</b>	<b>8</b>	<b>10</b>
<b>%</b>	<b>0.0%</b>	<b>0.0%</b>	<b>0.0%</b>	<b>10.0%</b>	<b>0.0%</b>	<b>0.0%</b>	<b>10.0%</b>	<b>80.0%</b>	

**2014–15 Program Members Demographic Summary**

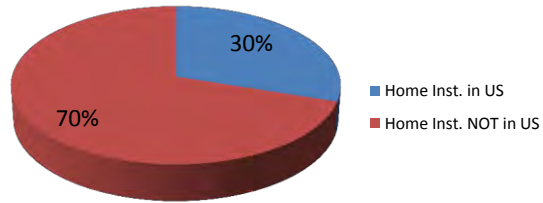
Gender	#	% (No Decl.)*	%
# of Distinct Members	10		100.0%
Male	8	80.00%	80.0%
Female	2	20.00%	20.0%
Decline to State Gender	0		0.0%



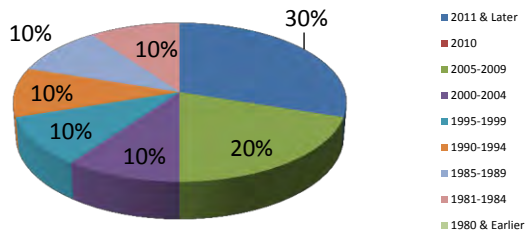
Ethnicities	#	% (No Decl.)*	%
Native American	0	0.00%	0.0%
Asian	3	30.00%	30.0%
Black	0	0.00%	0.0%
Hispanic	0	0.00%	0.0%
Pacific	0	0.00%	0.0%
White	7	70.00%	70.0%
Decline to State Ethnicities	1		10.0%
Unavailable Information	0		0.0%
Minorities	0		0.0%



Citizenships	#	%
US Citizen & Perm. Residents	4	40.0%
Foreign	6	60.0%
Unavailable information	0	0.0%
# of Distinct Members	10	100.0%
US Citizen	3	30.0%
Perm Residents	1	10.0%
Home Inst. in US	3	30.00%



Year of Ph.D	#	%
2011 & Later	3	30.0%
2010	0	0.0%
2005-2009	2	20.0%
2000-2004	1	10.0%
1995-1999	1	10.0%
1990-1994	1	10.0%
1985-1989	1	10.0%
1981-1984	1	10.0%
1980 & Earlier	0	0.0%
Unavailable Info.	0	0.0%
Total # of Distinct Members	10	100.0%



\*Statistic Calculation based on all participants that did not decline.



**Connections for Women:  
Geometric Representation Theory**  
August 28 to 29, 2014  
MSRI, Berkeley, CA, USA

Organizers:

**Monica Vazirani (University of California, Davis)**

**Eva Viehmann (TU München)**

## **Organizer Report for Connections for Women: Geometric Representation Theory**

As part of the rapidly developing research area of Geometric Representation Theory, the aims of the Connections Workshop were threefold. It focused on bringing together researchers from different topics within geometric representation theory. It gave junior researchers a broader picture of possible applications and of new developments, and established closer contact between junior and senior researchers. Besides, it aimed at encouraging and increasing the active participation of women and members of under-represented groups in the MSRI program.

Two speakers gave a series of 2 lectures each. While these were not quite mini-courses, they did allow the speakers to address the big picture, the motivating questions in their field, give plenty of examples, as well as theorems and even flavors of some proofs. Both of these speakers commented that preparing their talks benefitted them greatly by having them examine what motivates their research and why. One even formulated a new conjecture in the process of writing her talk as looking back over her work revealed new insights.

Other speakers gave 1-hour long lectures that were more like traditional research talks on cutting-edge developments (connected to the themes of the program and upcoming introductory workshop), giving them a chance to highlight the achievements of women mathematicians. The speakers were at varying levels of seniority or stages in their careers. (As well as from different countries.)

Notetakers took notes that will be available on the workshop website, along with the video recordings of the talks.

Postdocs were asked to chair several AM/PM sessions. The goal was to increase their visibility and also give them extra contact with the speaker they introduced. One of the session chairs later had a 2-hour mathematical discussion with the speaker she had introduced. For most, it was their first time chairing a session, so the lead organizer "coached" them through it. One participant noticed this and commented on how good an idea she thought it was. It also possibly exposed the chairs to some of the details behind the scenes of conference organization.

We held a poster session the first afternoon, at which 7 women presented their research. Before the group viewed the posters in the atrium, each presenter gave a 2-minute verbal summary of their poster in the lecture hall. By giving them only 2 minutes, they had to distill out the highlights of their work. Practicing presenting one's research in 2 minutes is a valuable skill -- for instance for upcoming job interviews. Some participants commented that they found the verbal introductions useful as it gave them more direction in navigating through the posters. Another goal of the summaries was to give these young researchers more visibility in the community. Poster presenters were also invited to submit a short abstract of their poster, to be posted on the workshop website. PDFs of the posters themselves might also become available.

When participants were invited to give posters, the organizer's email listed a few links

<http://www.awm-math.org/workshops/posters.html>

<http://www.siam.org/siamnews/general/poster.htm>

which have instructions and suggestions on making posters. When the lead organizer commented on how amazing one participant's poster was, the presenter admitted she'd always found posters confusing, but after she read the information at these links, it was so clear and helped her to construct this excellent poster.

Since those who presented posters were too engaged in explaining their work, they did not get a chance to view others' posters, so we also put up the posters during lunch of the second day. (For this reason, it is important to have the poster session the first day.)

The first day there was a panel on building and sustaining momentum. The panelists first gave a short bio of themselves. The 5 questions the panelists addressed are below.

1. What advice would you give to women beginning a career in mathematics?
2. What obstacles have you experienced in maintaining an active research program -- and what solutions have you discovered?
3. Have you found productive collaborations -- if yes, how did these collaborations begin? Are there problems to avoid in establishing collaborations?
4. How have you found new questions and areas of interest beyond your thesis research?
5. Can you recall a non-traditional path you took at some point, or extra resources you demanded, as an example to others of what is possible but that they might not think of trying or asking for?

We also discussed the importance of single-authored papers and not writing all one's papers with the same collaborator when junior. Another interesting question that came up was about writing papers with spouses.

There were 4 panelists, but the lead organizer also asked one participant who was very experienced and savvy to be a "plant" in the audience. She gave a few comments and spoke up, sometimes answering questions that arose, so the audience would feel more comfortable turning this into a discussion instead of merely a Q&A session. This was extremely effective in stimulating discussion.

We had a banquet the first evening. (I am in favor of suggesting that one's nametag is one's ticket to the dinner, so that participants will wear nametags and get to know each other and remember names better.)

Several participants commented to the lead organizer how useful and interesting they found the workshop and how much they enjoyed it. More of their comments should be available from the surveys. It is not yet known what new collaborations started from this workshop. However, one participant emailed us:

“Thank you for organizing another Connections for Women workshop—I have decided to return because I found these workshops so useful in the past. Last year I attended the Connections for Women workshop connected with the MSRI program "Noncommutative Algebraic Geometry and Representation Theory"--I presented a poster on my research in Lie theory even though it wasn't entirely connected to the topic of the workshop. I actually ended up meeting a collaborator there and we are currently writing a paper on a project which combines my expertise in representation theory and her expertise in noncommutative geometry. I presented a poster at this workshop about this research. I thought this might help illustrate why these workshops can be so helpful to the careers of female mathematicians."

### Organizers

First Name	Last Name	Institution
Monica	Vazirani	University of California, Davis
Eva	Viehmann	TU Munchen

### Speakers

First Name	Last Name	Institution
Miaofen	Chen	East China Normal University
Christine	Huyghe	Universite de Strasbourg I (Louis Pasteur)
Vera	Serganova	University of California, Berkeley
Julianna	Tymoczko	Smith College
Marie-France	Vigneras	Universite de Paris VII (Denis Diderot)



## Connections for Women Geometric Representation Theory

August 28-29, 2014

### Schedule

Thursday, August 28, 2014			
9:15AM - 9:30AM	Simons Auditorium		Welcome
9:30AM - 10:30AM	Simons Auditorium	Vera Serganova	Combinatorics, representations and geometry of algebraic supergroups
10:30AM - 11:00AM	Atrium		Tea
11:00AM - 12:00PM	Simons Auditorium	Julianna Tymoczko	Springer representations and other geometric representations Part 1
12:00PM - 2:00PM	Atrium		Lunch
2:00PM - 3:00PM	Simons Auditorium	Vera Serganova	Combinatorics, representations and geometry of algebraic supergroups
3:00PM - 3:30PM	Atrium		Tea
3:30PM - 4:30PM	Simons Auditorium		Panel Discussion
4:30PM - 5:30PM	Commons		Poster Session
6:30PM - 8:30PM	MSRI		Dinner at Taste of Himalayas

Friday, August 29, 2014			
9:30AM - 10:30AM	Simons Auditorium	Marie-France Vigneras	Pro-p-Iwahori-Hecke algebras of p-adic groups
10:30AM - 11:00AM	Atrium		Tea
11:00AM - 12:00PM	Simons Auditorium	Julianna Tymoczko	Springer representations and other geometric representations Part 2
12:00PM - 2:00PM	Atrium		Lunch
2:00PM - 3:00PM	Simons Auditorium	Christine Huyghe	Survey over localization theorems for representation theory of Lie algebras
3:00PM - 3:30PM	Atrium		Tea
3:30PM - 4:30PM	Simons Auditorium	Miaofen Chen	Connected components of moduli spaces of p-divisible groups

<b>Participants</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Darlayne	Addabbo	University of Illinois at Urbana-Champaign
Asilata	Bapat	University of Chicago
David	Ben-Zvi	University of Texas
Ana	Caraiani	Princeton University
Charlotte	Chan	University of Michigan
Miaofen	Chen	East China Normal University
Emily	Cliff	University of Oxford
Zsuzsanna	Dancso	MSRI - Mathematical Sciences Research Institute
Galyna	Dobrovolska	Columbia University
Anne	Dranovski	University of Toronto
Banafsheh	Farang-Hariri	Universite Paris-Sud (Orsay)
Rita	Fioresi	Universita di Bologna
Dragos	Fratila	Universite de Paris VII (Denis Diderot)
Elena	Gal	Tel-Aviv University
Adam	Gal	Tel-Aviv University
Iordan	Ganev	University of Texas
Emanuele	Ghedin	University of Oxford
Julien	Grivaux	Universite d'Aix-Marseille
Elmar	Grosse-Kloenne	Humboldt-Universitat
Vesselin	Gueorguiev	California State University
Yotam	Hendel	Bar-Ilan University
Johanna	Hennig	University of California
Florian	Herzig	University of Toronto
Christine	Huyghe	Universite de Strasbourg I (Louis Pasteur)
Pierre	Jaliniere	Universite de Paris VI (Pierre et Marie Curie)
Daniel	Juteau	Universite de Caen
Michael	Lau	Laval University
Ian	Le	University of Chicago
Ariane	Mezard	L'Institut de Mathematiques de Jussieu
Akhil	Mathew	University of California, Berkeley
Stephen	Morgan	University of Toronto
Emily	Norton	Kansas State University
Jacinta	Perez Gavilan Torres	University of Cologne
Darleen	Perez-Lavin	Florida Gulf Coast University
Dipendra	Prasad	Tata Institute of Fundamental Research
Catherine	Ray	Thiel Foundation
Shifra	Reif	University of Michigan
Kenneth	Ribet	University of California, Berkeley
Sean	Rostami	University of Wisconsin
Barbara	Schalke	Friedrich-Alexander-Universitat Erlangen-Nurnberg
Gus	Schrader	University of California, Berkeley
Vera	Serganova	University of California, Berkeley
Friederike	Steglich	Friedrich-Alexander-Universitat Erlangen-Nurnberg
Bolor	Turmunkh	University of Illinois at Urbana-Champaign
Julianna	Tymoczko	Smith College
Yakov	Varshavsky	Hebrew University

<b>Participants</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Monica	Vazirani	University of California, Davis
Marie-France	Vigneras	Universite de Paris VII (Denis Diderot)
Jiaowen	Yang	Ecole Polytechnique
Qiao	Zhou	University of California, Berkeley



**Officially Registered Participant Information**

<b>Participants</b>		<b>50</b>
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<b>Gender</b>		<b>50</b>
<b>Male</b>	44.00%	22
<b>Female</b>	56.00%	28
<b>Declined to state</b>	0.00%	0

<b>Ethnicity*</b>		<b>54</b>
<b>White</b>	66.67%	36
<b>Asian</b>	18.52%	10
<b>Hispanic</b>	3.70%	2
<b>Pacific Islander</b>	0.00%	0
<b>Black</b>	0.00%	0
<b>Native American</b>	0.00%	0
<b>Mixed</b>	3.70%	2
<b>Declined to state</b>	7.41%	4

\* ethnicity specifications are not exclusive

# 27 responses

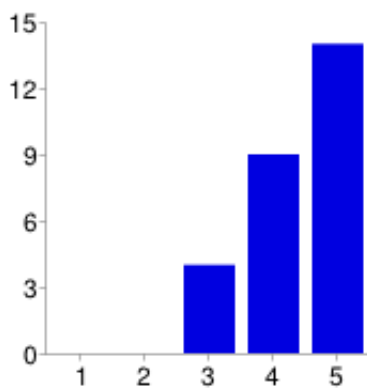
27 responses out of 50 participants = 54% response rate

[View all responses](#)   [Publish analytics](#)

## Summary

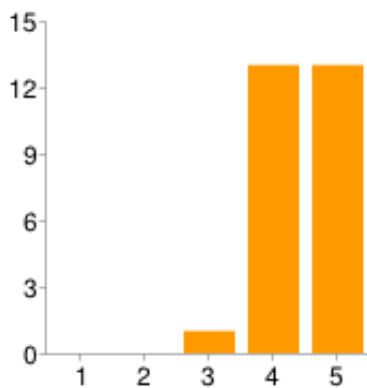
### Workshop assessment

The workshop was intellectually stimulating



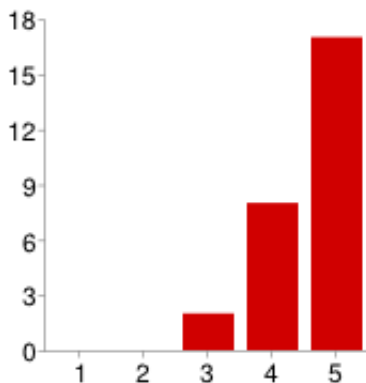
1	0	0%
2	0	0%
3	4	15%
4	9	33%
5	14	52%

The overall experience of the workshop was worthwhile



1	0	0%
2	0	0%
3	1	4%
4	13	48%
5	13	48%

The time between lectures was adequate for discussion



1	0	0%
2	0	0%
3	2	7%
4	8	30%
5	17	63%

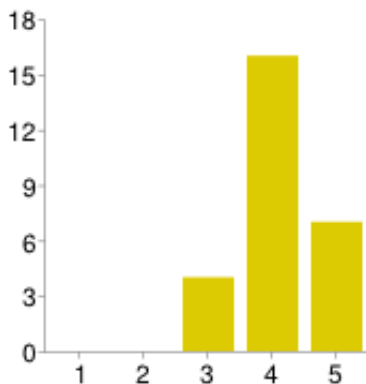
### Additional comments on the workshop organization

I was a bit disappointed because the people who were there for the semester program didn't seem to participate in the workshop. It seemed many of the speakers were from the other program in number theory or were not involved in the semester program, and so the workshop was not as good for making contacts with people in the field of geometric representation theory.

chris marshall was very on the ball-- extremely competent. thanks.

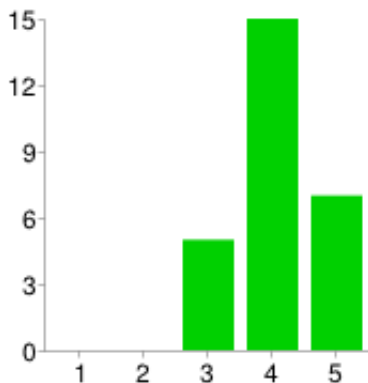
### Personal assessment

I was well prepared to benefit from the lectures



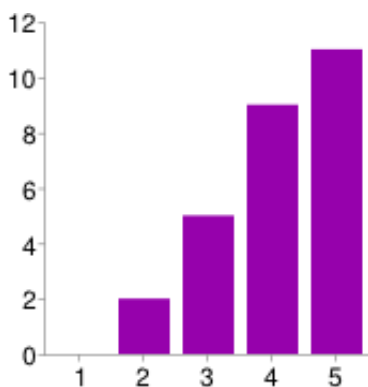
1	0	0%
2	0	0%
3	4	15%
4	16	59%
5	7	26%

My interest in the subject matter was increased by the workshop



1	0	0%
2	0	0%
3	5	19%
4	15	56%
5	7	26%

The workshop helped me meet people with similar scientific interests



1	0	0%
2	2	7%
3	5	19%
4	9	33%
5	11	41%

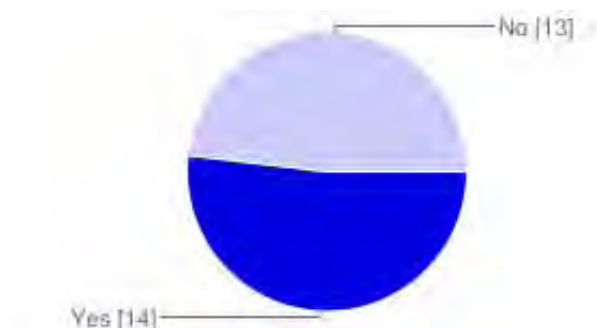
Additional comments on your personal assessment

Serganova and Tymoczko's talks were excellent.

It's very important to have activities that put so many women mathematicians in a room together, as it rarely happens w/o careful design.

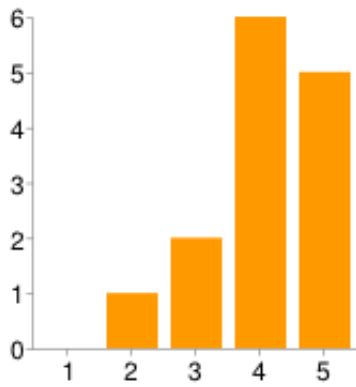
## Additional Activities

Did you attend the panel discussion?



Yes	14	52%
No	13	48%

If you did attend the panel discussion, did you find it worthwhile?



1	0	0%
2	1	4%
3	2	7%
4	6	22%
5	5	19%

What other subjects should be addressed in future panel discussions?

There should be more senior scientists (not just one)

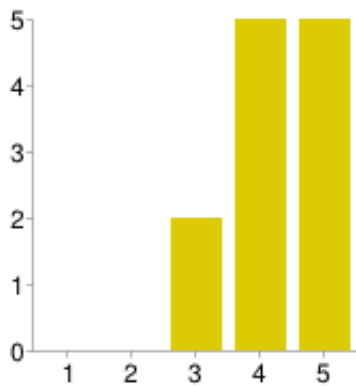
I think panelists should be briefed in advance about the kinds of questions that might be asked, so that they can be more prepared to answer them. Other than that it was great!

Did you attend the dinner?



Yes	12	44%
No	15	56%

If you did attend the dinner, did it help to solidify the contacts you made in the workshop?



1	0	0%
2	0	0%
3	2	7%
4	5	19%
5	5	19%

Please provide any comments on the dinner

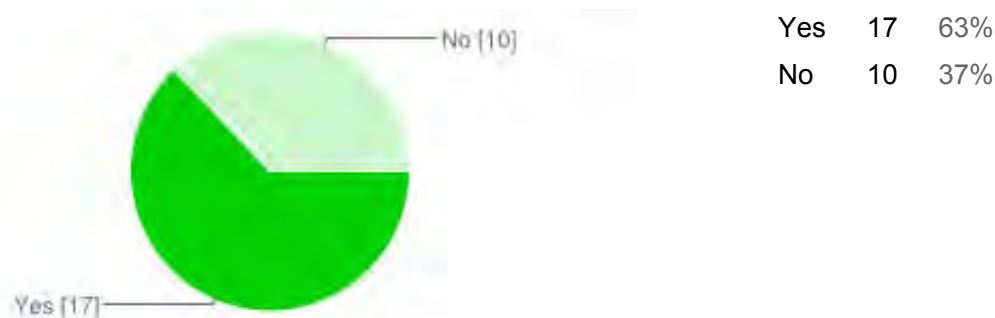
I would prefer a different restaurant/cuisine.

I

It was great!

I didn't mind, but it might be good to tread carefully with respect to discrimination laws, when specifically not inviting male participants to dinner.

Did you attend the poster session?



if you did attend the poster session, did you find it worthwhile?



Additional comments on the poster session

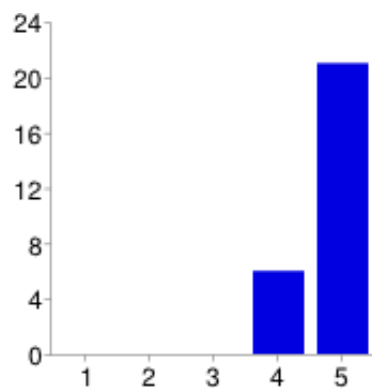
I was disappointed that we didn't present our posters until the end of the day, when many people had already gone home. The workshop was not integrated very well with the semester program--the only people who looked at my poster were other workshop participants and some folks from the number theory program, but no one participating in the program for geometric representation theory came to look at my poster. I was very disappointed by this.

It was a great idea to have the poster presenters summarize their posters briefly at the start of the poster session.

It was very good to have each presenter give an introduction to their poster before the session.

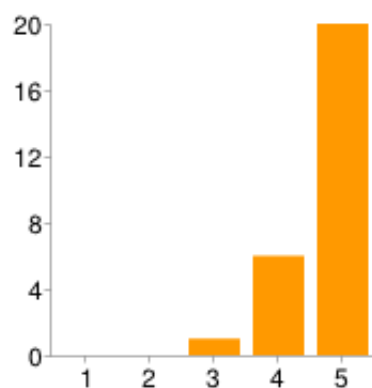
Venue

### I found the MSRI staff helpful



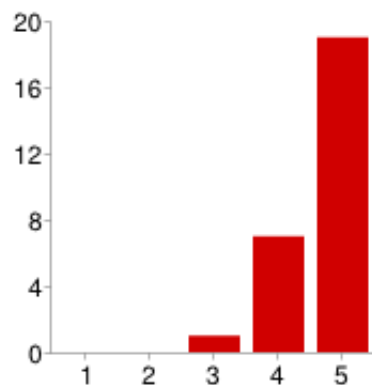
1	0	0%
2	0	0%
3	0	0%
4	6	22%
5	21	78%

### The MSRI physical facilities were conducive for such a workshop



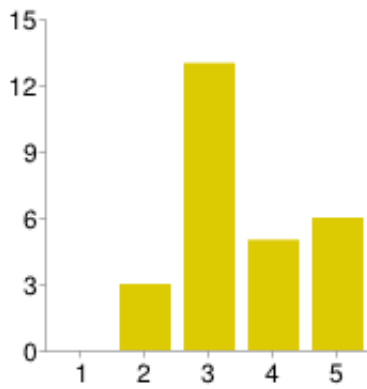
1	0	0%
2	0	0%
3	1	4%
4	6	22%
5	20	74%

### The MSRI computer facilities were adequate for such a workshop



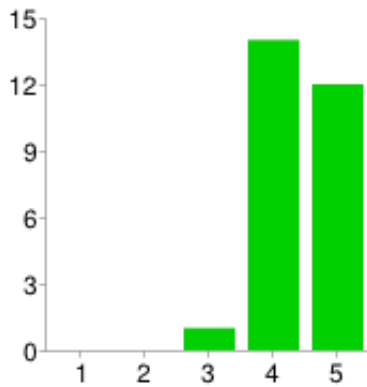
1	0	0%
2	0	0%
3	1	4%
4	7	26%
5	19	70%

### The MSRI lunch arrangements were satisfactory



1	0	0%
2	3	11%
3	13	48%
4	5	19%
5	6	22%

### The MSRI tea arrangements were satisfactory



1	0	0%
2	0	0%
3	1	4%
4	14	52%
5	12	44%

### Additional comments on the venue

I miss the hot food at lunch they had in summer '12.  
 Wonderful place to visit! Loved it!

## MSRI Wireless Network

Did you use MSRI's wireless network?

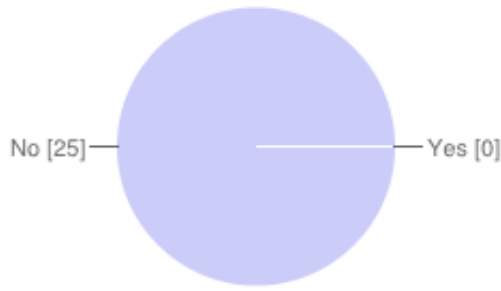


Yes	22	81%
No	5	19%

Did you experience any difficulties with the network?



Yes	0	0%
No	25	93%



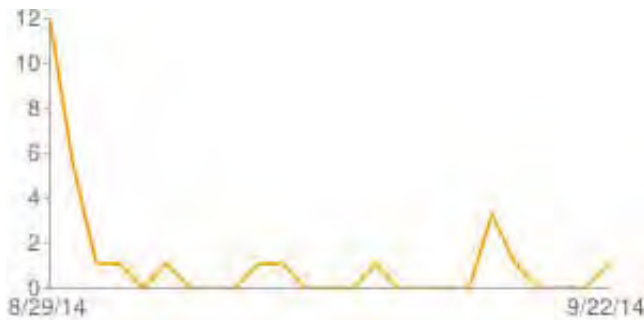
If you did experience difficulties with the network, please explain:  
No responses yet for this question.

Thank you for completing this survey

We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.

Vera Serganova's talks were fantastic and made my entire time at MSRI worthwhile.

### Number of daily responses



## **Connections for Women Workshop: Geometric Representation Theory August 28 - 29, 2014**

### **Additional Survey Responses**

#### **Additional comments on your personal assessment**

- Serganova and Tymoczko's talks were excellent.
- It's very important to have activities that put so many women mathematicians in a room together, as it rarely happens w/o careful design.

#### **Additional comments on the venue**

- Wonderful place to visit! Loved it!
- I miss the hot food at lunch they had in summer '12.

#### **We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.**

- Vera Serganova's talks were fantastic and made my entire time at MSRI worthwhile.

#### **What other subjects should be addressed in future panel discussions?**

- I think panelists should be briefed in advance about the kinds of questions that might be asked, so that they can be more prepared to answer them. Other than that it was great!
- There should be more senior scientists (not just one)

#### **Please provide any comments on the dinner**

- I didn't mind, but it might be good to tread carefully with respect to discrimination laws, when specifically not inviting male participants to dinner.
- I would prefer a different restaurant/cuisine.
- It was great!

#### **Additional comments on the workshop organization**

- chris marshall was very on the ball-- extremely competent. thanks.
- I was a bit disappointed because the people who were there for the semester program didn't seem to participate in the workshop. It seemed many of the speakers were from the other program in number theory or were not involved in the semester program, and so the workshop was not as good for making contacts with people in the field of geometric representation theory.

#### **Additional comments on the poster session**

- It was very good to have each presenter give an introduction to their poster before the session.
- It was a great idea to have the poster presenters summarize their posters briefly at the start of the poster session.
- I was disappointed that we didn't present our posters until the end of the day, when many people had already gone home. The workshop was not integrated very well with the semester program--the only people who looked at my poster were other workshop participants and some folks from the number theory program, but no one participating in the program for geometric representation theory came to look at my poster. I was very disappointed by this.

**Introductory Workshop:**  
**Geometric Representation Theory**  
September 2 to 5, 2014  
MSRI, Berkeley, CA, USA

Organizers:

**David Ben-Zvi (University of Texas)**

**Kevin McGerty (University of Oxford)**

## 1. OVERVIEW

The Introductory Workshop on Geometric Representation Theory, organized by David Ben-Zvi (U. of Texas at Austin) and Kevin McGerty (Oxford), took place at MSRI September 2-5 2014. The workshop was extremely well attended, with the spacious Simons Auditorium filled to near capacity for the entire week. There were five lectures a day (for a total of twenty), with three morning talks and two afternoon talks, and lunch and two tea breaks providing opportunities for discussion.

### 1.1. Speakers.

- Pramod Achar (Louisiana State University), 3 lectures
- Dmitro Arinkin (University of Wisconsin), 3 lectures
- Paul Baum (Penn State University), 1 lecture
- Edward Frenkel (University of California Berkeley), 2 lectures
- Victor Ginzburg (University of Chicago), 3 lectures
- Tom Hales (University of Pittsburgh), 3 lectures
- Nick Proudfoot (University of Oregon), 2 lectures
- Olivier Schiffmann (Jussieu), 3 lectures

The speakers demonstrated remarkable expository skill, in addition to their celebrated research. Most of the speakers (Achar, Arinkin, Hales, Ginzburg and Schiffmann) gave three-part mini courses, allowing for in-depth tours of areas of great current interest, coupled with two-part vignettes (Frenkel, Proudfoot) and a concluding lecture (Baum).

The workshop was a resounding success, with numerous participants approaching the organizers to express their appreciation of the clear and engaging lectures. The positive reactions ranged from graduate students (e.g. Lee Cohn from UT Austin claimed it was by far the best of many introductory workshops he'd attended) to legends of the field (Clay Professor Joseph Bernstein attended the entire workshop and wrote "The lectures were very beneficial for myself" and inquired after the written notes).

## 2. LECTURES

**2.1. The Langlands program.** Speakers: Dmitro Arinkin, Edward Frenkel, Tom Hales

One of the most important motivating philosophies in geometric representation theory (and in many adjacent fields) is the Langlands correspondence, which seeks to understand the theory of reductive groups in various contexts (local fields, number fields, function fields of curves) in terms of data associated to their "dual group". In the abelian case this is an essentially classical story, but in the case of higher rank we still have, despite spectacular achievements, many mysteries to decipher. As such it was clear that an introductory workshop should provide some overview of this fascinating web of conjectures and results.

Exposing the classical theory, where one is interested in reductive groups over number fields, Prof. Hales gave a series of three talks with impressive breadth and clarity: starting from essentially the character theory of finite groups, his talks provided a tour of the trace formula and the proof of the Fundamental Lemma, which is a remarkable story involving, among other things, a reduction to the setting of Lie algebras, model theoretic tools from logic which all one to deduce mixed characteristic results from equal characteristic ones (which Hales dubbed the

beginning of “logical representation theory”), and finally Ngô’s beautiful geometric arguments recasting endoscopy in geometric terms.

The work of Ngô has been one the resounded successes of the geometric theory in the Langlands program. The lectures of Prof. Frenkel elegantly described the various contexts in which a Langlands program exists: number fields, function fields, the geometric theory of Beilinson and Drinfeld, and most recently the connection with topological field theories and  $S$ -duality in mathematical physics. The task of understanding the analogies and inter-relations between these different contexts is an important one, and Prof. Frenkel’s lectures ended with a discussion of the role of the trace formula in context of the geometric Langlands correspondence.

Recently there has been significant progress in our understanding of the geometric Langlands correspondence: work of a number of people including Dennis Gaitsgory and our speaker, Prof. Arinkin, has led to a categorical version of the correspondence as a vastly generalized Fourier transform in which categories of sheaves replace spaces of functions. Namely, two geometric objects: the space of  $G$ -bundles on a curve on the one hand and the space of local systems on that curve, are linked by a categorical equivalence between  $D$ -modules on the one space and coherent sheaves on the other. As in classical harmonic analysis, there are many possible “function spaces” corresponding to growth and regularity condition, and the precise choice of categories needed is quite a subtle question, involving ideas from the rapidly developing field of derived algebraic geometry, among other things. Prof. Arinkin’s lectures gave an accessible introduction to these exiting new developments.

**2.2. Quiver varieties and Hall algebras.** Speakers: Victor Ginzburg, Nick Proudfoot and Olivier Schiffmann.

There are perhaps two most important families of spaces which arise in geometric representation theory: the first, perhaps most natural, are the homogenous spaces and their subvarieties such as Schubert varieties. The second, whose importance goes back to the seminal work of Ringel on Hall algebras and quantum groups, are quiver varieties, which are moduli spaces of representations of quivers. Work of Lusztig and Nakajima amongst others revealed how topological invariants of these spaces realize highest weight representations of Kac-Moody algebras, and looking more deeply, categories of sheaves on these spaces yield “categorifications” of the algebras and their representations, a process whereby vector spaces are replaced with categories, and linear maps by functors between categories. This process has driven a considerable body of research in recent years, using a broad range of techniques from combinatorics, algebra and geometry, and serves to reveal a deep combinatorial rigidity in the representation theory of these algebras. In the opposite direction, the representation theory also allows one to organize and understand the topological invariants associated to moduli spaces: the Nakajima-Grojnowski work on the cohomologies of Hilbert schemes being one celebrated example of this.

The lectures of Prof. Ginzburg gave an introduction to the construction and geometric properties of quiver varieties, reviewing general constructions such as Hamiltonian reduction, geometric invariant theory, and features specific to quivers such as the McKay correspondence and the construction of tautological bundles.

The lectures of Prof. Schiffmann related the subject of quiver varieties to the problem of computing the cohomology of the space of vector bundles on a curve using the structure of a Hall algebra to control counting rational points over a

finite field. The juxtaposition of his and Prof. Ginzburg’s lectures made clear the analogies between the different settings for geometric representation theory and its overall unity.

Recently work of Beauville, Namikawa and others have suggested a context where quiver varieties and the geometry of flag varieties (or rather their cotangent bundles) naturally coexist. This is the class of symplectic varieties and their resolutions. Prof. Proudfoot’s lectures gave an introduction to this theory and how to view it as a general setting for representation theory. He then explained a fascinating conjectural correspondence between pairs of such varieties known as “symplectic duality” (developed by Proudfoot and collaborators), which also appeared in the conclusion to Prof. Ginzburg’s lectures.

**2.3. Geometric representation theory of finite and p-adic groups.** Speakers: Pramod Achar and Paul Baum.

One of the main driving forces for geometric representation theory has been the representation theory of finite and p-adic reductive groups — the groups obtained by taking the points of an algebraic group, such as the group of invertible matrices, over a finite or p-adic field. Indeed one of the greatest achievements of the subject is Lusztig’s construction of the characters of all irreducible complex representations of finite reductive groups (in particular, of the vast majority of finite simple groups) using his theory of character sheaves. At the heart of this theory is Springer theory, which originates with Springer’s realization of Weyl group representations in the cohomology of subvarieties of the flag variety of the corresponding Lie group, or equivalently in the topology of the Springer resolution of the nilpotent cone by the cotangent bundle to the flag variety. Professor Achar’s lectures gave a methodical and insightful development of Springer theory from its origins, through Lusztig’s generalized Springer correspondence, and up to the cutting edge of current work (by Achar and collaborators) developing an analog for the still wild frontier of representations in finite characteristic.

Prof. Baum’s lecture concluded the workshop with a geometric invitation to the representation theory of p-adic groups. He explained the Bernstein center, the fundamental space parametrizing representations, and described an intriguingly simple conjectural picture (a conjecture by Baum and collaborators, established in many important cases) for the structure of representations in a given component .

## Organizers

First Name	Last Name	Institution
David	Ben-Zvi	University of Texas
Kevin	McGerty	University of Oxford

## Speakers

First Name	Last Name	Institution
Pramod	Achar	Louisiana State University
Dima	Arinkin	University of Wisconsin
Paul	Baum	Pennsylvania State University
Edward	Frenkel	University of California, Berkeley
Victor	Ginzburg	University of Chicago
Thomas	Hales	University of Pittsburgh
Nicholas	Proudfoot	University of Oregon
Olivier	Schiffmann	Universite Paris-Sud (Orsay)



## Introductory Workshop: Geometric Representation Theory

September 2-5, 2014

### Schedule

Tuesday, September 2, 2014			
8:45 AM - 9:00 AM	Simons Auditorium		Welcome
9:00 AM - 10:00 AM	Simons Auditorium	Thomas Hales	Introduction to the Langlands program and the Fundamental Lemma
10:00 AM - 10:30 AM	Atrium		Tea
10:30 AM - 11:30 AM	Simons Auditorium	Dima Arinkin	The Geometric Langlands Correspondence
11:30 AM - 12:30 PM	Simons Auditorium	Edward Frenkel	Gauge theory and Langlands duality
12:30 PM - 2:00 PM	Atrium		Lunch
2:00 PM - 3:00 PM	Simons Auditorium	Victor Ginzburg	Geometry of Quiver varieties
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:00 PM	Simons Auditorium	Olivier Schiffmann	Quivers, curves, Kac polynomials and the number of stable Higgs bundles
4:30 PM - 6:20 PM	Atrium		Reception

Wednesday, September 3, 2014			
9:00 AM - 10:00 AM	Simons Auditorium	Thomas Hales	Introduction to the Langlands program and the Fundamental Lemma
10:00 AM - 10:30 AM	Atrium		Tea
10:30 AM - 11:30 AM	Simons Auditorium	Dima Arinkin	The Geometric Langlands Correspondence
11:30 AM - 12:30 PM	Simons Auditorium	Pramod Achar	The Springer Correspondence
12:30 PM - 2:00 PM	Atrium		Lunch
2:00 PM - 3:00 PM	Simons Auditorium	Victor Ginzburg	Geometry of Quiver varieties
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:30 PM	Simons Auditorium	Olivier Schiffmann	Quivers, curves, Kac polynomials and the number of stable Higgs bundles

Thursday, September 4, 2014			
9:00 AM - 10:00 AM	Simons Auditorium	Thomas Hales	Introduction to the Langlands program and the Fundamental Lemma
10:00 AM - 10:30 AM	Atrium		Tea
10:30 AM - 11:30 AM	Simons Auditorium	Pramod Achar	The Springer Correspondence
11:30 AM - 12:30 PM	Simons Auditorium	Edward Frenkel	Gauge theory and Langlands duality
12:30 PM - 2:00 PM	Atrium		Lunch
2:00 PM - 3:00 PM	Simons Auditorium	Victor Ginzburg	Geometry of Quiver varieties
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:30 PM	Simons Auditorium	Nicholas Proudfoot	Quantizations of symplectic resolutions, part I

Friday, September 5, 2014			
9:00 AM - 10:00 AM	Simons Auditorium	Dima Arinkin	The Geometric Langlands Correspondence
10:00 AM - 10:30 AM	Atrium		Tea
10:30 AM - 11:30 AM	Simons Auditorium	Pramod Achar	The Springer Correspondence
11:30 AM - 12:30 PM	Simons Auditorium	Nicholas Proudfoot	Quantizations of symplectic resolutions, part II
12:30 PM - 2:00 PM	Atrium		Lunch
2:00 PM - 3:00 PM	Simons Auditorium	Olivier Schiffmann	Quivers, curves, Kac polynomials and the number of stable Higgs bundles
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:30 PM	Simons Auditorium	Paul Baum	Representations of p-adic groups



<b>Participants</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Pramod	Achar	Louisiana State University
Darlayne	Addabbo	University of Illinois at Urbana-Champaign
Noah	Arbesfeld	Columbia University
Dima	Arinkin	University of Wisconsin
Aswin	Balasubramanian	University of Texas
Asilata	Bapat	University of Chicago
Paul	Baum	Pennsylvania State University
David	Ben-Zvi	University of Texas
Joseph	Bernstein	Tel Aviv University
Marc	Besson	Dickinson College
Alexandre	Bouayad	University of Cambridge
Alina	Bucur	University of California
Charlotte	Chan	University of Michigan
Hui	Chen	Kansas State University
Miaofen	Chen	East China Normal University
Jingren	Chi	University of Chicago
Emily	Cliff	University of Oxford
Lee	Cohn	University of Texas
Ben	Cox	College of Charleston
Zsuzsanna	Dancso	MSRI - Mathematical Sciences Research Institute
Hailong	Dao	University of Kansas
Gurbir	Dhillon	Stanford University
Tudor	Dimofte	Institute for Advanced Study
Anne	Dranovski	University of Toronto
Banafsheh	Farang-Hariri	Universite Paris-Sud (Orsay)
Peter	Fiebig	Friedrich-Alexander-Universitat Erlangen-Nurnberg
Dragos	Fratila	Universite de Paris VII (Denis Diderot)
Edward	Frenkel	University of California, Berkeley
Adam	Gal	Tel-Aviv University
Elena	Gal	Tel-Aviv University
Benjamin	Gammage	University of California, Berkeley
Iordan	Ganev	University of Texas
Emanuele	Ghedini	University of Oxford
Victor	Ginzburg	University of Chicago
Julien	Grivaux	Universite d'Aix-Marseille
Elmar	Grosse-Kloenne	Humboldt-Universitat
Shamgar	Gurevich	University of Wisconsin
Thomas	Haines	University of Maryland
Thomas	Hales	University of Pittsburgh
Paul	Hamacher	Technische Universitat Munchen
xiao	he	Laval University
Aron	Heleodoro	Northwestern University
Yotam	Hendel	Bar-Ilan University
Florian	Herzig	University of Toronto
Justin	Hilburn	University of Oregon
Quoc	Ho	University of Chicago
Richard	Hughes	University of Texas

<b>Participants</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Christine	Huyghe	Universite de Strasbourg I (Louis Pasteur)
Brian	Hwang	California Institute of Technology
Mee Seong	Im	University of Illinois at Urbana-Champaign
Pierre	Jaliniere	Universite de Paris VI (Pierre et Marie Curie)
Wayne	Johnson	University of Wisconsin
Hassan	Jolany	Universite de Lille I (Sciences et Techniques de Lille Flandres Artois)
Daniel	Juteau	Universite de Caen
Daniel	Kaplan	University of Texas
Kiran	Kedlaya	University of California, San Diego
Noureen	Khan	University of North Texas
Sher	Khan	University of Ottawa
Clemens	Koppensteiner	Northwestern University
Michael	Lau	Laval University
Soo Hong	Lee	Massachusetts Institute of Technology
Liping	Li	University of California
Hao	Li	Johns Hopkins University
Seonhee	Lim	Seoul National University
Chia-Cheng	Liu	University of Toronto
Wen	Liu	University of California, Davis
Ariane	Mezard	L'Institut de Mathematiques de Jussieu
Viswambhara	Makam	University of Michigan
Shotaro	Makisumi	Stanford University
Madhusudan	Manjunath	UC Berkeley Math Faculty
Jacob	Matherne	Louisiana State University
Akhil	Mathew	University of California, Berkeley
Jasmin	Matz	Rheinische Friedrich-Wilhelms-Universitat Bonn
Kevin	McGerty	University of Oxford
George	Melvin	University of California, Berkeley
Stephen	Morgan	MSRI - Mathematical Sciences Research Institute
Gilbert	Moss	University of Texas
Lang	Mou	University of California, Davis
James	Mracek	University of Toronto
Dinakar	Muthiah	University of Toronto
Emily	Norton	Kansas State University
Jacinta	Perez Gavilan Torres	University of Cologne
Roger	Plymen	University of Southampton
Dipendra	Prasad	Tata Institute of Fundamental Research
Nicholas	Proudfoot	University of Oregon
Surya	Raghavendran	University of Texas
Sam	Raskin	Massachusetts Institute of Technology
Kenneth	Ribet	University of California, Berkeley
Sean	Rostami	University of Wisconsin
David	Rush	Massachusetts Institute of Technology
Sergei	Sagatov	University of Chicago
Barbara	Schalke	Friedrich-Alexander-Universitat Erlangen-Nurnberg
Henry	Scher	University of Chicago
olivier	schiffmann	Universite Paris-Sud (Orsay)

<b>Participants</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Lucius	Schoenbaum	Louisiana State University
Gus	Schrader	University of California, Berkeley
Michael	Schuster	University of North Carolina
Travis	Scrimshaw	University of California, Davis
Friederike	Steglich	Friedrich-Alexander-Universitat Erlangen-Nurnberg
Sean	Tang	University of Utah
Minh-Tam	Trinh	University of Chicago
Cheng-Chiang	Tsai	Harvard University
Bolor	Turmunkh	University of Illinois at Urbana-Champaign
Yakov	Varshavsky	Hebrew University
Monica	Vazirani	University of California, Davis
Kevin	Walker	Microsoft Station Q
Robin	Walters	University of Chicago
Jonathan	Wang	University of Chicago
Junqi	Wang	Rutgers University
Alex	Weekes	University of Toronto
Zhaoting	Wei	Indiana University
Tian An	Wong	City University of New York (CUNY)
Michael	Wong	University of Texas
Xinli	Xiao	Kansas State University
Yaping	Yang	MSRI - Mathematical Sciences Research Institute
Philsang	Yoo	Northwestern University
Shilin	Yu	University of Pennsylvania
Qiaochu	Yuan	University of California, Berkeley
Naizhen	Zhang	University of California, Davis
Qiao	Zhou	University of California, Berkeley
Alex	Zorn	University of California, Berkeley

**Officially Registered Participant Information**

<b>Participants</b>		<b>120</b>
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<b>Gender</b>		<b>120</b>
<b>Male</b>	76.67%	92
<b>Female</b>	20.83%	25
<b>Declined to state</b>	2.50%	3

<b>Ethnicity*</b>		<b>130</b>
<b>White</b>	49.23%	64
<b>Asian</b>	34.62%	45
<b>Hispanic</b>	1.54%	2
<b>Pacific Islander</b>	0.00%	0
<b>Black</b>	0.00%	0
<b>Native American</b>	0.00%	0
<b>Mixed</b>	3.85%	5
<b>Declined to state</b>	10.77%	14

\* ethnicity specifications are not exclusive

# 67 responses

67 responses out of 120 participants = 56% response rate

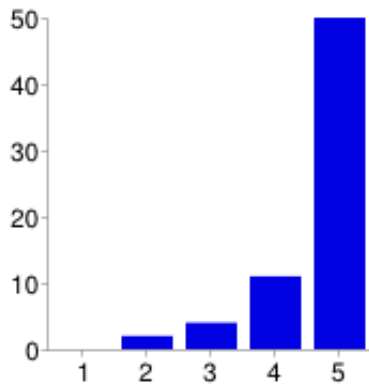
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## Summary

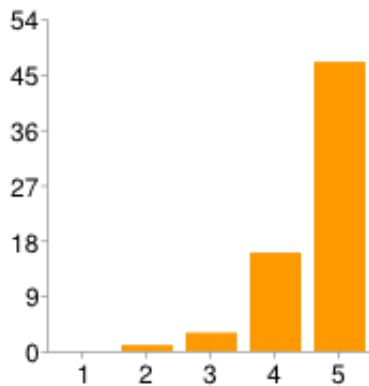
### Workshop assessment

The workshop was intellectually stimulating



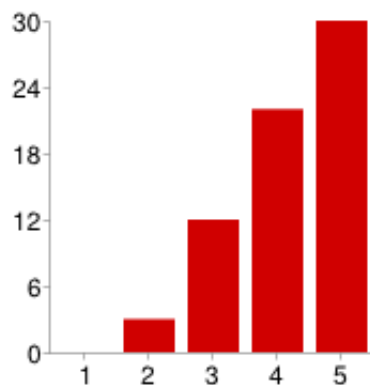
1	0	0%
2	2	3%
3	4	6%
4	11	16%
5	50	75%

The overall experience of the workshop was worthwhile



1	0	0%
2	1	1%
3	3	4%
4	16	24%
5	47	70%

The time between lectures was adequate for discussion



1	0	0%
2	3	4%
3	12	18%
4	22	33%
5	30	45%

## Additional comments on the workshop organization

The organization was phenomenal!

I was an organizer, so perhaps shouldn't comment on that. Also, the time between talks for discussions was limited for me probably because I was an organizer!

Many of the talks too elementary

I liked the relatively small number of lectures and the lecture series format

The talks were very uneven, some of them pitched far too high. However, the talks by Hales and Frenkel were outstanding.

Time to talk between lectures was limited, particularly as many sessions ran overtime. This also made it harder to keep up by the end of the day (five long lectures with short breaks is both physically and mentally exhausting).

Not enough space for informal discussions

Excellent in every aspects!

overall great, though it would be nice to have tastier and more nutritious lunches (since restaurants are far away)

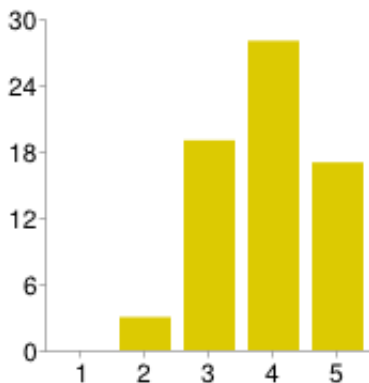
very good

Great lineup of speakers and topics.

I would have preferred a 2hour lunch break, and then having the talks run later into the afternoon. It felt crowded to have a 1.5 break then end at 4:30, which is fairly early.

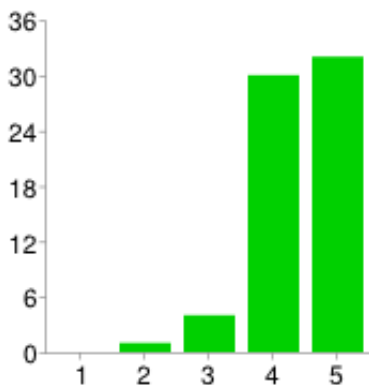
## Personal assessment

I was well prepared to benefit from the lectures



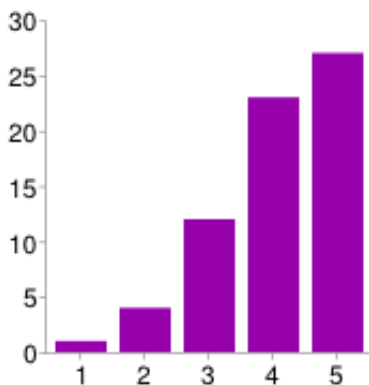
1	0	0%
2	3	4%
3	19	28%
4	28	42%
5	17	25%

### My interest in the subject matter was increased by the workshop



1	0	0%
2	1	1%
3	4	6%
4	30	45%
5	32	48%

### The workshop helped me meet people with similar scientific interests



1	1	1%
2	4	6%
3	12	18%
4	23	34%
5	27	40%

### Additional comments on your personal assessment

The required background knowledge was more than what I was expecting from an introductory workshop, but the lectures were well enough presented that I have a clear understanding of what I need to study on to get up to speed.

The workshop helped me gain a better perspective of the overall research area. It also benefited my specific research problem through discussions with visiting experts.

I already knew most of the people at the workshop, but that isn't a criticism I shouldn't think.

I made a lot of personal and collaborative connections during the workshop. This workshop definitely helped me in expanding my research interests.

No further comments.

Having most lecturers give a series of 3 lectures was FANTASTIC. I got so much out of that, and it ensured each of their 1st lectures was actually introductory. I found those talks well-prepared and structured.

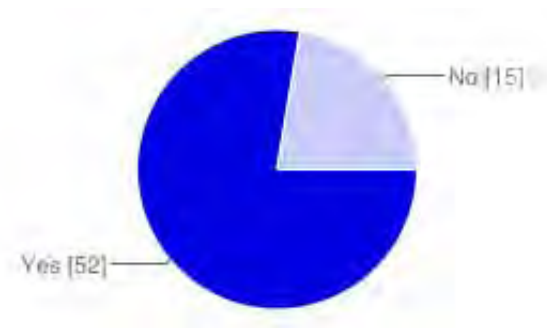
I liked the atmosphere at the women's workshop better, though I liked the talks at the coed workshop better. Somehow between talks there were so many people I didn't know what to do with myself, and felt nervous and uncomfortable. It felt intense and not always friendly. When I did have conversations with people they were often about trivial or boring things, no one would attempt to start a conversation about math with me. And people weren't very social in the afterhours. But I loved the talks and found the level to be a mixture of truly introductory and challenging. Pramod Achar's talks were maybe my favorites of this week. He was very clear and covered interesting material. I loved that Olivier Schiffmann gave very difficult talks and really opened up his research to the audience, giving a lot of detail, unlike Ginzburg, who crammed everything interesting he had to say into the last 5 minutes. Besides forcing him to speak, someone should have forced him to put the introductory material into one lecture and then spend the next two lectures explaining his proof of Kac's conjecture and the other conjecture he has ideas about proving. I think everyone would have liked to hear more details about those topics, and where else could we have learned them, but instead he spent 3 hours defining a quiver and its double and its framing. Maybe the organizers wanted the lectures to be very introductory, but a mix of introductory and faster-paced would have been nice. I think Frenkel hit that balance between his first and second talk. Anyways, loved the subject matter of the workshop. But hated the feeling of these people swarming looking for someone important to impress during the breaks. And almost no one to get a beer with. It makes me sad.

I new most of the people already

## Additional Activities

Did you attend the reception?

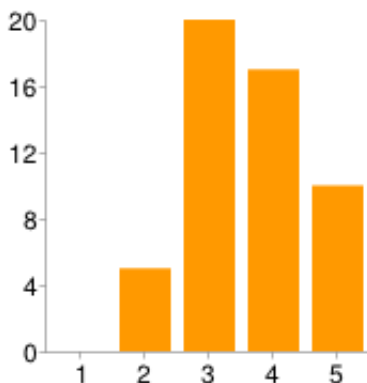




Yes	52	78%
No	15	22%

If you did attend the reception, did it help to solidify the contacts you made in the workshop?

contacts you made



1	0	0%
2	5	7%
3	20	30%
4	17	25%
5	10	15%

Please provide any comments on the reception

Very good reception.

It was so crowded, that I found it hard to get food and talk to people, and just ended up leaving for the night.

It was rather crowded, but otherwise great!

it was great!

I was in a research meeting during the reception.

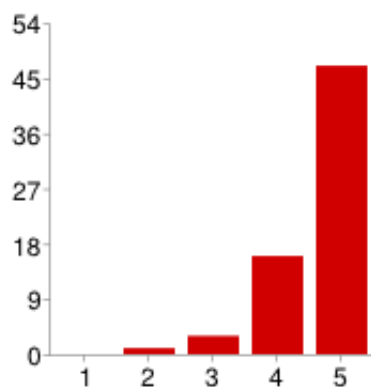
Good food.

The reception was on the first day. I was reuniting with old friends and meeting new faces, but there are only so many people you can meet on the first evening.

I think social settings where we're forced to sit at tables make it easier to meet new people

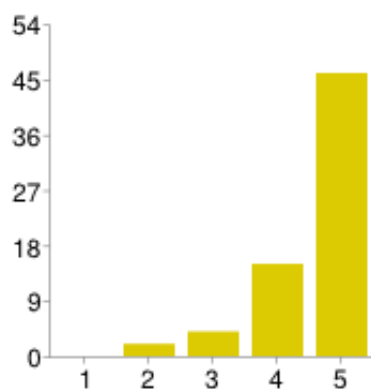
## Venue

I found the MSRI staff helpful



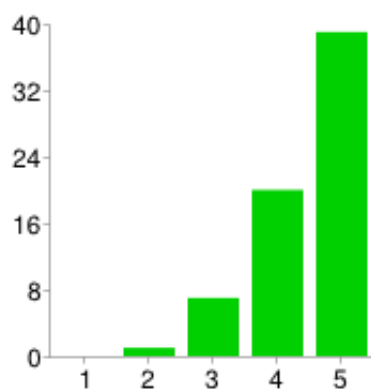
1	0	0%
2	1	1%
3	3	4%
4	16	24%
5	47	70%

The MSRI physical facilities were conducive for such a workshop



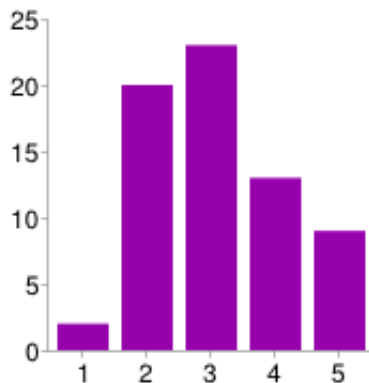
1	0	0%
2	2	3%
3	4	6%
4	15	22%
5	46	69%

The MSRI computer facilities were adequate for such a workshop



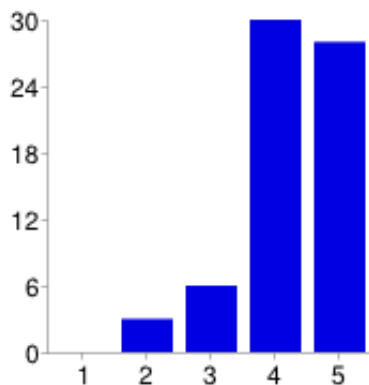
1	0	0%
2	1	1%
3	7	10%
4	20	30%
5	39	58%

The MSRI lunch arrangements were satisfactory



1	2	3%
2	20	30%
3	23	34%
4	13	19%
5	9	13%

### The MSRI tea arrangements were satisfactory



1	0	0%
2	3	4%
3	6	9%
4	30	45%
5	28	42%

### Additional comments on the venue

I wasn't a fan of the lunch at this workshop or the women's. If only there were hot lunches like at the grad workshop in summer '12! However, the afternoon snacks were amazing!! 5 stars!! The bowls of berries and peaches etc to go on angelfood cake was awesome!!

Lunch items were overpriced and there wasn't any alternative due to MSRI location.

Perhaps it would make sense to at least subsidize lunch items to make the price look reasonable, if not to provide lunch free of cost

I packed my own lunch-- quicker and cheaper.

I'm not really in a position to comment on the computing, as I am here for the semester, so have different access to that of a workshop participant I think.

The breakfast (prepacked pastries) was not that good. The orange juice was good, but I would suggest better breakfast options: bagels, fruit, better pastries, etc.

Maybe we need more restrooms.

I didn't interact much with the MSRI staff

Catering could have been improved. I am very grateful for what was provided, but I know better lunches and breakfasts would help convey the importance and professionalism of the Institute. I don't exactly know what could be done about this, but the cramped and loud area used for break between talks was not as conducive to pleasant and mathematically interesting conversation as I have experienced at other conferences. I

very much enjoyed the conference and don't mean to be overly critical; I'm just trying to be constructive.

No further comments

It would be nice to have some non-sweet breakfast options

More food options would have been better.

I would have preferred more healthy alternatives at tea (fresh fruit/vegetables). Some days there was fruit that seemed frozen or canned. And pastries/bagels, other starchy or unhealthy foods. N/A should be an option for some of the above questions.

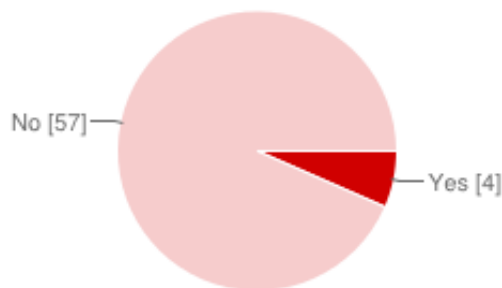
## MSRI Wireless Network

Did you use MSRI's wireless network?



Yes	57	85%
No	10	15%

Did you experience any difficulties with the network?



Yes	4	6%
No	57	85%

If you did experience difficulties with the network, please explain:

Lack of connectivity (no ip address given) and slow speeds

N/A.

Bad connection, low speed

Slow connection when using Skype

Slow connection, connection drops

## Thank you for completing this survey

We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.

I'm calling this workshop "missed connections for men." Or maybe it was just me. But I made no new friends here, and I had no interesting conversations about math or on a personal level with anyone I didn't meet somewhere else before. That said, I did get to know one or two people better who I'd barely known before and that was nice. There do not seem to be many women in geometric representation theory -- maybe that is part of what made the atmosphere vaguely unpleasant. Often I felt really out of place and quite miserable without knowing why. I just wanted to be somewhere else. Except during the talks, I felt I was where I wanted to be. So it was not the math it was the people. If I try to incorporate geometric representation theory into my research path, it won't be to make friends.

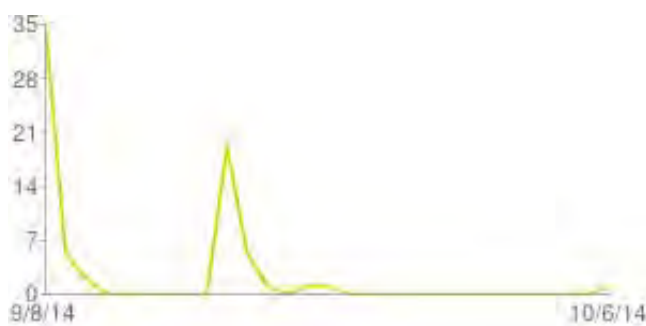
Thank you for the wonderful workshop, everyone!

It was an excellent workshop! Thanks so much to the organizers and to MSRI.

Thank you for the experience and the funding. I learned a lot!

I really appreciated the videos of the lectures were posted almost immediately.

## Number of daily responses



# Introductory Workshop: Geometric Representation Theory

## September 2 - 5, 2014

### Additional Survey Responses

#### Additional comments on your personal assessment

- I made a lot of personal and collaborative connections during the workshop. This workshop definitely helped me in expanding my research interests.
- I already knew most of the people at the workshop, but that isn't a criticism I shouldn't think.
- The workshop helped me gain a better perspective of the overall research area. It also benefited my specific research problem through discussions with visiting experts.
- The required background knowledge was more than what I was expecting from an introductory workshop, but the lectures were well enough presented that I have a clear understanding of what I need to study on to get up to speed.
- I new most of the people already
- I liked the atmosphere at the women's workshop better, though I liked the talks at the coed workshop better. Somehow between talks there were so many people I didn't know what to do with myself, and felt nervous and uncomfortable. It felt intense and not always friendly. When I did have conversations with people they were often about trivial or boring things, no one would attempt to start a conversation about math with me. And people weren't very social in the afterhours. But I loved the talks and found the level to be a mixture of truly introductory and challenging. Pramod Achar's talks were maybe my favorites of this week. He was very clear and covered interesting material. I loved that Olivier Schiffmann gave very difficult talks and really opened up his research to the audience, giving a lot of detail, unlike Ginzburg, who crammed everything interesting he had to say into the last 5 minutes. Besides forcing him to speak, someone should have forced him to put the introductory material into one lecture and then spend the next two lectures explaining his proof of Kac's conjecture and the other conjecture he has ideas about proving. I think everyone would have liked to hear more details about those topics, and where else could we have learned them, but instead he spent 3 hours defining a quiver and its double and its framing. Maybe the organizers wanted the lectures to be very introductory, but a mix of introductory and faster-paced would have been nice. I think Frenkel hit that balance between his first and second talk. Anyways, loved the subject matter of the workshop. But hated the feeling of these people swarming looking for someone important to impress during the breaks. And almost no one to get a beer with. It makes me sad.
- Having most lecturers give a series of 3 lectures was FANTASTIC. I got so much out of that, and it ensured each of their 1st lectures was actually introductory. I found those talks well-prepared and structured.

#### Additional comments on the venue

- More food options would have been better.
- I'm not really in a position to comment on the computing, as I am here for the semester, so have different access to that of a workshop participant I think.
- Lunch items were overpriced and there wasn't any alternative due to MSRI location. Perhaps it would make sense to at least subsidize lunch items to make the price look reasonable, if not to provide lunch free of cost
- I didn't interact much with the MSRI staff

- Maybe we need more restrooms.
- I packed my own lunch-- quicker and cheaper.
- The breakfast (prepacked pastries) was not that good. The orange juice was good, but I would suggest better breakfast options: bagels, fruit, better pastries, etc.
- It would be nice to have some non-sweet breakfast options
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**We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.**

- Thank you for the wonderful workshop, everyone!
- It was an excellent workshop! Thanks so much to the organizers and to MSRI.
- I'm calling this workshop "missed connections for men." Or maybe it was just me. But I made no new friends here, and I had no interesting conversations about math or on a personal level with anyone I didn't meet somewhere else before. That said, I did get to know one or two people better who I'd barely known before and that was nice. There do not seem to be many women in geometric representation theory -- maybe that is part of what made the atmosphere vaguely unpleasant. Often I felt really out of place and quite miserable without knowing why. I just wanted to be somewhere else. Except during the talks, I felt I was where I wanted to be. So it was not the math it was the people. If I try to incorporate geometric representation theory into my research path, it won't be to make friends.
- Thank you for the experience and the funding. I learned a lot!
- I really appreciated the videos of the lectures were posted almost immediately.

**If you did experience difficulties with the network, please explain:**

- Slow connection when using Skype
- Lack of connectivity (no ip address given) and slow speeds
- Bad connection, low speed
- Slow connection, connection drops

**Please provide any comments on the reception**

- The reception was on the first day. I was reuniting with old friends and meeting new faces, but there are only so many people you can meet on the first evening.
- I think social settings where we're forced to sit at tables make it easier to meet new people
- Very good reception.
- I was in a research meeting during the reception.
- It was rather crowded, but otherwise great!

- It was so crowded, that I found it hard to get food and talk to people, and just ended up leaving for the night.
- it was great!
- Good food.

**Additional comments on the workshop organization**

- Many of the talks too elementary
- Excellent in every aspects!
- I was an organizer, so perhaps shouldn't comment on that. Also, the time between talks for discussions was limited for me probably because I was an organizer!
- The talks were very uneven, some of them pitched far too high. However, the talks by Hales and Frenkel were outstanding.
- Great lineup of speakers and topics.
- Not enough space for informal discussions
- The organization was phenomenal!
- Time to talk between lectures was limited, particularly as many sessions ran overtime. This also made it harder to keep up by the end of the day (five long lectures with short breaks is both physically and mentally exhausting).
- I liked the relatively small number of lectures and the lecture series format
- overall great, though it would be nice to have tastier and more nutritious lunches (since restaurants are far away)
- I would have preferred a 2hour lunch break, and then having the talks run later into the afternoon. It felt crowded to have a 1.5 break then end at 4:30, which is fairly early.
- very good



## **Categorical Structures in Harmonic Analysis**

November 17 to 21, 2014

MSRI, Berkeley, CA, USA

Organizers:

**Thomas Haines (University of Maryland)**

**Florian Herzig (University of Toronto)**

**David Nadler (University of California, Berkeley)**

## REPORT ON THE MSRI TOPICAL WORKSHOP “CATEGORICAL STRUCTURES IN HARMONIC ANALYSIS” NOVEMBER 17–21, 2014

### 1. ORGANIZERS

- Thomas Haines (Maryland)
- Florian Herzig (Toronto)
- David Nadler (Berkeley)

### 2. SCIENTIFIC DESCRIPTION

The one-semester MSRI program *Geometric Representation Theory* brought together researchers at the frontiers of the subject, with an emphasis on its consequences for the Langlands program. The subject has had profound interactions with many other fields, including number theory, harmonic analysis, and theoretical physics, all of which appeared prominently in the Topical Workshop.

The main theme of the Topical Workshop was the role of *categorical structures* found in geometric constructions. There are many instances where difficult questions in representation theory can be translated into more tractable questions in geometry. Celebrated examples of this include Grothendieck’s sheaf-function correspondence, Lusztig’s character sheaves, Deligne-Lusztig’s theory of representations of finite groups of Lie type, Kazhdan-Lusztig’s theory of Hecke algebras, Lusztig and Nakajima’s theory of quiver varieties, Ngô’s proof of the Fundamental Lemma, and the rapidly developing fields of canonical bases, cluster algebras, algebraic positivity, and categorification of manifold and knot invariants.

The Topical Workshop was a forum for researchers from diverse subjects to come together and compare problems and strategies for solutions. The speakers emphasized background and context in their presentations, and many of the talks (now in the MSRI film archive) provide the best currently available expository accounts of new topics. One of our main guidelines in making funding decisions was to offer support to participants in earlier stages of their careers, and as a result, the audience included a large number of students and postdocs, a noteworthy contribution to the continued health of a subject where expert knowledge has dramatically outpaced the written literature. The

workshop also attracted participation from the concurrent MSRI program *New Geometric Techniques in Number Theory and Automorphic Forms*, an auspicious development for further cross-pollination of ideas.

### 3. HIGHLIGHTS OF PRESENTATIONS

The speakers at the Topical Workshop included leading international figures from several generations and different mathematical cultures:

- Konstantin Ardakov (University of Oxford)
- Joseph Bernstein (Tel Aviv University)
- Alexander Braverman (Brown University)
- Ngo Bao Chau (University of Chicago)
- Hélène Esnault (Freie Universität Berlin)
- Dennis Gaitsgory (Harvard University)
- Alexander Goncharov (Yale University)
- Julia Gordon (University of British Columbia)
- Ivan Mirković (University of Massachusetts, Amherst)
- Hiraku Nakajima (Kyoto University)
- Yiannis Sakellaridis (Rutgers University)
- Peter Scholze (Universität Bonn)
- Marie-France Vignéras (Université de Paris VII (Denis Diderot))
- Geordie Williamson (Max-Planck-Institut für Mathematik)
- Zhiwei Yun (Stanford University)
- Xinwen Zhu (California Institute of Technology)

The opening workshop talk by Peter Scholze (Bonn) was the highlight of the workshop. Using his theory of perfectoid spaces, he can construct analogues of Beilinson-Drinfeld Grassmannians in the setting of  $p$ -adic fields. This is surprising because traditional Beilinson-Drinfeld Grassmannians live over the self-product of the fixed base curve and self-products over the integers or  $p$ -adic integers do not naively make any sense. Details of his construction were explained in his Chancellor's Professor graduate course. There is considerable excitement that by further developing these methods, ideas from geometric Langlands may find applications to the classical Langlands correspondence.

In his Evans Lecture during the workshop, Ngo Bao Chau (Chicago) discussed Langlands' proposal for functoriality beyond endoscopy and his progress studying Hitchin systems constructed from Vinberg semigroups. In his workshop talk, Dennis Gaitsgory (Harvard) reported on his student Simon Schieder's thesis work on Picard-Lefschetz oscillators which encode the degeneration of moduli of bundles along Vinberg semigroups. Yiannis Sakellaridis (Rutgers) presented parallel

constructions in a classical setting for the degeneration of spherical varieties along analogues of Vinberg semigroups. Julia Gordon (UBC) explained the model-theoretic methods (motivic integration) that reduced the statement of the Fundamental Lemma to the function field case, the setting of Ngo's proof. She also explained new applications to uniform bounds on orbital integrals.

The focus on the ongoing or potential impact of geometry to the classical or  $p$ -adic Langlands program continued in many other workshop talks. Joseph Bernstein (Tel Aviv) talked about the "relative Langlands program," specifically introducing canonical maps between periods of a fixed automorphic representation, leading to a new global invariant of automorphic representations, which he made explicit in several examples. Alexander Braverman (Brown) presented a conjectural construction of local  $L$ -factors associated to representations of reductive groups in the local function field case. In contrast to the standard construction it relies on geometric methods, namely perverse sheaves on loop spaces. Konstantin Ardakov (Oxford) reported on progress on establishing an analogue of Beilinson-Bernstein localisation for locally analytic representations of  $p$ -adic reductive groups. There is hope that this will eventually provide a geometric approach to the  $p$ -adic Langlands correspondence. Xinwen Zhu (Caltech) explained his proof of the geometric Satake correspondence in mixed characteristic and its consequences for Rapoport-Zink spaces, part of his incredible recent results applying geometric techniques to arithmetic questions. In a more traditional representation-theoretic vein, Marie-France Vignéras (Paris 7) explained the classification of irreducible modules of the Iwahori-Hecke algebra of an arbitrary  $p$ -adic reductive group over a field of characteristic  $p$ .

Another prominent theme of workshop talks was the close interaction between geometric representation theory and high-energy physics. Alexander Goncharov (Yale) gave a highly engaging talk with many colorful pictures explaining his combinatorial approach to canonical bases via their relation to the tropical points of positive varieties. Zhiwei Yun (Stanford) described his construction of finite-dimensional representations of rational Cherednik algebras from the cohomology of affine Springer fibers and Hitchin fibers with extra symmetry. Ivan Mirkovic (U Mass) gave a detailed account of his factorization construction of new "affine Grassmannians" starting purely from abelian data. Hiraku Nakajima (Kyoto) presented his proposal for a mathematically precise construction of the coordinate ring of the mysterious hyperkahler Coulomb branch for 3d  $N = 4$  supersymmetric gauge theories.

Finally, there were talks about exciting new developments in characteristic  $p$  geometry and modular representation theory. Geordie Williamson (MPI) gave a typically beautiful presentation of the important role of the “failure” of Hodge theory, and ultimately the Decomposition Theorem, for sheaves with characteristic  $p$  coefficients. He explained how this underlies his discovery of counterexamples to Lusztig’s conjecture on modular representations and new asymptotics for when it holds. Hélène Esnault (FU Berlin) gave a highly valuable survey on the relationship between different versions of the fundamental group of a reasonable variety. Traditionally, this is studied in characteristic zero, while her talk focused on characteristic  $p$  where much current research interest lies.

## Organizers

First Name	Last Name	Institution
Thomas	Haines	University of Maryland
Florian	Herzig	University of Toronto
David	Nadler	University of California, Berkeley

## Speakers

First Name	Last Name	Institution
Konstantin	Ardakov	University of Oxford
Ngo	Bao Chau	University of Chicago
Joseph	Bernstein	Tel Aviv University
Alexander	Braverman	Brown University
Helene	Esnault	Freie Universitat Berlin
Dennis	Gaitsgory	Harvard University
Alexander	Goncharov	Yale University
Julia	Gordon	University of British Columbia
Ivan	Mirkovic	University of Massachusetts, Amherst
Hiraku	Nakajima	Kyoto University
Yiannis	Sakellaridis	Rutgers University
Peter	Scholze	Universitat Bonn
Marie-France	Vigneras	Universite de Paris VII (Denis Diderot)
Geordie	Williamson	Max-Planck-Institut fur Mathematik
Zhiwei	Yun	Stanford University
Xinwen	Zhu	California Institute of Technology



## Categorical Structures in Harmonic Analysis

November 17-21, 2014

### Schedule

<b>Monday, November 17, 2014</b>			
9:15 AM - 9:30 AM	Simons Auditorium		Welcome
9:30 AM - 10:30 AM	Simons Auditorium	Peter Scholze	Some structures from geometric Langlands in the setting of a p-adic field
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00 PM	Simons Auditorium	Julia Gordon	Transfer principles and uniform estimates for orbital integrals
12:00 PM - 2:00 PM	Atrium		Lunch
2:00 PM - 3:00 PM	Simons Auditorium	Zhiwei Yun	Geometric representations of rational Cherednik algebras
3:00 PM - 3:30 PM	Atrium		Tea
4:10 PM - 5:00 PM	740 Evans Hall, UC Berkeley	Ngo Bảo Châu	Geometry related the beyond endoscopy proposal
<b>Tuesday, November 18, 2014</b>			
9:30 AM - 10:30 AM	Simons Auditorium	Joseph Bernstein	Periods and Global Invariants of Automorphic representations
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00 PM	Simons Auditorium	Hiraku Nakajima	Coulomb branches of 3d N=4 gauge theories and motivic DT-invariants
12:00 PM - 2:00 PM	Atrium		Lunch
2:00 PM - 3:00 PM	Simons Auditorium	Alexander Braverman	Local L-factors and perverse sheaves on certain loop
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:30 PM	Simons Auditorium	Ivan Mirkovic	LOOP GRASSMANNIANS from the point of view of LOCAL SPACES
4:30 PM - 6:20 PM	Atrium		Reception
<b>Wednesday, November 19, 2014</b>			
9:30 AM - 10:30 AM	Simons Auditorium	Hélène Esnault	Relation between the Étale fundamental group and stratifications.
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00 PM	Simons Auditorium	Konstantin Ardakov	Equivariant D-cap modules on rigid analytic spaces
<b>Thursday, November 20, 2014</b>			
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00 PM	Simons Auditorium	Geordie Williamson	Modular representation theory and the Hecke category
12:00 PM - 2:00 PM	Atrium		Lunch
2:00 PM - 3:00 PM	Simons Auditorium	Dennis Gaiety	Picard-Lefschetz oscillators for the Drinfeld-Lafforgue compactification
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:30 PM	Simons Auditorium	Alexander Goncharov	Ideal webs, moduli spaces of local systems, and 3d Calabi-Yau categories
<b>Friday, November 21, 2014</b>			
9:30 AM - 10:30 AM	Simons Auditorium	Marie-France Vigneras	Simple modules of pro-p Iwahori Hecke algebras
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00 PM	Simons Auditorium	Yiannis Sakellaridis	Non-categorical structures in harmonic analysis
12:00 PM - 2:00 PM	Atrium		Lunch
2:00 PM - 3:00 PM	Simons Auditorium	Xinwen Zhu	Commutativity constraints revisited
3:00 PM - 3:30 PM	Atrium		Tea

<b>Participants</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Noriyuki	Abe	Hokkaido University
Pramod	Achar	Louisiana State University
Xiaohua	Al	Institut de Mathematiques de Jussieu
Andrea	Appel	University of Southern California
Konstantin	Ardakov	University of Oxford
Ngo	Bao Chau	University of Chicago
David	Ben-Zvi	University of Texas
Dario	Beraldo	University of Oxford
Joseph	Bernstein	Tel Aviv University
Raphael	Beuzart	Institute for Advanced Study
Thomas	Bitoun	Massachusetts Institute of Technology
Alexandre	Bouayad	University of Cambridge
Alexander	Braverman	Brown University
Ana	Caraiani	Princeton University
Jorge	Cely	University of Pittsburgh
Shuyang	Cheng	University of Chicago
Jingren	Chi	University of Chicago
Pierre	Clare	Dartmouth College
Lee	Cohn	University of Texas
Zsuzsanna	Dancso	MSRI - Mathematical Sciences Research Institute
Tanmay	Deshpande	Kavli Institute for the Physics and Mathematics of the Universe
Elden	Elmanto	Northwestern University
Helene	Esnault	Freie Universitat Berlin
Peter	Fiebig	Friedrich-Alexander-Universitat Erlangen-Nurnberg
Jessica	Fintzen	Harvard University
Dragos	Fratila	Universite de Paris VII (Denis Diderot)
Ildar	Gaisin	Institut de Mathematiques de Jussieu
Dennis	Gaitsgory	Harvard University
Benjamin	Gammage	University of California, Berkeley
Iordan	Ganev	University of Texas
Sachin	Gautam	Columbia University
Emanuele	Ghedin	University of Oxford
Alexander	Goncharov	Yale University
Julia	Gordon	University of British Columbia
Vesselin	Gueorguiev	CSU Stanislaus
Sam	Gunningham	University of Texas
Thomas	Haines	University of Maryland
Paul	Hamacher	Technische Universitat Munchen
Michael	Harris	Institut de Mathematiques de Jussieu
xiao	he	Laval University
Aron	Heleodoro	Northwestern University
Florian	Herzig	University of Toronto
Justin	Hilburn	University of Oregon
Quoc	Ho	University of Chicago



<b>Participants</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Christine	Huyghe	Universite de Strasbourg I (Louis Pasteur)
Brian	Hwang	California Institute of Technology
Naoki	Imai	University of Tokyo
David	Jordan	University of Edinburgh
Daniel	Juteau	Universite de Caen
Chris	Kapulkin	University of Western Ontario
Kiran	Kedlaya	University of California, San Diego
Inkang	Kim	Korea Institute for Advanced Study (KIAS)
Oscar	Kivinen	Aalto University
Clemens	Koppensteiner	Northwestern University
Oleksandr	Kravets	Columbia University
Kai-Wen	Lan	University of Minnesota, Twin Cities
Arthur-Cesar	Le Bras	Institut de Mathematiques de Jussieu
Hao	Li	Johns Hopkins University
Yiqiang	Li	University at Buffalo (SUNY)
Jie	LIN	Universite de Paris VII (Denis Diderot)
Elon	Lindenstrauss	Hebrew University
Chia-Cheng	Liu	University of Toronto
Luis	Lomeli	MSRI - Mathematical Sciences Research Institute
Li	MA	Universite de Paris VI (Pierre et Marie Curie)
Shotaro	Makisumi	Stanford University
Jacob	Matherne	Louisiana State University
Akhil	Mathew	University of California, Berkeley
Carl	Mautner	Max-Planck-Institut fur Mathematik
Kevin	McGerty	University of Oxford
Ariane	Mezard	Institut de Mathematiques de Jussieu
Ivan	Mirkovic	University of Massachusetts, Amherst
Dinakar	Muthiah	University of Toronto
David	Nadler	University of California, Berkeley
Hiraku	Nakajima	Kyoto University
Marc-Hubert	Nicole	Universite d'Aix-Marseille (AMU)
Emily	Norton	Kansas State University
Tadashi	Ochiai	Osaka University
Hendrik	Orem	University of Texas
Eric	Peterson	University of California, Berkeley
Dipendra	Prasad	Tata Institute of Fundamental Research
Michael	Rapoport	Universitat Bonn
Sam	Raskin	Massachusetts Institute of Technology
Kenneth	Ribet	University of California, Berkeley
philippe	roche	Centre National de la Recherche Scientifique (CNRS)
Pavel	Safronov	University of Oxford
Sergei	Sagatov	University of Chicago
Daniel	Sage	Louisiana State University
Yiannis	Sakellaridis	Rutgers University

<b>Participants</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Barbara	Schalke	Friedrich-Alexander-Universitat Erlangen-Nurnberg
Travis	Schedler	University of Texas
Simon	Schieder	Harvard University
Peter	Scholze	Universitat Bonn
Benjamin	Schraen	Centre National de la Recherche Scientifique (CNRS)
Friederike	Steglich	Friedrich-Alexander-Universitat Erlangen-Nurnberg
Cheng-Chiang	Tsai	Harvard University
Monica	Vazirani	University of California, Davis
Marie-France	Vigneras	Universite de Paris VII (Denis Diderot)
Kari	Vilonen	Northwestern University
Michael	Viscardi	Massachusetts Institute of Technology
Alex	Weekes	University of Toronto
Geordie	Williamson	Max-Planck-Institut fur Mathematik
Tian An	Wong	City University of New York (CUNY)
Ting	Xue	University of Helsinki
Oded	Yacobi	University of Sydney
Yaping	Yang	MSRI - Mathematical Sciences Research Institute
Shilin	Yu	University of Pennsylvania
Zhiwei	Yun	Stanford University
Gufang	Zhao	Institut de Mathematiques de Jussieu
Qiao	Zhou	University of California, Berkeley
Xinwen	Zhu	California Institute of Technology

**Officially Registered Participant Information**

<b>Participants</b>		<b>110</b>
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<b>Gender</b>		<b>110</b>
<b>Male</b>	83.64%	92
<b>Female</b>	15.45%	17
<b>Declined to state</b>	0.91%	1

<b>Ethnicity*</b>		<b>116</b>
<b>White</b>	56.03%	65
<b>Asian</b>	31.03%	36
<b>Hispanic</b>	1.72%	2
<b>Pacific Islander</b>	0.00%	0
<b>Black</b>	0.00%	0
<b>Native American</b>	0.00%	0
<b>Mixed</b>	2.59%	3
<b>Declined to state</b>	8.62%	10

\* ethnicity specifications are not exclusive

# 42 responses

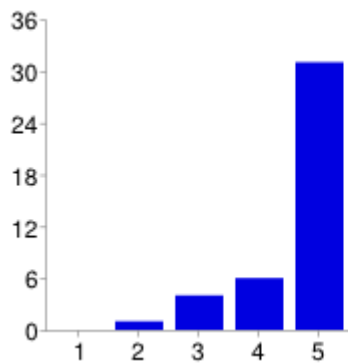
42 Responses/110 Participants = 38% Response Rate

[View all responses](#)   [Publish analytics](#)

## Summary

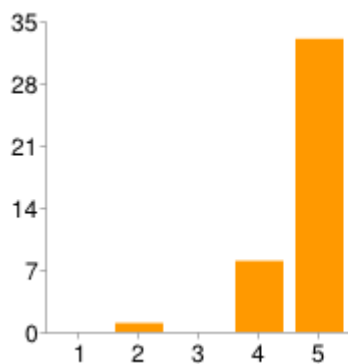
### Workshop assessment

#### The workshop was intellectually stimulating



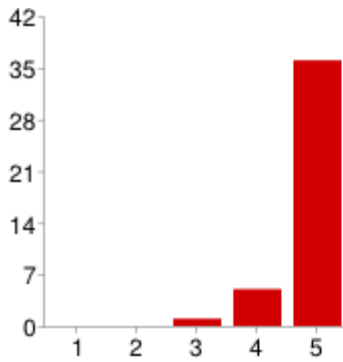
1	<b>0</b>	0%
2	<b>1</b>	2%
3	<b>4</b>	10%
4	<b>6</b>	14%
5	<b>31</b>	74%

#### The overall experience of the workshop was worthwhile



1	<b>0</b>	0%
2	<b>1</b>	2%
3	<b>0</b>	0%
4	<b>8</b>	19%
5	<b>33</b>	79%

#### The time between lectures was adequate for discussion



1	0	0%
2	0	0%
3	1	2%
4	5	12%
5	36	86%

### Additional comments on the workshop organization

I greatly appreciated that the conference schedules were not over-packed (more time for discussion).

There are two themes of the workshop, those are parent programs, Geometric Representation Theory and New Geometric Methods in Number Theory and Automorphic Forms. I am interested in the first theme, and some lectures from the second were difficult to follow.

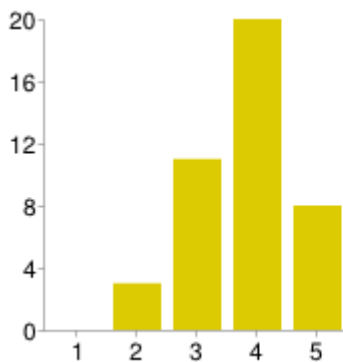
Excellent organization

Wonderful!

Excellent.

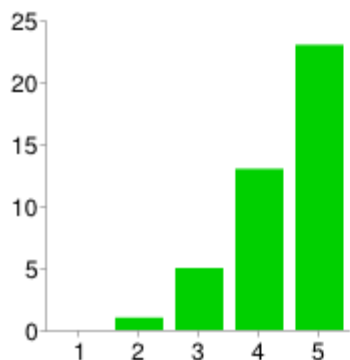
### Personal assessment

#### I was well prepared to benefit from the lectures



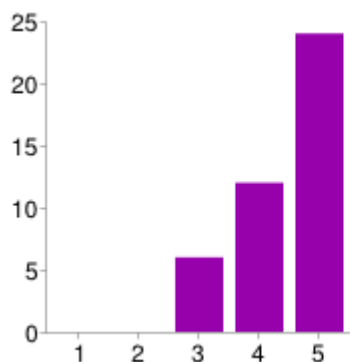
1	0	0%
2	3	7%
3	11	26%
4	20	48%
5	8	19%

#### My interest in the subject matter was increased by the workshop



1	<b>0</b>	0%
2	<b>1</b>	2%
3	<b>5</b>	12%
4	<b>13</b>	31%
5	<b>23</b>	55%

### The workshop helped me meet people with similar scientific interests



1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>6</b>	14%
4	<b>12</b>	29%
5	<b>24</b>	57%

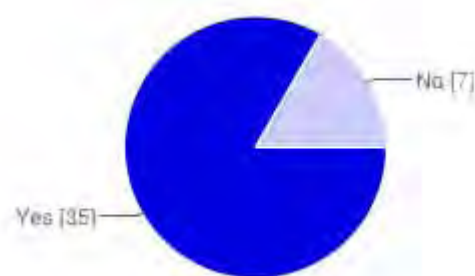
### Additional comments on your personal assessment

I found several lectures extremely stimulating; I am still reading some more background literature and watching the videos of a couple lectures again, and my point of view on a whole field is changing.

Very stimulating

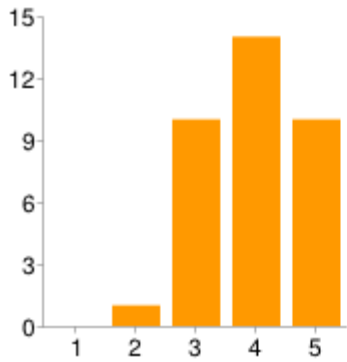
### Additional Activities

#### Did you attend the reception?



Yes	<b>35</b>	83%
No	<b>7</b>	17%

If you did attend the reception, did it help to solidify the contacts you made in the workshop?



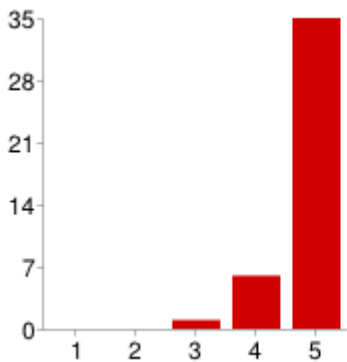
1	<b>0</b>	0%
2	<b>1</b>	2%
3	<b>10</b>	24%
4	<b>14</b>	33%
5	<b>10</b>	24%

### Please provide any comments on the reception

the reception was great but mostly I talked to friends I already know. Mathematically I think other times were more productive than the reception! But it was great!

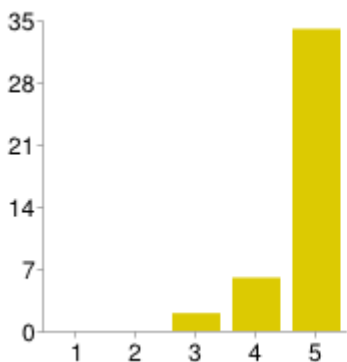
## Venue

### I found the MSRI staff helpful



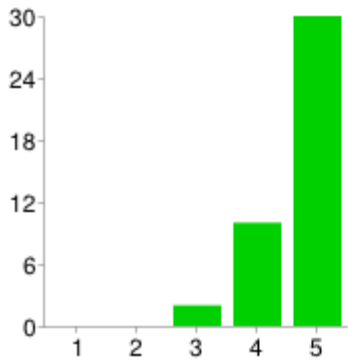
1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>1</b>	2%
4	<b>6</b>	14%
5	<b>35</b>	83%

### The MSRI physical facilities were conducive for such a workshop



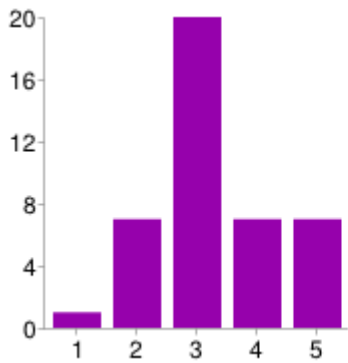
1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>2</b>	5%
4	<b>6</b>	14%
5	<b>34</b>	81%

### The MSRI computer facilities were adequate for such a workshop



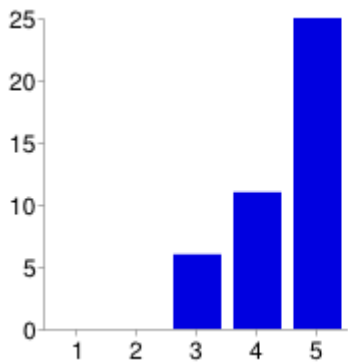
1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>2</b>	5%
4	<b>10</b>	24%
5	<b>30</b>	71%

### The MSRI lunch arrangements were satisfactory



1	<b>1</b>	2%
2	<b>7</b>	17%
3	<b>20</b>	48%
4	<b>7</b>	17%
5	<b>7</b>	17%

### The MSRI tea arrangements were satisfactory



1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>6</b>	14%
4	<b>11</b>	26%
5	<b>25</b>	60%

### Additional comments on the venue

Well as people pointed out to me, there are no lights in the hallways so that you can't have a mathematical discussion in those spaces once the sun goes down. Maybe there should be lights? I think the MSRI venue is great. The view is inspiring and there is a lot of space for discussions, lots of natural light from windows and skylights so that one feels comfortable in the space, great offices, and so on. I think MSRI is quite a special place and very beautiful.

Enabling pre-ordered food together with on-site catering would reduce lines and provide better options. Also, coffee at MSRI is pretty bad.

Make every day a bagel day.



MSRI needs a proper cafeteria or similar option.

Lunch was too expensive and line too long.

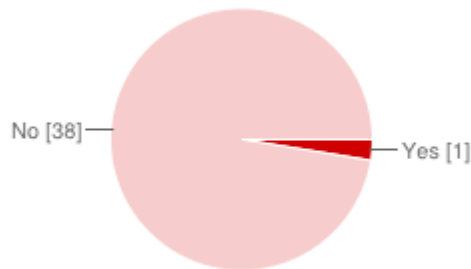
## MSRI Wireless Network

**Did you use MSRI's wireless network?**



Yes	<b>38</b>	90%
No	<b>4</b>	10%

**Did you experience any difficulties with the network?**



Yes	<b>1</b>	2%
No	<b>38</b>	90%

**If you did experience difficulties with the network, please explain:**

No responses yet for this question.

## Thank you for completing this survey

**We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.**

Thanks!

The conference was very enjoyable!

Thank you for a fantastic workshop! I enjoyed it much more than I was expecting -- it was a very intimidating line-up of speakers and an intimidating topic, and I was afraid I would waste my time to come here, but quite the opposite. A number of the talks were actually understandable :). And beyond the talks, it was an amazing group of people who attended this workshop. I enjoyed chatting with people I hadn't seen for a few years. But most of all I really enjoyed the opportunity

to talk to people who are working on projects related to mine -- these discussions were invaluable to me. It was one of the most productive visits I've had to a workshop maybe ever. Thank you to the organizers and to MSRI for putting this together and for extending to me an invitation to attend. Thank you thank you thank you!

## Number of daily responses



**Connections for Women:  
New Geometric Methods in Number Theory  
and Automorphic Forms**  
August 14 to 15, 2014  
MSRI, Berkeley, CA, USA

Organizers:

**Wenching Li (Pennsylvania State University)**

**Elena Mantovan (California Institute of Technology)**

**Sophie Morel (Princeton University)**

**Ramdorai Sujatha (University of British Columbia)**

# Report on the MSRI workshop "Connections for Women: New Geometric Methods in Number Theory and Automorphic Forms", August 14-15, 2014

ORGANIZERS: Wenching Li (Pennsylvania State University), Elena Mantovan (California Institute of Technology), Sophie Morel (Princeton University), Ramdorai Sujatha (University of British Columbia).

## 1 Description of the Workshop

This is a brief report on the activities of the 'Connections for Women' workshop associated with the program "New Geometric Methods in Number Theory and Automorphic Forms", held on Aug 14-15, 2014. The aim of this 2-day workshop was to showcase the contributions of women mathematicians in areas related to the three main themes of the associated MSRI program: Shimura varieties, p-adic automorphic forms, periods and L-functions. It was also a wonderful opportunity to bring together women working in this area at all stages in their careers. In fact, many of the participants were graduate students and young postdocs. The workshop featured 8 research lectures reporting on recent progress in the field; it also included an informal panel discussion on career issues and a social dinner for the female participants.

We postpone discussion of the scientific achievements of the workshop to later, and first report on the goals we set for the workshop, the structure of the planned activities and our assessment of its success and accomplishments.

### 1.1 Organized Activities

First and foremost, we wished for this workshop to be an exciting and engaging research activity. We hoped each participant would have the opportunity to discuss mathematics, and to present (whether in lectures or in conversation) their own research. Lectures were all well attended, and several mathematical conversations sparked during the breaks both inside the auditorium and outside at the many blackboards in the common area.

Yet, this was also without doubt one of those rare opportunities for women in the field to meet each other, and make connections. It is often the case that younger mathematicians

have many questions to ask and rarely the opportunity to do so in a friendly environment outside their home institution. We wished for this to be one of those occasions, and with that intention we chose to host an informal panel discussion on career issues. Most if not all participants attended the panel, and the discussion ranged from general career advice to some gender related issues. Among other topics we discussed the convenience of having a mathematical journal, how to choose a mentor and how to be one, helpful advice for job applicants and the role of web forums such as Math Overflow. Yet, one of the most animated discussions was in fact on gender, specifically on how both men and women react to the perception that affirmative action gives women an advantage on job searches. The panel ran easily for the scheduled hour and it had to be interrupted in time for the dinner. Many of the conversations during coffee and lunch breaks the following day centered around questions that did not find time during the panel.

The social dinner in the evening was just the perfect way to end a long and exciting first day. Meetings outside work environment are often catalysts to deeper relations, and new friendships. This dinner was mostly an opportunity for networking, for people to share their personal experience. Many of the conversations centered around early career experiences and on how to balance work and family.

## 1.2 Assessment

Overall, we received great positive feedback on the workshop. Everyone really enjoyed the lectures; several people positively commented on the great impact of having MSRI workshops recorded and available for viewing by the broader mathematical community. They serve as a valuable reference both for active researchers as well as younger entrants to this important area of mathematics.

The panel and dinner were also well received, and the overall perception was that the activities were well suited for the event. Yet, some of the following constructive remarks were brought to the attention of the organizers and are worth considering when planning future similar activities.

It was quite evident that there was a widespread confusion regarding the participation of male mathematicians to the workshop. Some men already in residence at MSRI were unsure whether they were welcome to attend lectures, some assumed they were not. Others assumed they were but they extended their participation to the social dinner and had to be turned down. These made for few awkward conversations which would probably be avoidable in the future by making the "rules of engagement" crystal clear, if possible in writing on the website or by announcement once at MSRI. This might be the most serious of the complaints.

A different question is whether the participation of male mathematicians was/should be welcome. It was our intention to be inclusive of everyone. We agreed that all would benefit by a larger audience to the lectures, and in retrospect no one objected to opening the lectures to everyone and there was no visible negative impact. We also intentionally

included male mathematicians at the panel discussion (Dr. Peter Schneider and Dr. Marc-Huber Nicole were among the panelists). We thought the discussion would benefit from including different perspectives, and in many ways it did. On the other hand, a few expressed some reservations regarding the participation of men in the panel (whether as panelist or as audience), as they feared that some of the younger participants might have felt intimidated and effectively withdrew from actively participating in the discussion. This indeed is quite possible, but hard to test (as the panel nevertheless run without gaps). The social dinner was exclusively for the female participants, and indeed there were some complaints, not just from the male mathematicians excluded from the event but also from the participants for the exclusion of spouses/partners.

Finally, a participant coming with a small child remarked that while MSRI does offer help with finding child care, those are solutions best suited for long-term visitors and members, and more could be done for short-term visitors (such as workshop participants). This opinion was shared by others as well, and some mentioned making a room available for on-site babysitting during workshops as a possible solution.

Overall thought, these are quite minor flaws in what was a very successful workshop; the majority/most of the participants will no doubt happily participate in more events of this type in the future.

## 2 Scientific description: highlights of presentations

The range of talks covered current areas of research that uses a wide variety of techniques and methods in studying a broad range of problems in number theory. Starting with the problem of counting points, on curves over number fields or finite fields, the talks progressed into  $p$ -adic theory as well as automorphic theory, and connections between these different areas of number theory.

Throughout  $p$  denotes an odd prime number. The first two talks were broadly related to the theme of counting rational points on curves over finite fields.

The first speaker was Ling Long from Louisiana State University and the title of the talk was ‘Generalized Legendre Curves and Abelian Varieties with Quaternionic multiplication’. The talk discussed some results on generalized Legendre curves and 2-dimensional abelian varieties with Quaternion Multiplication, based on explicit computations on the corresponding Galois representations and periods. This was joint work with Alyson Deines, Jenny Fuselier, Holly Swisher and Fang-Ting Tu. The arithmetic triangle groups are closely related to modular curves, and a model for the modular curve associated to the arithmetic triangle group  $(\infty, \infty, \infty)$  is the Legendre family of curves  $y^2 = x(x-1)(x-\lambda)$ . There is also an associated Hypergeometric series, which is a solution of a Hypergeometric Differential equation (HDE) whose monodromy group is a triangle group. This work is motivated by the question whether the Jacobian of the associated generic generalized Legendre curve contains a 2-dimensional subabelian variety whose endomorphism algebra

contains the quaternion algebra associated with the monodromy group. This talk outlined the connections of this investigation to Galois representations, and approaching them via Hypergeometric series.

The second speaker was Julia Gordon from the University of British Columbia, on ‘Local Heuristics and exact formulas for counting elliptic curves over finite fields’, based on joint work with Jeff Achter. The underlying question was the following: How likely is a random elliptic curve over the finite field  $\mathbb{F}_p$  to have exactly  $N$  rational points, where  $N$  is a given integer in an appropriate range. An explicit answer to this question by Gekeler postulates some heuristics. In this talk, the speaker provided an explanation for Gekeler’s work and outlined a very natural connection with a formula of Langlands and Kottwitz which expresses the size of an isogeny class of principally polarized abelian varieties in terms of an orbital integral that is adelic in nature.

The two talks in the afternoon session were in the broad area of the Langlands program. The Langlands program had its origins in the work of Robert Langlands, in the middle of the last century, in trying to understand the non-abelian Galois extensions of the field of rational numbers, and more generally, their finite extensions. It has had a profound influence in the development of new research frontiers in modern number theory and continues to grow organically. The youngest offshoot of this area of research is the so-called ‘ $p$ -adic local Langlands correspondence’, which studies Galois representations of  $\mathbb{F}_p$ -vector spaces.

The first talk in the afternoon session of the first day was by Ana Caraiani from Princeton University, titled ‘Patching and  $p$ -adic local Langlands’. It was based on joint work with Matthew Emerton, Toby Gee, David Geraghty, Vytautas Paskunas and Sug Woo Shin. Let  $F/\mathbb{Q}_p$  be a finite extension. The classical Local Langlands correspondence provides a bijection between the set of irreducible (equivalence classes of) smooth representations of  $\mathrm{GL}_n(F)$  with the set of  $n$ -dimensional Frobenius semi-simple, Weil-Deligne representations of the Weil-Deligne group. The Weil-Deligne group constitutes a large part of the Galois group of the local field  $\mathbb{Q}_p$ , which in turn is a subgroup of the Galois group of the rationals. Currently, this is well-understood only for  $\mathbb{Q}_p$  and  $n = 2$ . Using the theory of completed cohomology and the Taylor-Wiles-Kisin patching technique, this work attempts to study the case of finite extensions of  $\mathbb{Q}_p$  using global methods.

The final talk on the first day was delivered by Ila Varma from Princeton University, titled ‘Local global compatibility of regular algebraic cuspidal automorphic representations when  $l \neq p$ ’. The Langlands program traditionally has two components to it; one is the global correspondence, where one studies representations of the Galois group of a number field  $F$  over  $n$ -dimensional vector spaces over  $\mathbb{Q}_p$ . The Langlands conjectures predict a relationship between these representations and algebraic cuspidal automorphic representations of  $\mathrm{GL}_n(\mathbb{A}_F)$ , where  $\mathbb{A}_F$  denotes the adèles. The conjectures also outline exactly how the local theory mentioned above dovetail compatibly into the global one. This talk discusses the compatibility statement in general, and also in some specific new cases related to work of Harris-Lan-Taylor-Thorne and Peter Scholze.

The first talk on the second day of the workshop was delivered by Sarah Zerbes from

University College, London, titled ‘Euler systems and the Birch-Swinnerton-Dyer (BSD) conjecture’. The BSD conjecture predicts a relationship between the algebraic rank of the (finitely generated) abelian group of rational points of an elliptic curve defined over a number field, and the order of vanishing of the associated Hasse-Weil  $L$ -function of the elliptic curve. There is also an associated exact formula, which, along with the conjectured finiteness of the mysterious Tate-Shafarevich group of the elliptic curve gives the value of the leading term of the  $L$ -function in terms of arithmetical invariants associated to the elliptic curve. Kolyvagin’s work on Euler systems is crucial to proving this and relies on the theory of Euler systems. This talk described new Euler systems constructed in joint work with King and Loeffler which makes important progress in proving equivariant versions of the BSD conjecture.

The second talk was given by Ellen Eischen from University of North Carolina on ‘ $p$ -adic families of Eisenstein series and applications’. The theory of  $p$ -adic  $L$ -functions play an important role in arithmetic as they interpolate values of the complex  $L$ -functions, thereby providing a broader canvas to study the classical  $L$ -functions and their special values. In addition, they are known to provide valuable arithmetic information in the context of automorphic theory and arithmetic geometry. A classical construction allows for the construction of  $p$ -adic  $L$ -functions for elliptic modular forms using a  $p$ -adic family of Eisenstein series, This talk explained how to construct such  $p$ -adic families for certain unitary groups. The talk also dealt with how one could interpolate certain values of both holomorphic and non-holomorphic Eisenstein series, along with some applications to number theory and beyond.

The first talk in the afternoon session was delivered by Pei-Yu Tsai from California Institute of Technology. The study of elliptic curves has been enriched enormously by its linkages to classical modular forms and the research in this area was instrumental in settling the classical Fermat’s Last theorem, as elucidated in the work of Andrew Wiles. A natural generalization of this would be the search to associate automorphic forms to general ‘motives’, and was posed in a letter of Benedict Gross to Jean-Pierre Serre. The theory of motives is itself a work in progress but one which has tantalizing connections to geometry and number theory. This work generalizes the notion of newforms associated to symplectic motives of higher ranks by determining its local components, the new vectors, associated to the symplectic Langlands parameters, and makes some progress in special cases of associating automorphic forms to symplectic motives.

The final talk of the workshop was delivered by Birgit Speh from Cornell University on ‘Modular Symbols’. Birgit Speh gave a series of lectures in the subsequent workshop on the same theme, and this talk set the stage for the series of lectures. The cohomology of compact symmetric spaces places a central role in the representation theory of algebraic groups. This talk discussed the difference between the cohomology of compact and non-compact symmetric spaces. It also explained a construction of special harmonic forms that represented non trivial cohomology classes for non compact symmetric classes. Connections to automorphic theory were explained and applications towards understanding the part of



the cohomology contributions coming from the cusps of symmetric spaces associated to algebraic groups were discussed.

### Organizers

First Name	Last Name	Institution
Wenching	Li	Pennsylvania State University
Elena	Mantovan	California Institute of Technology
Sophie	Morel	Princeton University
Ramdorai	Sujatha	University of British Columbia

### Speakers

First Name	Last Name	Institution
Ana	Caraiani	Princeton University
Ellen	Eischen	University of North Carolina
Julia	Gordon	University of British Columbia
Ling	Long	Louisiana State University
Birgit	Speh	Cornell University
Pei-Yu	Tsai	California Institute of Technology
Ila	Varma	Princeton University
Sarah	Zerbes	University College



**Connections for Women:  
New Geometric Methods in Number Theory and Automorphic Forms**

August 14-15, 2014

**Schedule**

<b>Thursday, August 14, 2014</b>			
9:15AM - 9:30AM	Simons Auditorium		Welcome
9:30AM - 10:30AM	Simons Auditorium	Ling Long	Generalized Legendre Curves and Abelian Varieties with Quaternion Multiplication
10:30AM - 11:00AM	Atrium		Tea
11:00AM - 12:00PM	Simons Auditorium	Julia Gordon	Local heuristics and exact formulas for counting elliptic curves over finite fields
12:00PM - 2:00PM	Atrium		Lunch
2:00PM - 3:00PM	Simons Auditorium	Ana Caraiani	Patching and p-adic local Langlands
3:00PM - 3:30PM	Atrium		Tea
3:30PM - 4:30PM	Simons Auditorium	Ila Varma	Local-global compatibility of regular algebraic cuspidal automorphic representations when $l$ is not equal to $p$
4:30PM - 5:30PM	Commons		Panel Discussion
6:30PM - 8:30PM	MSRI		Dinner at Taste of Himalayas

<b>Friday, August 15, 2014</b>			
9:30AM - 10:30AM	Simons Auditorium	Sarah Zerbes	Euler systems and the Birch--Swinerton-Dyer conjecture
10:30AM - 11:00AM	Atrium		Tea
11:00AM - 12:00PM	Simons Auditorium	Ellen Eischen	p-adic families of Eisenstein series and applications
12:00PM - 2:00PM	Atrium		Lunch
2:00PM - 3:00PM	Simons Auditorium	Pei-Yu Tsai	Newforms for odd orthogonal groups
3:00PM - 3:30PM	Atrium		Tea
3:30PM - 4:30PM	Simons Auditorium	Birgit Speh	Construction of some modular symbols

<b>Participants</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Ramla	Abdellatif	Ecole Normale Superieure de Lyon
Rebecca	Bellovin	Imperial College, London
Ana	Caraiani	Princeton University
Charlotte	Chan	University of Michigan
Agnes	David	University of Luxembourg
Hansheng	Diao	Institute for Advanced Study
Daniel	Disegni	McGill University
Ellen	Eischen	University of North Carolina
Jessica	Fintzen	Harvard University
Julia	Gordon	University of British Columbia
Nadezhda	Gurevich	Ben Gurion University of the Negev
Paul	Hamacher	Technische Universitat Munchen
geeta	johal	Vanier College
Daniel	Kirch	Rheinische Friedrich-Wilhelms-Universitat Bonn
Karol	Koziol	Columbia University
Jaclyn	Lang	University of California, Los Angeles
Wenching	Li	Pennsylvania State University
David	Loeffler	University of Warwick
Luis	Lomeli	MSRI - Mathematical Sciences Research Institute
Ling	Long	Louisiana State University
Elena	Mantovan	California Institute of Technology
Jasmin	Matz	Rheinische Friedrich-Wilhelms-Universitat Bonn
Andreas	Mihatsch	Universitat Bonn
Sophie	Morel	Princeton University
Laura	Peskin	University of British Columbia
Shrenik	Shah	Princeton University
Romyar	Sharifi	University of Arizona
Yiwei	She	University of Chicago
Birgit	Speh	Cornell University
Ramdorai	Sujatha	University of British Columbia
Ashley	Toth	Colorado State University
Pei-Yu	Tsai	California Institute of Technology
Ila	Varma	Princeton University
Christelle	Vincent	Stanford University
Jiaowen	Yang	Ecole Polytechnique
Sarah	Zerbes	University College

## Officially Registered Participant Information

<b>Participants</b>		<b>36</b>
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<b>Gender</b>		<b>36</b>
<b>Male</b>	30.56%	11
<b>Female</b>	63.89%	23
<b>Declined to state</b>	5.56%	2

<b>Ethnicity*</b>		<b>38</b>
<b>White</b>	52.63%	20
<b>Asian</b>	26.32%	10
<b>Hispanic</b>	2.63%	1
<b>Pacific Islander</b>	0.00%	0
<b>Black</b>	0.00%	0
<b>Native American</b>	0.00%	0
<b>Mixed</b>	2.63%	1
<b>Declined to state</b>	15.79%	6

\* ethnicity specifications are not exclusive

# 11 responses

11 responses out of 36 participants = 31% response rate

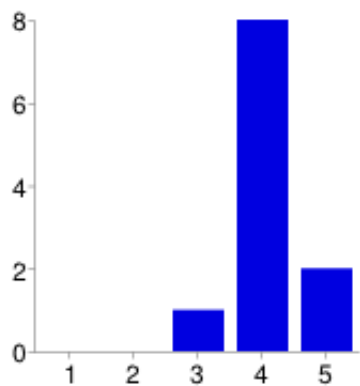
[View all responses](#)   [Publish analytics](#)

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## Summary

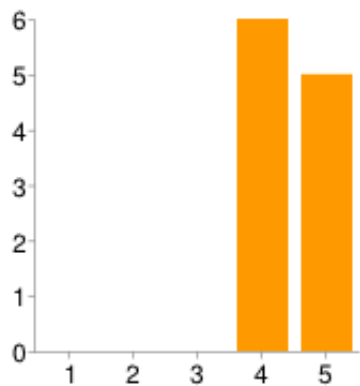
### Workshop assessment

The workshop was intellectually stimulating



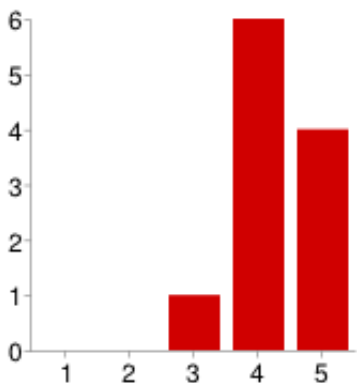
1	0	0%
2	0	0%
3	1	9%
4	8	73%
5	2	18%

The overall experience of the workshop was worthwhile



1	0	0%
2	0	0%
3	0	0%
4	6	55%
5	5	45%

The time between lectures was adequate for discussion



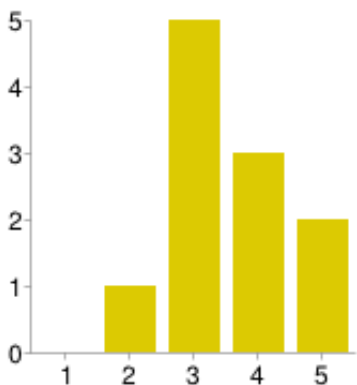
1	0	0%
2	0	0%
3	1	9%
4	6	55%
5	4	36%

### Additional comments on the workshop organization

It was really well organized, congratulations!

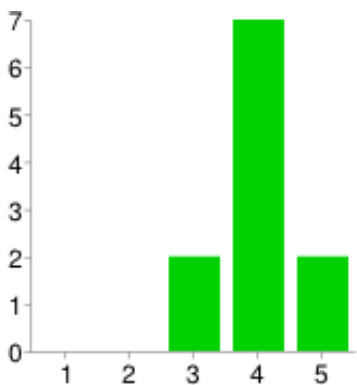
### Personal assessment

#### I was well prepared to benefit from the lectures



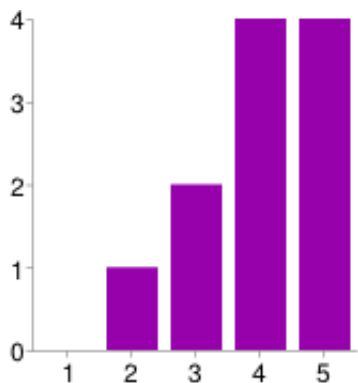
1	0	0%
2	1	9%
3	5	45%
4	3	27%
5	2	18%

#### My interest in the subject matter was increased by the workshop



1	0	0%
2	0	0%
3	2	18%
4	7	64%
5	2	18%

The workshop helped me meet people with similar scientific interests



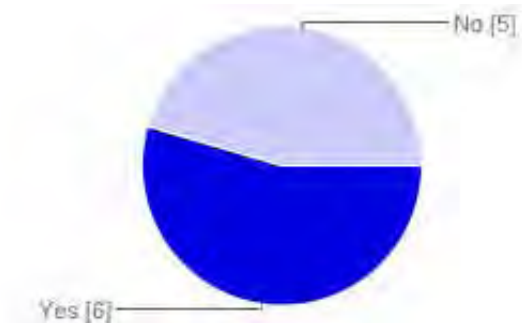
1	0	0%
2	1	9%
3	2	18%
4	4	36%
5	4	36%

### Additional comments on your personal assessment

My responses would probably have been much more enthusiastic if my research area was more in line with the focus of the conference.

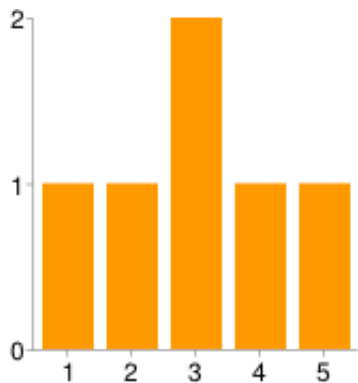
### Additional Activities

Did you attend the panel discussion?



Yes	6	55%
No	5	45%

If you did attend the panel discussion, did you find it worthwhile?



1	1	9%
2	1	9%
3	2	18%
4	1	9%
5	1	9%

What other subjects should be addressed in future panel discussions?



Anything! Just make it more specific -- this discussion was totally vague and unfocused. Transition between different stages of the career (especially between PhD and first position), or how to maximally benefit from the period before getting "a serious position" (i.e. while Post-Doc); what could help would be to make a "question box" where participants could let their questions and to open it during the panel : that would make it helpful for everyone I think

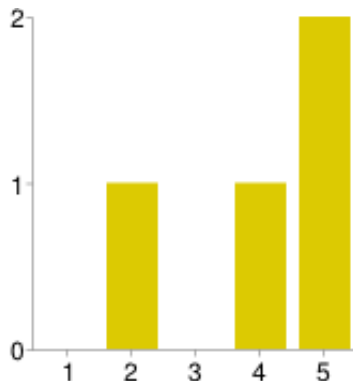
Did you attend the dinner?



Yes	4	36%
No	7	64%

If you did attend the dinner, did it help to solidify the contacts you made in the workshop?

cts you made in



1	0	0%
2	1	9%
3	0	0%
4	1	9%
5	2	18%

Please provide any comments on the dinner

I felt that the dinner group was too large to get to know any of the other participants well.

I wasn't allowed to attend

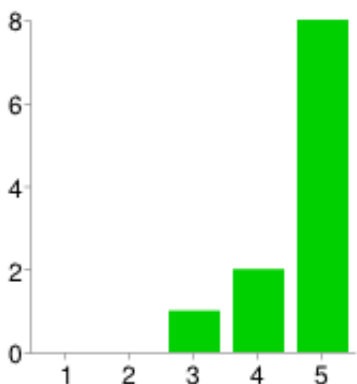
It was a great idea to limit it to female participants, so that we can really discuss together and not stay with the "usual people we stay with during other conferences"

I fail to understand the reason for which, while the panel (which might conceivably be a place to discuss political issues of specific concern to women, for some of which, one could argue, the presence of men might be seen as an obstacle to free discussion) was open to men also, the dinner, an informal social moment where one would anyway not speak with more than the few neighbours she chose to sit next to, was women-only. I know of no other instance of conferences where a minority of the registered participants

is not allowed in the social part. If its goal is indeed to help "solidify the contacts made in the workshop" then it is unclear why contacts possibly made with the few male colleagues do not deserve to be solidified too.

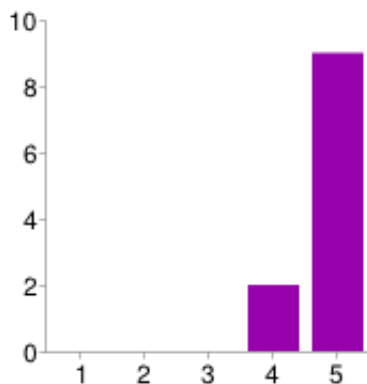
## Venue

I found the MSRI staff helpful



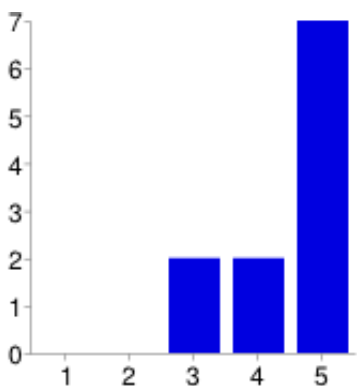
1	0	0%
2	0	0%
3	1	9%
4	2	18%
5	8	73%

The MSRI physical facilities were conducive for such a workshop



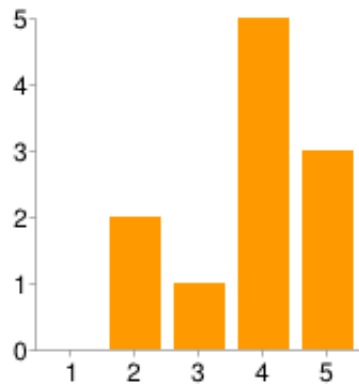
1	0	0%
2	0	0%
3	0	0%
4	2	18%
5	9	82%

The MSRI computer facilities were adequate for such a workshop



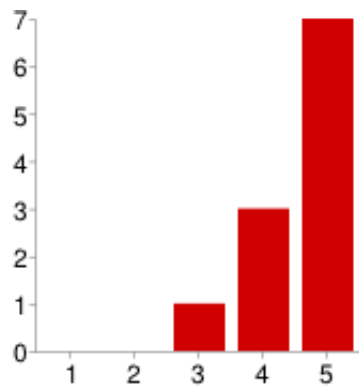
1	0	0%
2	0	0%
3	2	18%
4	2	18%
5	7	64%

### The MSRI lunch arrangements were satisfactory



1	0	0%
2	2	18%
3	1	9%
4	5	45%
5	3	27%

### The MSRI tea arrangements were satisfactory



1	0	0%
2	0	0%
3	1	9%
4	3	27%
5	7	64%

### Additional comments on the venue

I think the lunch could be more consistant (considering the price of sandwiches, it is a bit expansive I think)

## MSRI Wireless Network

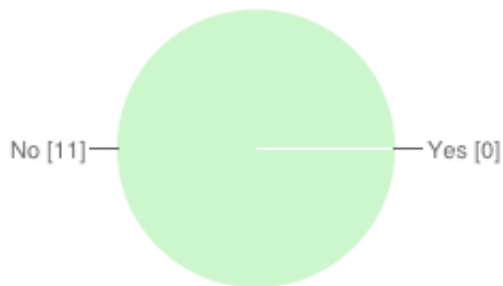
Did you use MSRI's wireless network?



Yes	11	100%
No	0	0%

Did you experience any difficulties with the network?

Yes	0	0%
No	11	100%



If you did experience difficulties with the network, please explain:  
No responses yet for this question.

### Thank you for completing this survey

We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.

I think it is better to put the "Connection for women" before the "Introductory workshop", as it helps meeting female colleagues before getting "lost" in the middle of far many more participants. I also wanted to say that it was a pleasure to be part of this workshop, and I am looking forward to attend others!

### Number of daily responses



**Introductory Workshop:  
New Geometric Methods in Number Theory  
and Automorphic Forms**  
August 18 to 22, 2014  
MSRI, Berkeley, CA, USA

Organizers:

**Laurent Berger (École Normale Supérieure de Lyon)**

**Ariane Mézard (L'Institut de Mathématiques de Jussieu)**

**Akshay Venkatesh (Stanford University)**

**Shou-Wu Zhang (Princeton University)**

**INTRODUCTORY WORKSHOP  
NEW GEOMETRIC METHODS IN NUMBER THEORY  
AND AUTOMORPHIC FORMS**

**Organizers**

The organizers of this workshop were:

- (i) Lauren Berger (Ecole Normale Supérieure de Lyon, France).
- (ii) Ariane Mézard (Institut de Mathématiques de Jussieu, France).
- (iii) Ashkay Venkatesh (Stanford University, USA).
- (iv) Shou-Wu Zhang (Princeton University, USA).

**General presentation**

This 5-day conference was held on Aug 18-22 2014 and was an introduction to the MSRI program New Geometric Techniques in Number Theory and Automorphic Forms. There were more than 80 participants, 8 speakers, many of whom are leaders of the fields. The quality of the talks were very high, in terms of their content as well as presentation. There were lecture series on periods of automorphic forms, Shimura varieties, and representations of  $p$ -adic groups, as well as more advanced topics, including  $p$ -adic Hodge theory and the cohomology of arithmetic groups.

**Results**

The high quality of the lectures was an extremely strong point of this introductory workshop. The lecturers were extremely clear despite of the advanced scientific level. The participants were avid of taking part of all activities. The ambience was very constructive with many open discussions everywhere in the MSRI building during the tea-lunch breaks and after the talks. The early date of this conference presented many benefit: this conference was crucial for the further benefit of the participation of the young mathematicians to the whole semester. At the beginning of the semester the experts in the field were available, open to discussion, not already involved in many scientific activities. Unfortunately some of them were missing due to their presence to the International Congress of Mathematics at Seoul.

<b>Organizers</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Laurent	Berger	École Normale Supérieure de Lyon
Ariane	Mezard	L'Institut de Mathématiques de Jussieu
Akshay	Venkatesh	Stanford University
Shou-Wu	Zhang	Princeton University
<b>Speakers</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Frank	Calegari	Northwestern University
Gabriel	Dospinescu	Ecole Normale Supérieure de Lyon
Payman	Kassaei	McGill University
Kai-Wen	Lan	University of Minnesota, Twin Cities
Rachel	Ollivier	University of British Columbia
Birgit	Speh	Cornell University
Jared	Weinstein	Boston University
Shou-Wu	Zhang	Princeton University



## Introductory Workshop: New Geometric Methods in Number Theory and Automorphic Forms

August 18- 22, 2014

### Schedule

Monday, August 18, 2014			
9:15 AM - 9:30 AM	Simons Auditorium		Welcome
9:30 AM - 10:30 AM	Simons Auditorium	Shou-Wu Zhang	Gross--Zagier formula: why is it right?
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00 PM	Simons Auditorium	Kai-Wen Lan	An example-based introduction to Shimura varieties and their compactifications
12:00 PM - 2:00 PM	Atrium		Lunch
2:00 PM- 3:00 PM	Simons Auditorium	Birgit Speh	Construction of some modular symbols
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:30 PM	Simons Auditorium	Payman Kassaei	Analytic continuation of $p$ -adic modular forms and applications to modularity

Tuesday, August 19, 2014			
9:30 AM - 10:30 AM	Simons Auditorium	Shou-Wu Zhang	Gross--Zagier formula: why is it right?
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00 PM	Simons Auditorium	Kai-Wen Lan	An example-based introduction to Shimura varieties and their compactifications
12:00 PM - 2:00 PM	Atrium		Lunch
2:00 PM - 3:00 PM	Simons Auditorium	Birgit Speh	Construction of some modular symbols
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:30 PM	Simons Auditorium	Payman Kassaei	Analytic continuation of $p$ -adic modular forms and applications to modularity
4:30 PM - 6:20 PM	Atrium		Reception

Wednesday, August 20, 2014			
9:00 AM - 10:00 AM	Simons Auditorium	Shou-Wu Zhang	Gross--Zagier formula: why is it right?
10:00 AM - 10:30 AM	Atrium		Tea
10:30 AM - 11:30 PM	Simons Auditorium	Kai-Wen Lan	An example-based introduction to Shimura varieties and their compactifications
11:30 AM - 12:30 PM	Simons Auditorium	Rachel Ollivier	Aspects of the mod $p$ representation theory of $p$ -adic reductive groups

Thursday, August 21, 2014			
9:30 AM - 10:30 AM	Simons Auditorium	Frank Calegari	Cohomology of Arithmetic Groups
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00 PM	Simons Auditorium	Rachel Ollivier	Aspects of the mod $p$ representation theory of $p$ -adic reductive groups
12:00 PM - 2:00 PM	Atrium		Lunch
2:00 PM - 3:00 PM	Simons Auditorium	Jared Weinstein	An overview of the theory of $p$ -adic Galois representations
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:30 PM	Simons Auditorium	Gabriel Dospinescu	Phi-gamma modules and $p$ -adic Hodge theory

Friday, August 22, 2014			
9:30 AM - 10:30 AM	Simons Auditorium		
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00 PM	Simons Auditorium	Frank Calegari	Cohomology of Arithmetic Groups
12:00 PM - 2:00 PM	Atrium		Lunch
2:00 PM- 3:00 PM	Simons Auditorium	Jared Weinstein	An overview of the theory of $p$ -adic Galois representations
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:30 PM	Simons Auditorium	Gabriel Dospinescu	Phi-gamma modules and $p$ -adic Hodge theory



<b>Participants</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Ramla	Abdellatif	Ecole Normale Superieure de Lyon
Shishir	Agrawal	University of California, Berkeley
Bander	Almutairi	King Saud University
Gabriel	Andrade	University of Massachusetts
Rebecca	Bellovin	Imperial College, London
Laurent	Berger	École Normale Supérieure de Lyon
Alina	Bucur	University of California
Ashay	Burungale	University of California, Los Angeles
Frank	Calegari	Northwestern University
Ana	Caraiani	Princeton University
Charlotte	Chan	University of Michigan
YoungJu	Choie	Pohang University of Science and Technology (POSTECH)
Jonathan	Cohen	University of Maryland
Agnes	David	University of Luxembourg
Giovanni	Di Matteo	Johns Hopkins University
Hansheng	Diao	Institute for Advanced Study
Gabriel	Dospinescu	Ecole Normale Superieure de Lyon
Ellen	Eischen	University of North Carolina
Sin Tsun Edward	Fan	California Institute of Technology
Joseph	Ferrara	University of California, Santa Cruz
Ioan	Filip	Columbia University
Jessica	Fintzen	Harvard University
Ralph	Furmaniak	Stanford University
Adam	Gamzon	Mount Holyoke College
Daniel	Gulotta	Columbia University
Shamgar	Gurevich	University of Wisconsin
Paul	Hamacher	Technische Universitat Munchen
Florian	Herzig	University of Toronto
Serin	Hong	California Institute of Technology
Sean	Howe	University of Chicago
Catherine	Hsu	University of North Carolina
Brian	Hwang	California Institute of Technology
Pierre	Jaliniere	Universite de Paris VI (Pierre et Marie Curie)
Subhajit	Jana	University of British Columbia
Christian	Johansson	University of Oxford
Payman	Kassaei	McGill University
Kiran	Kedlaya	University of California, San Diego
Daniel	Kirch	Rheinische Friedrich-Wilhelms-Universität Bonn
Karol	Koziol	Columbia University
Stephen	Kudla	University of Toronto
Kai-Wen	Lan	University of Minnesota, Twin Cities
Jaclyn	Lang	University of California, Los Angeles
Daniel	Le	University of Chicago
Pak-Hin	Lee	Columbia University

<b>Participants</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Marianne	Leitner	Dublin Institute for Advanced Studies
Wenching	Li	Pennsylvania State University
Elon	Lindenstrauss	Hebrew University
Michael	Lipnowski	Duke University
David	Loeffler	University of Warwick
Luis	Lomeli	MSRI - Mathematical Sciences Research Institute
Ding	Ma	University of Arizona
Ariane	Mezard	L'Institut de Mathematiques de Jussieu
Elena	Mantovan	California Institute of Technology
Gabriel	Martins	University of California, Santa Cruz
Akhil	Mathew	University of California, Berkeley
Jasmin	Matz	Rheinische Friedrich-Wilhelms-Universitat Bonn
Andreas	Mihatsch	Universitat Bonn
Shahriar	Mirzadeh	Brandeis University
Stefano	Morra	University of Toronto
Rachel	Ollivier	University of British Columbia
Vivek	Pal	Columbia University
Laura	Peskin	University of British Columbia
Aaron	Pollack	Stanford University
Davide	Reduzzi	University of Chicago
Kenneth	Ribet	University of California, Berkeley
Niccolo'	Ronchetti	Stanford University
Sean	Rostami	University of Wisconsin
David	Savitt	University of Arizona
Justin	Scarf	University of British Columbia
Shrenik	Shah	Princeton University
Romyar	Sharifi	University of Arizona
Yiwei	She	University of Chicago
Kazuma	Shimomoto	Meiji University
Jesse	Silliman	University of Chicago
Birgit	Speh	Cornell University
Danny	Stoll	University of Chicago
Ramdorai	Sujatha	University of British Columbia
Joshua	Sussan	Medgar Evers College
Ashley	Toth	Colorado State University
Cheng-Chiang	Tsai	Harvard University
Pei-Yu	Tsai	California Institute of Technology
Shawn	Tsosie	University of California, Santa Cruz
Shen-Ning	Tung	University of British Columbia
Tetsuya	Uematsu	Toyota National College of Technology
Ila	Varma	Princeton University
Akshay	Venkatesh	Stanford University
Christelle	Vincent	Stanford University
Masha	Vlasenko	University College Dublin

<b>Participants</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Chen	Wan	University of Minnesota Twin Cities
Yingying	Wang	University of California, Santa Barbara
Carl	Wang Erickson	Brandeis University
Jared	Weinstein	Boston University
Peter	Woit	Columbia University
Victoria	Wood	University of California, Berkeley
Bin	Xu	University of Toronto
HANG	XUE	Columbia University
Jiaowen	Yang	Ecole Polytechnique
Foo Yee	Yeo	California Institute of Technology
Serena	Yuan	New York University, Courant Institute
Shou-Wu	Zhang	Princeton University

## Officially Registered Participant Information

<b>Participants</b>		<b>100</b>
---------------------	--	------------

<b>Gender</b>		<b>100</b>
<b>Male</b>	70.00%	70
<b>Female</b>	26.00%	26
<b>Declined to state</b>	4.00%	4

<b>Ethnicity*</b>		<b>108</b>
<b>White</b>	42.59%	46
<b>Asian</b>	31.48%	34
<b>Hispanic</b>	2.78%	3
<b>Pacific Islander</b>	0.00%	0
<b>Black</b>	0.93%	1
<b>Native American</b>	0.93%	1
<b>Mixed</b>	3.70%	4
<b>Declined to state</b>	17.59%	19

\* ethnicity specifications are not exclusive

# 50 responses

50 responses out of 100 participants = 50% response rate

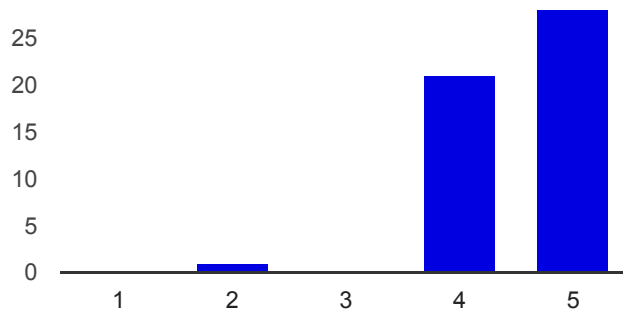
[View all responses](#)   [Publish analytics](#)

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## Summary

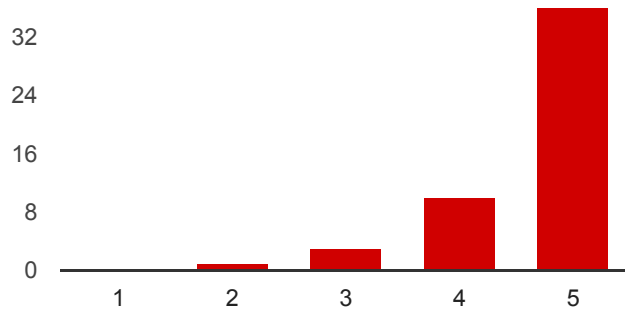
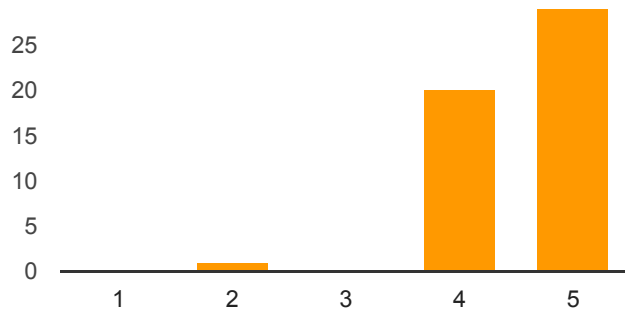
### Workshop assessment

The workshop was intellectually stimulating



Not at all: 1	0	0%
2	1	2%
3	0	0%
4	21	42%
Very: 5	28	56%

The overall experience of the workshop was worthwhile



Not at all:	1	0	0%
	2	1	2%
	3	3	6%
	4	10	20%
Very:	5	36	72%

### Additional comments on the workshop organization

strange to have a "TBA" open slot on the last day with no lecture.

More food during the break

excellent for new researchers

Excellent

Only that it was peculiar that we didn't know until the last minute whether there would be a morning talk on Friday. Otherwise fine.

While it's tempting to say that breaks should be longer so that I'd have more time to talk math with colleagues between them, 30mins is good because longer breaks would slow down the day too much.

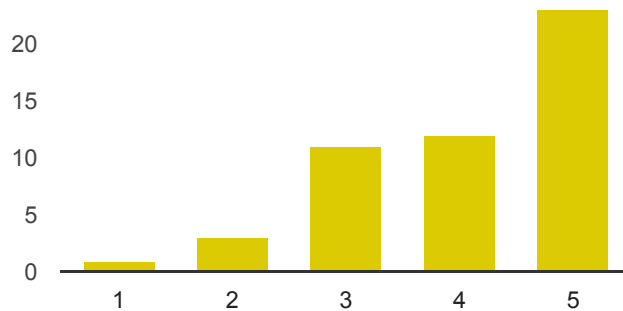
Very good

1) The talk by Prof. Birgit Speh was impertinent, and this was foreseeable by the information available on the internet.

1) The talk by Prof. Birgit Speh was impertinent, and this was actually foreseeable by the information available on the internet. 2) It would have been helpful if MSRI had made clear earlier that it would support room sharing among participants. I wasn't sure about whether a reasonably priced room would be available on very short notice and booked a place for myself just a few hours before Jacari sent around the first respective email. 3) I would have appreciated if the Hill Line bus would have been free for registered participants as there is no other reasonable way to get to the venue every day.  
wonderful lectures

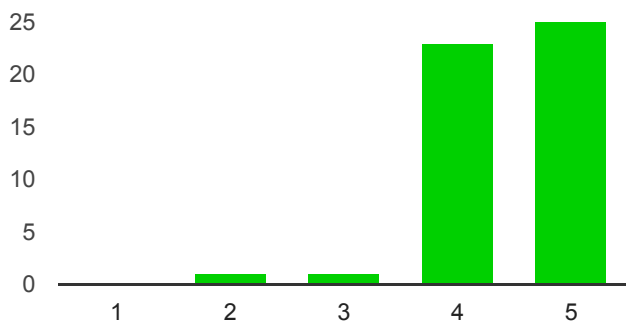
## Personal assessment

I was well prepared to benefit from the lectures

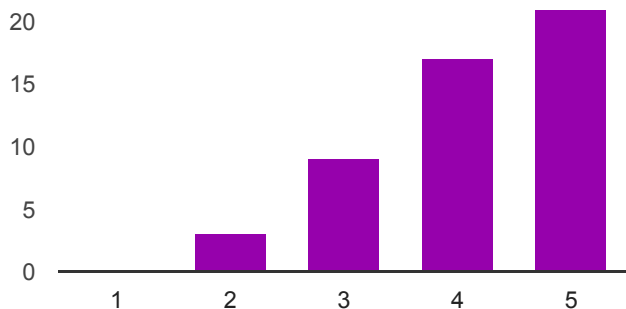


Not at all: 1	1	2%
2	3	6%
3	11	22%
4	12	24%
Very: 5	23	46%

My interest in the subject matter was increased by the workshop



The workshop helped me meet people with similar scientific interests



Not at all:	1	0	0%
	2	3	6%
	3	9	18%
	4	17	34%
Very Much:	5	21	42%

Additional comments on your personal assessment

Certain of the talks could have afforded to start at a more basic level and give more motivation, for the benefit of those with less background.

The chance to make new contacts with colleagues and discuss math between lectures was the most valuable part to me, personally

I should find a way to ask questions at an appropriate time.

It would have been helpful if the program had been specified at an earlier stage. Though I think that p-adic modular forms are a highly interesting and appealing subject, my own research goes into the direction of higher genus automorphic forms, which haven't been addressed to in any of the talks. I would have been better prepared for them, too.

I would have found helpful if the program had been specified at an earlier stage. Though p-adic modular forms are an interesting and appealing topic, my own research goes into

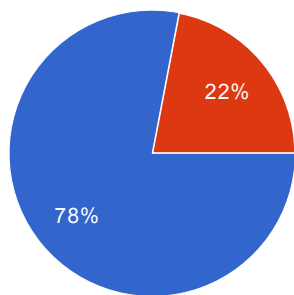


a different direction (higher genus automorphic forms) which hasn't been addressed in any talk. I would have been better prepared for this and would have had more time to learn about the actual subjects of the workshop.

It helped me reconnect with people that I already know, but I didn't really meet anyone new.

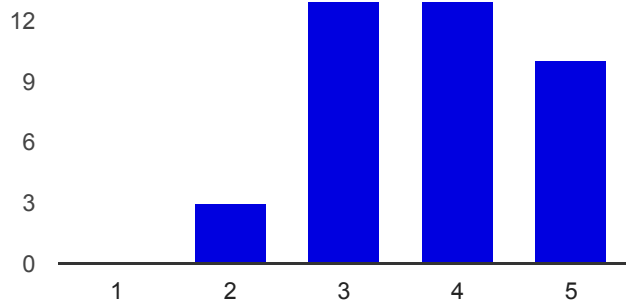
## Additional Activities

Did you attend the reception?



Yes	39	78%
No	11	22%

If you did attend the reception, did it help to solidify the contacts you made in the workshop?



Not at all:	1	0	0%
	2	3	6%
	3	13	26%
	4	13	26%
Very much:	5	10	20%

Please provide any comments on the reception

It's great!

There wasn't really enough room for all the participants. Maybe it would be beneficial to use both the first floor and the second floor area?

the timing was a strange one for food - too early for dinner.

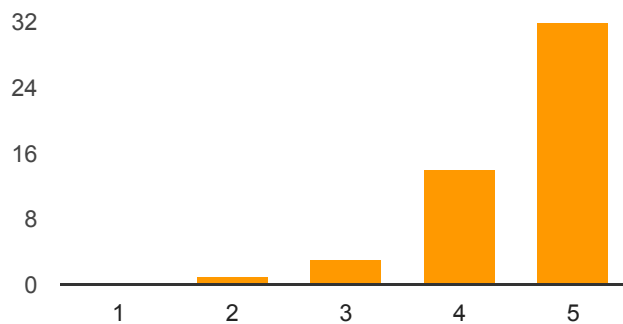
I was sick and hence absent.

A very good chance to find people about common research interest.

The food was great, thank you.

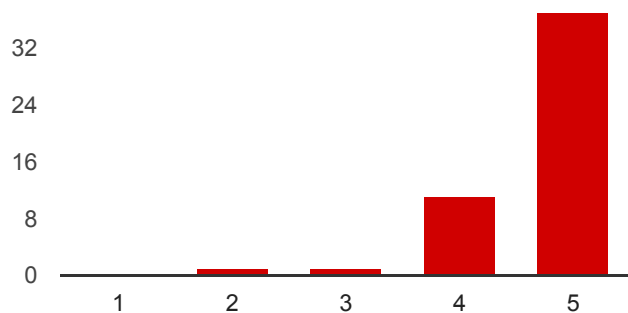
## Venue

I found the MSRI staff helpful

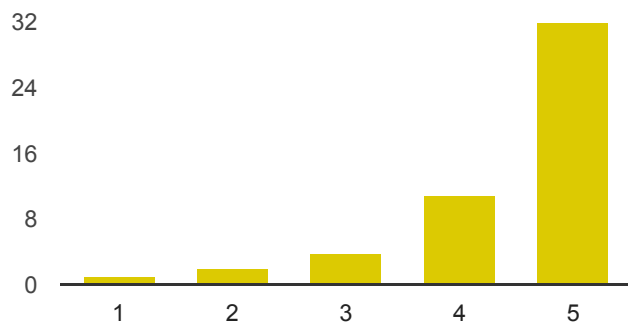


Not at all:	1	0	0%
	2	1	2%
	3	3	6%
	4	14	28%
Very:	5	32	64%

The MSRI physical facilities were conducive for such a workshop

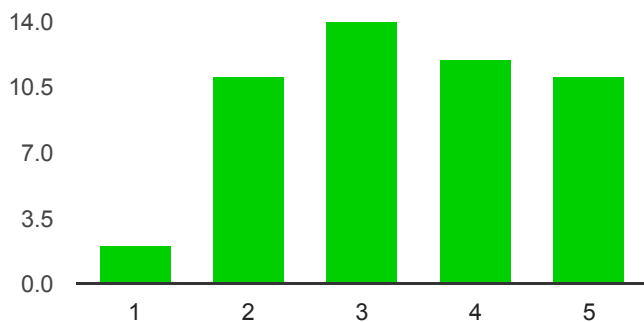


The MSRI computer facilities were adequate for such a workshop



Not at all:	1	1	2%
	2	2	4%
	3	4	8%
	4	11	22%
Very:	5	32	64%

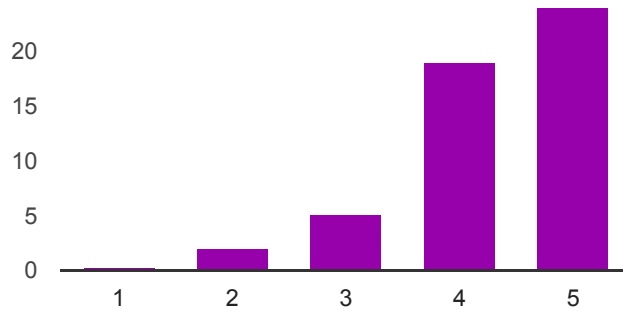
The MSRI lunch arrangements were satisfactory



Not at all:	1	2	4%
	2	11	22%

3	14	28%
4	12	24%
Very: 5	11	22%

### The MSRI tea arrangements were satisfactory



Not at all: 1	0	0%
2	2	4%
3	5	10%
4	19	38%
Very: 5	24	48%

### Additional comments on the venue

It's great to have the live TV screens in the auditorium now. That was a great outgrowth of the perfectoid workshop, which was over-subscribed.

More items for lunch.

the lunch choice was wide enough, but some sandwiches were wet on one side - I can't explain why.

The sense of community fostered was really refreshing and wonderful.

Of the three lab computers, usually only one was functioning at a given time.

The lunch caterer was very poorly prepared and did not have enough ones to give as change (repeatedly throughout the week, not just the first day), which pressured people to buy more than they wanted to make round numbers

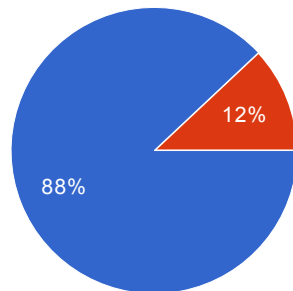
Everything inside MSRI is set well.

Snacks either too sweet or too salty.

Snacks either too sweet or too salty (nuts), but the fruit was great.

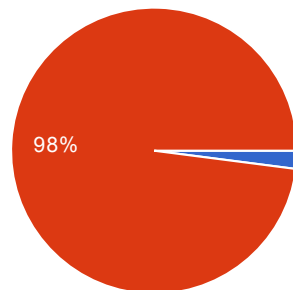
## MSRI Wireless Network

Did you use MSRI's wireless network?



Yes	44	88%
No	6	12%

Did you experience any difficulties with the network?



Yes	1	2%
No	48	96%

If you did experience difficulties with the network, please explain:

Slightly slow

Bad connection, low speed

## Thank you for completing this survey

We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.

It's a great workshop.

It was overall a great experience! The topics plus having the videos available soon after the lectures was very helpful when discussing with others in the evenings. Keep up the good work!

I can't tell if this is already being done or not, but it shouldn't be too difficult to vet the content of the talks beforehand. One or two of the speakers operated at a level that was well in excess of what I'd consider reasonable for an "introductory workshop." With those exceptions, this was one of the best experiences I've had during my time as a graduate

student, and I deeply appreciate that it ran and that the videos were quickly put up on the website.

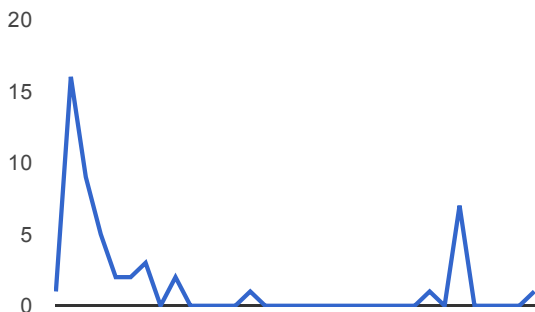
It would be really helpful if the video recordings of the lectures had some way of incorporating audience questions; right now only the speaker is recorded through their mic and only the reply can be heard on the video. The context for the answer is lost, sometimes the question is all the content, and the speaker only affirms whatever the asker said. This also happened during the Feb. hot topics workshop on Scholze's work; the attempted solution then was to have the speaker repeat the question. Practically, this didn't work because the speaker almost never did repeat the question; also the audience frequently had discussion among itself. In the videos, these came out only as extended periods of silence. I think the videos themselves are a really valuable resource for both participants who are present, and those who cannot come, and some method of recording all the mathematical content would make them even more useful. Some suggestions: another designated note taker whose only job is to record discussion (I have tried to take notes which include discussion and found it almost impossible to do simultaneously, but maybe a more mature mathematician can manage this?), another possibility is microphones at the seats or suspended from the ceiling, but I have no idea for how feasible this is. (Oh and a small note, it would've been easier to submit this comment if this comment box had been larger than a single line, I had wanted to make this comment after the Feb workshop but thought perhaps only short comments were expected due to the formatting of the feedback page). Cheers, and thanks for the amazing scientific programming.

I think we need board erasers with better quality. It is important for presenters to clean the board clearly.

MSRI is a lovely place to work at and exchange ideas. Thank you.

thanks

## Number of daily responses



**Automorphic forms, Shimura varieties,  
Galois representations and L-functions**

December 1 to 5, 2014

MSRI, Berkeley, CA, USA

Organizers:

**Pierre Colmez (Institut de Mathématiques de Jussieu)**

**Wee Teck Gan (National University of Singapore)**

**Stephen Kudla (University of Toronto)**

**Elena Mantovan (California Institute of Technology)**

**Ariane Mézard (Institut de Mathématiques de Jussieu)**

**Richard Taylor (Institute for Advanced Study)**

**FINAL WORKSHOP  
AUTOMORPHIC FORMS, SHIMURA VARIETIES,  
GALOIS REPRESENTATIONS AND L-FUNCTIONS**

**Organizers**

The organizers of this workshop were:

- (i) Pierre Colmez (Institut de Mathématiques de Jussieu, France).
- (ii) Wee Teck Gan (National University of Singapore, Singapore).
- (iii) Stephen Kudla (University of Toronto, Canada).
- (iv) Elena Mantovan (California Institute of Technology, USA).
- (v) Ariane Mézard (Institut de Mathématiques de Jussieu, France).
- (vi) Richard Taylor (Institute for Advanced Studies, USA).

**Introduction**

This 5-day conference was held on December 1-5, 2014, and was in honour of Michael Harris whose work has had huge influence on the main themes of the MSRI program New Geometric Techniques in Number Theory and Automorphic Forms. There were more than 300 participants from around the world, 17 speakers, many of whom are leaders of the fields. The quality of the talks were very high, in terms of their content as well as presentation. Some talks were devoted to recent breakthroughs, such as the talks by Vigneras, Scholze, Skinner, Darmon, Zerbes, while others concerned newly created directions, such as the talks by Venkatesh, Prasad, Fargues, Clozel. One participant remarked that it was rare to attend a conference where there were surprises in every talk. All in all, it is a fitting end to an intensive and stimulating semester.

The workshop focused on Langlands correspondence (construction of Galois representations attached to automorphic forms via the cohomology of Shimura varieties, modularity of Galois representations...) and arithmetic of special values of L-functions. Among these recent breakthroughs, Sholze Chancellor's course on a new class of geometric objects was followed by many participants of the MSRI program and by many other mathematicians in the world, thanks to the recording and broadcasting on MSRI's website. It brought a sense of excitement that was matched by the final workshop where many striking results were presented. Participants in the final workshop left with many new things to think about, and it can be said that the final workshop was a big success.



## 1. Research developments

We would like to highlight some research developments presented during the final workshop.

(1) One of the highlights of the program is undoubtedly the Chancellor lectures given by **Peter Scholze**. The course introduces an evolving theory of a new geometric structure, which Scholze has termed “Diamond”, which is a generalization of algebraic spaces (for the pro-stale topology) and builds upon Scholze’s theory of perfectoid spaces. The goal of introducing these new geometric objects is to develop a local theory of shtukas over  $\mathbb{Q}_p$ , generalizing Beilinson-Drinfeld’s Grassmannian, thus enabling the application of ideas from the Geometric Langlands program to the mixed characteristic setting, with the potential application of proving the local Langlands correspondence for general  $G$ . Thus, the lectures were of interest to participants of both NGM and GRT (our companion program).

In the final workshop, Scholze explained new developments on integral  $p$ -adic Hodge theory. During the MSRI Program, Scholze also initiated a new collaboration with **Ana Caraiani** (an NGM postdoc) on the construction of Hodge-Tate period map (reported in Caraiani’s lecture in final workshop).

(2) The technology introduced in the Chancellor lectures was nicely exploited by **Laurent Fargues** in his lecture during the final workshop of the program, in which he explained a compelling geometric framework for formulating the local Langlands correspondence, in the spirit of the Geometric Langlands correspondence and in the style of the work of Adams-Barbasch-Vogan for the archimedean case. More precisely, given a quasi-split reductive group  $G$  over the field of  $p$ -adic numbers, Fargues has proved that the points of the stack of  $G$ -bundles on the Fargues-Fontaine curve are in bijection with the Kottwitz set of  $\sigma$ -conjugacy classes in  $G$ . Fargues formulated a conjecture asserting the existence of a functor associating to a Langlands parameter with values in the Langlands dual group of  $G$  a perverse sheaf on the stack of  $G$ -bundles, together with a long list of natural properties. The work of Scholze and the conjectures of Fargues will surely serve as a roadmap for the future development of the local Langlands correspondence. (See, for example, comments: <http://mathoverflow.net/questions/14763/what-are-the-local-langlands-conjectures-nowadays-for-connected-reductive-group/189074#189074>)

(3) Wee Teck Gan and **Dipendra Prasad** are finishing up a paper (jointly with Benedict Gross) on the formulation of the Gross-Prasad conjecture for nontempered Arthur packets.

(4) **Akshay Venkatesh** presented his ideas on derived deformations ring with powerful applications to integral structures in cohomology. (See Comments: <https://galoisrepresentations.wordpress.com/tag/akshay-venkatesh/>)

(5) During the program, Jan Nekovar and Tony Scholl formulated the plectic conjecture: in the presence of real multiplication (said if  $F$  is a totally real number field), motives have an additional canonical structure, the  $F$ -plectic structure. They give a cohomological  $\ell$ -adic version of the plectic conjecture in the case where  $G$  is a reductive group.

(6) Loeffler and **Sarah Zerbes** (jointly with Kings and Lei) constructed a new Euler system attached to the Rankin-Selberg convolution of two modular forms.

(7) There are many leading experts on the  $p$ -modular representation theory of  $p$ -adic groups who are members of the two MSRI programs, One of the highlights for this area is the completion of a joint paper of Abe-Henniart-Herzig-Vigneras on the classification of irreducible  $p$ -modular representations of an arbitrary reductive  $p$ -adic groups, in terms of supersingular ones. This completely resolves a question which was first investigated by Barthel-Livne for  $GL(2)$ , followed by the work of Herzig (for  $GL(n)$ ) and Abe (for split  $G$ ). This progress is reported in **Marie-France Vigneras**' lecture in the final workshop.

(8) Michael Harris, **Kai-Wen Lan**, Richard Taylor (jointly with Jack Thorne) constructed the compatible system of  $l$ -adic representations associated to a regular algebraic cuspidal automorphic representation of  $GL(n)$  over a CM field. Lan establish a Higher Koecher's principle for any Shimura variety in mixed characteristic.

<b>Organizers</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Pierre	Colmez	Institut de Mathematiques de Jussieu
Wee Teck	Gan	Natioal University of Singaporite
Stephen	Kudla	University of Toronto
Elena	Mantovan	California Institute of Technology
Ariane	Mezard	Institut de Mathematiques de Jussieu
Richard	Taylor	Institute for Advanced Study

<b>Speakers</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Frank	Calegari	Northwestern University
Ana	Caraiani	Princeton University
Gaetan	Chenevier	CNRS
Laurent	Clozel	Univ. paris-sud
Pierre	Colmez	Institut de Mathematiques de Jussieu
Henri	Darmon	McGill University
Matthew	Emerton	University of Chicago
Laurent	Fargues	Institut de Mathematiques de Jussieu
Benjamin	Howard	Boston College
Kai-Wen	Lan	University of Minnesota, Twin Cities
Dipendra	Prasad	Tata Institute of Fundamental Research
A.	Raghuram	Indian Institute of Science Education and Research
Peter	Scholze	Universitat Bonn
Christopher	Skinner	Princeton University
Akshay	Venkatesh	Stanford University
Marie-France	Vigneras	Universite de Paris VII (Denis Diderot)
Sarah	Zerbes	University College
Wei	Zhang	Columbia University



**Workshop: Automorphic forms, Shimura varieties, Galois representations and L-functions**

December 1-5, 2014

**Schedule**

<b>Monday, December 1, 2014</b>			
9:15 AM - 9:30 AM	Simons Auditorium		Welcome
9:30 AM - 10:30 AM	Simons Auditorium	Marie-France Vigneras	Parabolically induced mod p representations of reductive p-adic
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00 PM	Simons Auditorium	Matthew Emerton	Moduli stacks of local Galois representations
12:00 PM - 2:00 PM	Atrium		Lunch
2:00 PM - 3:00 PM	Simons Auditorium	Peter Scholze	Integral p-adic Hodge theory
3:00 PM - 3:30 PM	Atrium		Tea
4:10 PM - 05:00 PM	740 Evans Hall UC Berkeley	Pierre Colmez	MSRI/Evans Lecture
<b>Charter buses depart MSRI at 3:20 and 3:50</b>			

<b>Tuesday, December 2, 2014</b>			
9:30 AM - 10:30 AM	Simons Auditorium	Wei Zhang	Special parahorics and exotic good reduction
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00 PM	Simons Auditorium	Ben Howard	Cycles on Shimura varieties and applications to Faltings heights
12:00 PM - 2:00 PM	Atrium		Lunch
2:00 PM - 3:00 PM	Simons Auditorium	Ana Caraiani	On the Hodge-Tate period map for Shimura varieties of Hodge type
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:30 PM	Simons Auditorium	Kai-Wen Lan	Higher Koecher's principle
4:30 PM - 5:00 PM	2nd Floor		Poster Session
5:00 PM - 9:00 PM	Atrium		Banquet at Hong Kong East Ocean Seafood Restaurant
<b>Charter buses depart MSRI at 5:00</b>			

<b>Wednesday, December 3, 2014</b>			
9:00 AM - 10:00 AM	Simons Auditorium	A. Raghuram	Special Values of automorphic L-functions and congruences
10:00 AM - 10:30 AM	Atrium		Tea
10:30 AM - 11:30 AM	Simons Auditorium	Akshay Venkatesh	The exterior algebra in the cohomology of an arithmetic group
11:30 AM - 12:00 PM	Atrium		Break
12:00 PM - 1:00 PM	Simons Auditorium	Dipendra Prasad	Branching laws and period integrals for non-tempered representations.
<b>Charter buses depart MSRI at 1:20 and 1:50</b>			

<b>Thursday, December 4, 2014</b>			
9:30 AM - 10:30 AM	Simons Auditorium	Henri Darmon	Modularity of non-semisimple Galois representations
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00 PM	Simons Auditorium	Frank Calegari	The Bloch Kato Conjecture for some Adjoint Selmer Groups.
12:00 PM - 2:00 PM	Atrium		Lunch
2:00 PM - 3:00 PM	Simons Auditorium	Sara Zerbes	Euler System
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:30 PM	Simons Auditorium	Chris Skinner	p-adic L-functions, Iwasawa theory, and elliptic curves
<b>Charter buses depart MSRI at 4:50 and 5:20</b>			

<b>Friday, December 5, 2014</b>			
9:00 AM - 10:00 AM	Simons Auditorium	Laurent Fargues	G-bundles and the local Langlands correspondence
10:00 AM - 10:30 AM	Atrium		Tea
10:30 AM - 11:30 AM	Simons Auditorium	Gaetan Chenevier	On conductor 1 algebraic automorphic representations of GL(n) over Q, and applications
11:30 AM - 12:00 PM	Atrium		Break
12:00 PM - 1:00 PM	Simons Auditorium	Laurent Clozel	P-radicial base change, mod p
<b>Charter buses depart MSRI at 1:20 and 1:50</b>			

<b>Participants</b>		
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Ahmed	Abbes	Institut des Hautes Etudes Scientifiques (IHES)
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Arash	Ahmadi	University of California, Davis
Xiaohua	Al	Institut de Mathematiques de Jussieu
Patrick	Allen	Northwestern University
Zavosh	Amir-Khosravi	Fields Institute for Research in Mathematical Sciences
UK	Anandavardhanan	Indian Institute of Technology Bombay
Hiraku	Atobe	Kyoto University
Daniel	Barrera	CRM - Centre de Recherches Mathematiques
Joel	Bellaiche	Brandeis University
Rebecca	Bellovin	University of California, Berkeley
David	Ben-Zvi	University of Texas
John	Bergdall	Boston University
Tobias	Berger	University of Sheffield
Laurent	Berger	Ecole Normale Superieure de Lyon
Raphael	Beuzart	Institute for Advanced Study
Bhargav	Bhatt	University of Michigan
Don	Blasius	University of California, Los Angeles
George	Boxer	Harvard University
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Jim	Brown	Clemson University
Ashay	Burungale	University of California, Los Angeles
Kazim	Buyukboduk	Koc University
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Ana	Caraiani	Princeton University
Francesc	Castella	University of California, Los Angeles
Kestutis	Cesnavicius	University of California, Berkeley
Charlotte	Chan	University of Michigan
Pierre-Henri	Chaudouard	Universite de Paris VII (Denis Diderot)
Huan	Chen	Universite de Paris XIII (Paris-Nord)
Gaetan	Chenevier	CNRS
Masataka	Chida	Kyoto University
Youn-seo	Choi	Korea Institute for Advanced Study (KIAS)
Kwangho	Choiy	Oklahoma State University
Laurent	Clozel	Univ. paris-sud
Jonathan	Cohen	University of Maryland
Pierre	Colmez	Institut de Mathematiques de Jussieu
Andrea	Conti	Universite de Paris XIII (Paris-Nord)
Hailong	Dao	University of Kansas
Henri	Darmon	McGill University
Taiwang	Deng	Universite de Paris XIII (Paris-Nord)
Shaunak	Deo	Brandeis University
Giovanni	Di Matteo	Johns Hopkins University
Fred	Diamond	King's College London
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Mladen	Dimitrov	University Lille 1

<b>Participants</b>		
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Matthew	Emerton	University of Chicago
Laurent	Fargues	Institut de Mathematiques de Jussieu
Joseph	Ferrara	University of California, Santa Cruz
Ioan	Filip	Columbia University
Jessica	Fintzen	Harvard University
Benjamin	Fischer	Boston University
Masaaki	Furusawa	Osaka City University
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Ziyang	Gao	Universite Paris-Sud (Orsay)
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Benjamin	Green	University of Oxford
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Daniel	Gulotta	Columbia University
Robert	Guralnick	University of Southern California
Thomas	Haines	University of Maryland
Paul	Hamacher	TU Munchen
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Sebastian	Herrero Miranda	Pontificia Universidad Catolica de Chile
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Quoc	Ho	University of Chicago
Benjamin	Howard	Boston College
Sean	Howe	University of Chicago
Catherine	Hsu	University of North Carolina
Brian	Hwang	California Institute of Technology
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Naoki	Imai	University of Tokyo
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Jean-Pierre	Labesse	Institut Mathematique de Luminy

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Zheng	Liu	Columbia University
Ruochuan	Liu	Peking University
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Arthur	Ogus	University of California, Berkeley
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Laura	Peskin	University of British Columbia
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Jonathan	Pottharst	
Dipendra	Prasad	Tata Institute of Fundamental Research
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Giovanni	Rosso	KU Leuven
Sandra	Rozensztajn	Ecole Normale Superieure de Lyon
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David	Savitt	University of Arizona
Michael	Schein	Bar-Ilan University
Anthony	Scholl	Center for Mathematical Sciences
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Benjamin	Schraen	Centre National de la Recherche Scientifique (CNRS)
Arijit	Sehanobish	University of Maryland
Richard	Shadrach	Rice University
Shrenik	Shah	Columbia University
Romyar	Sharifi	University of Arizona
Yiwei	She	University of Chicago
Xu	Shen	University of Regensburg
Samir	Siksek	University of Warwick
Christopher	Skinner	Princeton University
Brian	Smithling	Johns Hopkins University
Matthias	Strauch	Indiana University
Junecue	Suh	University of California, Santa Cruz
Richard	Taylor	Institute for Advanced Study
Pham	Tiep	University of Arizona
Shawn	Tsosie	University of California, Santa Cruz
Jeanine	Van Order	Max-Planck-Institut fur Mathematik
Akshay	Venkatesh	Stanford University
Marie-France	Vigneras	Universite de Paris VII (Denis Diderot)
John	Voight	Dartmouth College
Preston	Wake	University of Chicago
Carl	Wang Erickson	Brandeis University
Jared	Weinstein	Boston University
John	Willis	University of Colorado
Bin	Xu	Institute for Advanced Study
Hang	Xue	Columbia University
Cong	Xue	Universite Paris-Sud (Orsay)
Shunsuke	Yamana	Kyushu University
Sarah	Zerbes	University College
Wei	Zhang	Columbia University
Bin	Zhao	Universite de Paris XIII (Paris-Nord)
Yihang	Zhu	Harvard University



## Officially Registered Participant Information

<b>Participants</b>		<b>191</b>
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<b>Gender</b>		<b>191</b>
<b>Male</b>	87.96%	168
<b>Female</b>	11.52%	22
<b>Declined to state</b>	0.52%	1

<b>Ethnicity*</b>		<b>198</b>
<b>White</b>	49.49%	98
<b>Asian</b>	32.83%	65
<b>Hispanic</b>	2.53%	5
<b>Pacific Islander</b>	0.00%	0
<b>Black</b>	1.01%	2
<b>Native American</b>	0.51%	1
<b>Mixed</b>	2.02%	4
<b>Declined to state</b>	11.62%	23

\* ethnicity specifications are not exclusive

# 90 responses

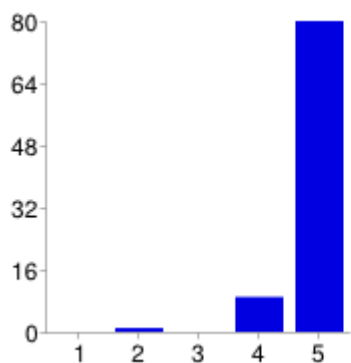
90 responses out of 191 participants = 47% response rate

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## Summary

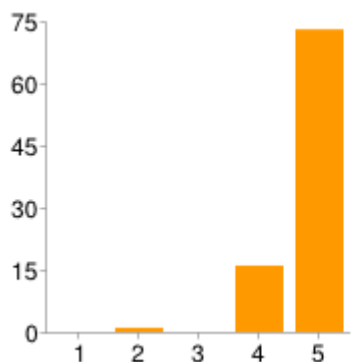
### Workshop assessment

#### The workshop was intellectually stimulating



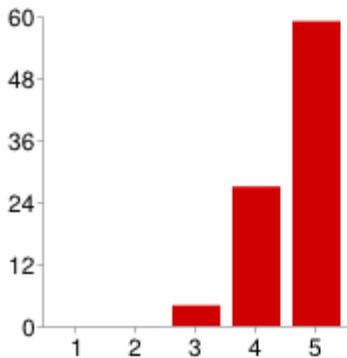
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2	<b>1</b>	1%
3	<b>0</b>	0%
4	<b>9</b>	10%
5	<b>80</b>	89%

#### The overall experience of the workshop was worthwhile



1	<b>0</b>	0%
2	<b>1</b>	1%
3	<b>0</b>	0%
4	<b>16</b>	18%
5	<b>73</b>	81%

#### The time between lectures was adequate for discussion



1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>4</b>	4%
4	<b>27</b>	30%
5	<b>59</b>	66%

### Additional comments on the workshop organization

Overflow tv plus rapid online access to lectures is excellent

really great workshop!

Thank you very much!

Basically that was an awesome seminar!

It made a big difference having only four talks per day, rather than five a day as at most conferences. This meant that we weren't too tired from the lectures to collaborate on various other projects.

Greatly organized! Very friendly staff.

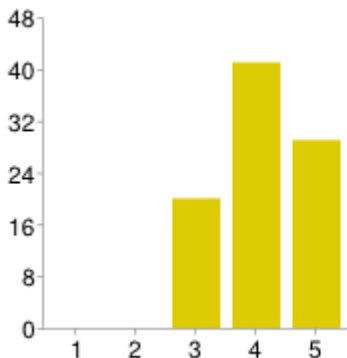
Very good!

The program was great.

Excellent

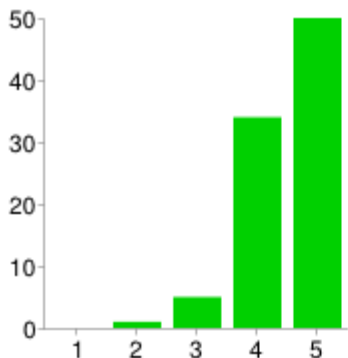
### Personal assessment

#### I was well prepared to benefit from the lectures



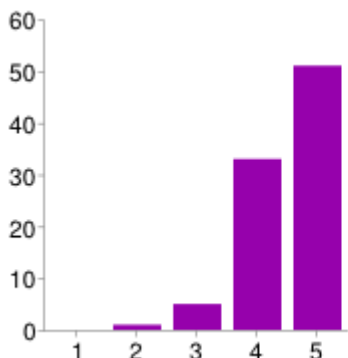
1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>20</b>	22%
4	<b>41</b>	46%
5	<b>29</b>	32%

#### My interest in the subject matter was increased by the workshop



1	<b>0</b>	0%
2	<b>1</b>	1%
3	<b>5</b>	6%
4	<b>34</b>	38%
5	<b>50</b>	56%

### The workshop helped me meet people with similar scientific interests



1	<b>0</b>	0%
2	<b>1</b>	1%
3	<b>5</b>	6%
4	<b>33</b>	37%
5	<b>51</b>	57%

### Additional comments on your personal assessment

wished the common area is bigger...

I found it intimidating to talk to others, and my mentor had no time for me at all.

A tremendous intellectual high point of the entire subject

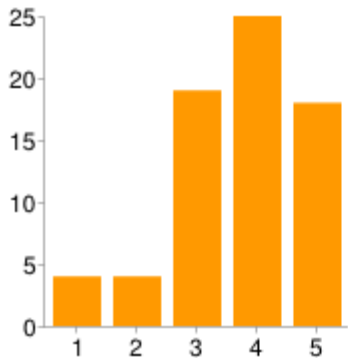
### Additional Activities

#### Did you attend the special dinner?



Yes	<b>69</b>	77%
No	<b>21</b>	23%

**If you did attend the special dinner, did it help to solidify the contacts you made in the workshop?**



1	<b>4</b>	4%
2	<b>4</b>	4%
3	<b>19</b>	21%
4	<b>25</b>	28%
5	<b>18</b>	20%

### Please provide any comments on the special dinner

Well-planned

The bad microphone device distracted while congratulatory speeches

People generally sat with whom they already knew, which was not good for making new contacts.

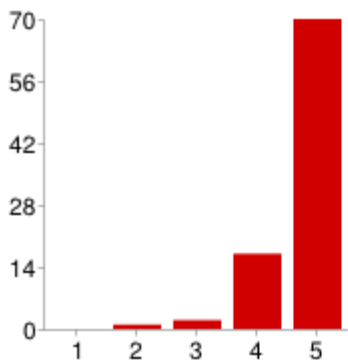
It was excellent.

Delicious food

It was amazing!

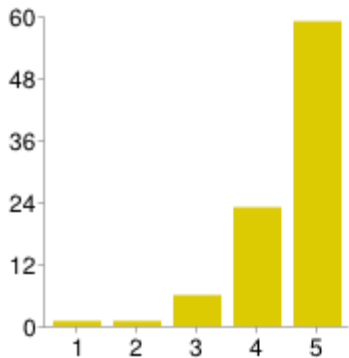
### Venue

#### I found the MSRI staff helpful



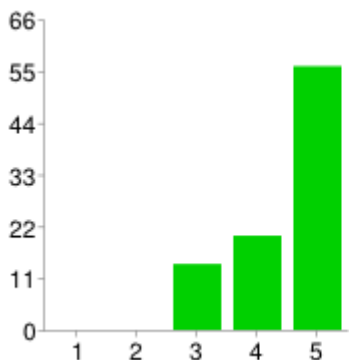
1	<b>0</b>	0%
2	<b>1</b>	1%
3	<b>2</b>	2%
4	<b>17</b>	19%
5	<b>70</b>	78%

#### The MSRI physical facilities were conducive for such a workshop



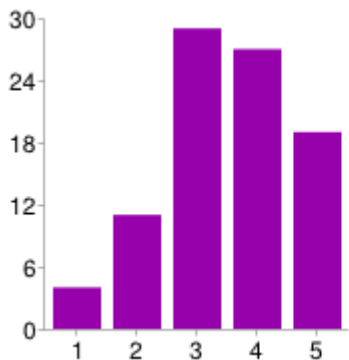
1	<b>1</b>	1%
2	<b>1</b>	1%
3	<b>6</b>	7%
4	<b>23</b>	26%
5	<b>59</b>	66%

**The MSRI computer facilities were adequate for such a workshop**



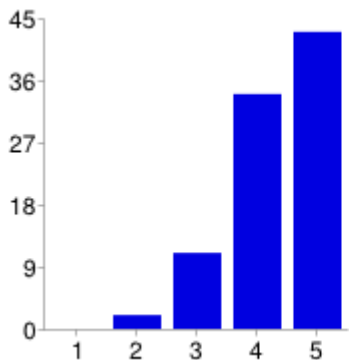
1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>14</b>	16%
4	<b>20</b>	22%
5	<b>56</b>	62%

**The MSRI lunch arrangements were satisfactory**



1	<b>4</b>	4%
2	<b>11</b>	12%
3	<b>29</b>	32%
4	<b>27</b>	30%
5	<b>19</b>	21%

**The MSRI tea arrangements were satisfactory**



1	<b>0</b>	0%
2	<b>2</b>	2%
3	<b>11</b>	12%
4	<b>34</b>	38%
5	<b>43</b>	48%

### Additional comments on the venue

It would be good to provide food before the morning lectures start, so that people getting up and arriving early can have breakfast.

I regretted that there is no cantine at MSRI

Did not use anything but wireless.

There were too many people for the size of the main lecture hall and the room where we could eat.

Would like more robust system for recording questions and comments from the audience. Also, less of a priority: more/better options for lunch; could the lunch ordering system be extended to non-member conference participants?

There were many participants and I'm not sure that MSRI is equipped to handle such a crowd  
Lecture hall too small

It would be better if bagels and such were put out before the first talk in the morning

In some lectures it was not easy to read the boards in the lecture room as they had not been cleaned properly.

I brought my own lunch

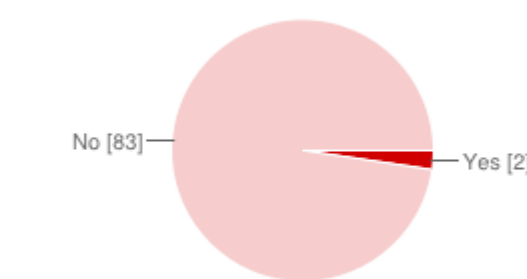
### MSRI Wireless Network

Did you use MSRI's wireless network?



Yes	81	90%
No	9	10%

Did you experience any difficulties with the network?



Yes	2	2%
No	83	92%

If you did experience difficulties with the network, please explain:

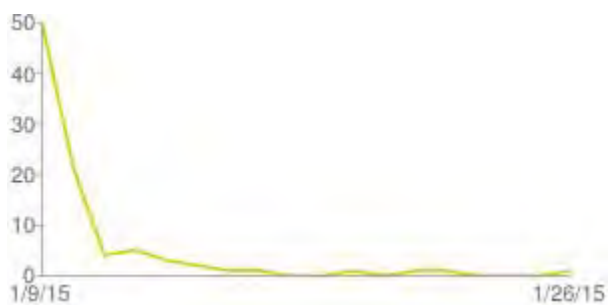
It sometimes would cut out for a short period of time.

## Thank you for completing this survey

**We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.**

Varies the lunch if possible.

## Number of daily responses





## **Advances in Homogeneous Dynamics**

May 11, 2015 - May 15, 2015

MSRI, Berkeley, CA, USA

Organizers:

**Dmitry Kleinbock (Brandeis University)**

**Hee Oh (Yale University)**

**Alireza Salehi Golesefidy (University of California, San Diego)**

**Ralf Spatzier (University of Michigan)**

## REPORT ON THE MSRI WORKSHOP: ADVANCES IN HOMOGENEOUS DYNAMICS, MAY 11, 2015 – MAY 15, 2015

### 1. ORGANIZERS

- Dmitry Kleinbock (Brandeis University)
- Hee Oh (Yale University)
- Alireza Salehi Golsefidy (University of California, San Diego)
- Ralf Spatzier (University of Michigan)

### 2. SCIENTIFIC DESCRIPTION

The focus of the MSRI half-year program, *Geometric and arithmetic aspects of homogeneous dynamics*, has been on the study of dynamical properties of natural algebraic actions on quotients of Lie groups by discrete subgroups. Such quotient spaces are interesting from many points of view and can be studied using a variety of tools, which explains the very rich interactions between homogeneous dynamics and other areas, in particular several branches of number theory, combinatorics, geometry, moduli spaces etc.

The “Advances in Homogeneous Dynamics” workshop was the final event of the MSRI semester on Geometric and Arithmetic Aspects of Homogeneous Dynamics. The five-day conference aimed to summarize recent progress and bring together established researchers who work in the broad area of homogeneous dynamics as well as graduate students and recent PhDs. There were 26 lectures, out of which 6 were short talks by younger mathematicians. The workshop was open to all mathematicians and was well attended, not just by program members but also by people from the companion program.

### 3. THEMES AND PRESENTATIONS

The main themes of the workshop were effective equidistribution results, random walks and the spectral gap, generalizations of Ratner’s orbit closure theorem, and Diophantine applications of homogeneous dynamics.

The first talk of the workshop was “Effective equidistribution of certain adelic periods” by Amir Mohammadi, who reported on recent joint work with Einsiedler, Margulis and Venkatesh. It represented one of the central themes in homogeneous dynamics these days – **effectivization** of results obtained earlier by methods which did not allow any control of the rates of convergence in limit theorems, or of the size of solutions of inequalities arising in number theory, such as in the proof of the Oppenheim Conjecture. The history and recent

developments related to the original conjecture were surveyed in a lecture “Oppenheim conjecture and related problems” by Gregory Margulis. This topic was featured in other talks, such as: “Effective density of unipotent orbits” by Elon Lindenstrauss and “Some Effective Estimates in Reduction Theory of Quadratic Forms” by Han Li.

The effective estimates in homogeneous dynamics and in applications to number theory often come from the **spectral gap** property. The latter was featured in several talks, such as in “Local spectral gap” by Alireza Salehi Golsefidy, “Counting and dynamics in  $SL_2$ ” by Michael Magee and “Bottom of spectrum and equivariant family of measures at the boundary in negative curvature” by Francois Ledrappier.

Ledrappier’s work is also central to the study of **random walks**, another important theme of the workshop. Jean-François Quint gave an overview on random walks on semisimple algebraic groups with emphasis on relaxing conditions like the finite first moment. Alex Eskin spoke on a new proof of the classification of stationary measures for lattice action on homogeneous spaces first obtained by Benoist and Quint. Generalizing these ideas to non-homogeneous actions, Federico Rodriguez Hertz spoke on stationary measures for random composition of surface diffeomorphisms. Also related is the recent work by Nalini Anantharaman and Etienne Le Masson on quantum unique ergodicity and expander graphs. Anantharaman gave an overview of this topic and of quantum unique ergodicity in general. Shirali Kadyrov’s talk was about singular systems of linear forms, divergent orbits of one-parameter diagonal groups on the space of lattices and relations with entropy. On a related matter, Uri Shapira spoke on escape of mass for the diagonal group in  $SL(n, \mathbb{R})$  acting on the space of lattices, a phenomenon arising in the context of quantum unique ergodicity properties of this locally symmetric space.

Other connections with theoretical physics came from the talk of Andreas Strombergsson on the dynamics of a point particle in an array of spherical scatterers with centers at quasi-crystals. Corinna Ulcigrai discussed the dynamics in a class of pseudo-integrable billiards in ellipses and the behaviour of light rays in arrays of Eaton lenses. This critically uses equidistribution results in the space of affine lattices.

Another central theme of the workshop has been a multifaceted relationship between **Diophantine approximation** and homogeneous dynamics. Emmanuel Breuillard discussed how fast products of elements in a Lie group can approach the identity. This is a non-commutative version of classical Diophantine approximation problem. Hillel Furstenberg related Diophantine properties of cubic irrationals to special orbits in homogeneous dynamics. Alex Gorodnik spoke on limit distributions and central limit theorems for the counting

function for solutions of Diophantine inequalities. Lei Yang spoke on equidistribution of expanding translates of curves in homogeneous spaces, a topic intimately connected with the problem of improving Dirichlet's theorem in simultaneous approximation.

Zhiren Wang discussed the Zimmer program on smooth actions by lattices in higher rank semisimple Lie groups, and gave a classification of Anosov actions of such lattices on tori and nilmanifolds. These turn out to be homogeneous actions, as is the central tenet of the Zimmer program.

One of the most fundamental results in homogeneous dynamics is Ratner's Orbit Closure Theorem. Studying **orbit closures** in the situations not covered by Ratner has been an important direction in this area of research. Hee Oh discussed closures of totally geodesic immersions of hyperbolic planes in infinite volume hyperbolic 3-manifolds, generalizing earlier work of Ratner and Shah in finite volume. Maryam Mirzakhani gave an overview of orbit closures for the action of  $SL(2, \mathbb{R})$  on the moduli space of flat structures.

A number of additional topics were discussed: Peter Varju on Bernoulli convolutions, Nicolas de Saxce on the Hausdorff dimension of triple products of set in simple Lie groups, and Ilya Gekhtman on asymptotics of non-loxodromic elements in Gromov hyperbolic groups.

Finally, Marc Burger discussed integral Hitchin representations and their growth properties. This work lies at the intersection of the two programs in session during Spring 2015.

<b>Organizers</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Dmitry	Kleinbock	Brandeis University
Hee	Oh	Yale University
Alireza	Salehi Golsefidy	University of California, San Diego
Ralf	Spatzier	University of Michigan
<b>Speakers</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Nalini	Anantharaman	Université de Strasbourg
Emmanuel	Breillard	Université de Paris XI
Marc	Burger	Eidgenössische TH Zürich-Hönggerberg
Nicolas	de Saxce	Université de Paris XIII (Paris-Nord)
Alex	Eskin	University of Chicago
Hillel	Furstenberg	Hebrew University
Ilya	Gekhtman	Yale University
Alexander	Gorodnik	University of Bristol
Shirali	Kadyrov	Nazarbayev University
François	Ledrappier	University of Notre Dame
Han	Li	University of Texas
Elon	Lindenstrauss	Hebrew University
Michael	Magee	Institute for Advanced Study
Gregory	Margulis	Yale University
Maryam	Mirzakhani	Stanford University
Amir	Mohammadi	University of Texas
Hee	Oh	Yale University
Jean-François	Quint	Université de Bordeaux I
Federico	Rodriguez Hertz	Pennsylvania State University
Alireza	Salehi Golsefidy	University of California, San Diego
Uri	Shapira	Technion--Israel Institute of Technology
Andreas	Strombergsson	Uppsala University
Corinna	Ulcigrai	University of Bristol
Peter	Varju	University of Cambridge
Zhiren	Wang	Pennsylvania State University
Lei	Yang	Yale University



## Advances in Homogeneous Dynamics

May 11-15, 2015

### Schedule

Monday, May 11, 2015			
9:30 AM - 9:45 AM	Simons Auditorium		Welcome
9:50 AM - 10:40 AM	Simons Auditorium	Amir Mohammadi	Effective equidistribution of certain adelic periods
10:40 AM - 11:10 AM	Atrium		Tea
11:10 AM - 12:00 PM	Simons Auditorium	Nalini Anantharaman	Quantum ergodicity on large graphs
12:00 PM - 1:30 PM	Atrium		Lunch
1:30 PM - 2:20 PM	Simons Auditorium	Hee Oh	Geodesic planes in hyperbolic 3-manifolds
2:30 PM - 2:55 PM	Simons Auditorium	Lei Yang	Equidistribution of expanding translates of curves in homogeneous spaces and its application to Diophantine approximation.
2:55 PM - 3:20 PM	Simons Auditorium	Shirali Kadyrov	Entropy in the cusp and singular systems of linear forms
3:20 PM - 3:50 PM	Atrium		Tea
3:50 PM - 4:40 PM	Simons Auditorium	Alireza Salehi Golsefidy	Local spectral gap
Tuesday, May 12, 2015			
9:30 AM - 10:20 AM	Simons Auditorium	Alexander Gorodnik	Randomness in Diophantine approximation
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 11:50 PM	Simons Auditorium	Corinna Ulcigrai	Genericity along curves and applications
12:00 PM - 1:30 PM	Atrium		Lunch
1:30 PM - 2:20 PM	Simons Auditorium	Peter Varju	Bernoulli convolutions for algebraic parameters
2:30 PM - 2:55 PM	Simons Auditorium	Michael Magee	Counting and dynamics in $SL_2$
2:55 PM - 3:20 PM	Simons Auditorium	Nicolas de Saxce	Hausdorff dimension of product sets in Lie groups
3:20 PM - 3:50 PM	Atrium		Tea
3:50 PM - 4:40 PM	Simons Auditorium	Hillel Furstenberg	Diophantine approximation for algebraic numbers
4:40 PM - 6:20 PM	Atrium		Reception
Wednesday, May 13, 2015			
9:00 AM - 9:50 AM	Simons Auditorium	Emmanuel Breuillard	Metric diophantine approximation on Lie groups
9:50 AM - 10:20 AM	Atrium		Tea
10:20 AM - 11:10 PM	Simons Auditorium	Uri Shapira	Escape of mass for measures invariant under the diagonal group
11:20 AM - 12:10 PM	Simons Auditorium	Gregory Margulis	Oppenheim conjecture and related problems
Thursday, May 14, 2015			
9:00 AM - 9:50 AM	Simons Auditorium	Elon Lindenstrauss	Effective density of unipotent orbit
10:00 AM - 10:50 AM	Simons Auditorium	Marc Burger	On integer points in the Hitchin moduli space
10:50 AM - 11:20 PM	Atrium		Tea
11:20 PM - 12:00 PM	Simons Auditorium		Concert
12:00 PM - 1:30 PM	Atrium		Lunch
1:30 PM - 2:20 PM	Simons Auditorium	Federico Rodriguez Hertz	Random Dynamics and a formula for Furstenberg, Kullback-Ledrappier Entropy
2:30 PM - 2:55 PM	Simons Auditorium	Ilya Gekhtman	Word metric asymptotics for actions of hyperbolic groups on Gromov hyperbolic spaces
2:55 PM - 3:20 PM	Simons Auditorium	Han Li	Some Effective Estimates in Reduction Theory of Quadratic Forms
3:20 PM - 3:55 PM	Atrium		Tea
3:50 PM - 4:40 PM	Simons Auditorium	François Ledrappier	Bottom of spectrum and equivariant family of measures at the boundary in negative curvature.
Friday, May 15, 2015			
9:00 AM - 9:50 AM	Simons Auditorium	Jean-François Quint	Random walks on semisimple groups
9:50 AM - 10:20 AM	Atrium		Tea
10:20 AM - 11:10 PM	Simons Auditorium	Zhiren Wang	Global rigidity of Anosov actions by higher rank lattices
11:20 PM - 12:10 PM	Simons Auditorium	Maryam Mirzakhani	Dynamics on the moduli space of flat structures
12:10 PM - 1:30 PM	Atrium		Lunch
1:30 PM - 2:20 PM	Simons Auditorium	Andreas Strombergsson	Kinetic transport in quasicrystals
2:30 PM - 3:20 PM	Simons Auditorium	Alex Eskin	Stiffness for Random Walks on Locally symmetric spaces
3:20 PM - 3:50 PM	Atrium		Tea-Goodbye

<b>Participants</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Herbert	Abels	Universität Bielefeld
Ilesanmi	Adeboye	Wesleyan University
Ian	Agol	University of California, Berkeley
Fahd	Alshammari	King Saud University
Nalini	Anantharaman	Université de Strasbourg
Paul	Apisa	University of Chicago
Caleb	Ashley	Howard University
David	Aulicino	University of Chicago
Yves	Benoist	Université de Paris XI
Francis	Bonahon	University of Southern California
Emmanuel	Breuillard	Université de Paris XI
Martin	Bridgeman	Boston College
C. Davis	Buenger	Ohio State University
Marc	Burger	Eidgenössische TH Zürich-Hönggerberg
Claire	Burrin	Eidgenössische TH Zürich-Hönggerberg
Gabriel	Calsamiglia	Fluminense Federal University
Rex	Cheung	Yale University
Yitwah	Cheung	San Francisco State University
Suh Young	Choi	Korea Advanced Institute of Science and Technology (KAIST)
Michelle	Chu	University of Texas
Kathryn	Dabbs	University of Texas
Jeffrey	Danciger	University of Texas
Shrikrishna	Dani	Indian Institute of Technology
Carlos Alberto	De la Cruz Mengual	Eidgenössische TH Zürich-Hönggerberg
Nicolas	de Saxce	Université de Paris XIII (Paris-Nord)
Benjamin	Dozier	Stanford University
David	Dumas	University of Illinois at Chicago
Alena	Erchenko	Pennsylvania State University
Alex	Eskin	University of Chicago
David	Fisher	Indiana University
Hillel	Furstenberg	Hebrew University
Ilya	Gekhtman	Yale University
Alexis	Gilles	École Normale Supérieure
Alexander	Gorodnik	University of Bristol
Ursula	Hamenstädt	Universität Bonn
Jiyoung	Han	Seoul National University
Weikun	He	Université de Paris XI
Byron	Heersink	University of Illinois at Urbana-Champaign
Aloysius	Helminck	North Carolina State University
Soon ki	Hong	Seoul National University
Tal	Horesh	Technion---Israel Institute of Technology
Alessandra	Iozzi	Eidgenössische TH Zürich-Hönggerberg
Shirali	Kadyrov	Nazarbayev University
Lien-Yung	Kao	University of Notre Dame

<b>Participants</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Fanny	Kassel	Université de Lille I (Sciences et Techniques de Lille Flandres Artois)
Dubi	Kelmer	Boston College
Fariba	Khoshnasib	University of Texas at Dallas
Inkang	Kim	Korea Institute for Advanced Study (KIAS)
Dmitry	Kleinbock	Brandeis University
Ioannis	Konstantoulas	University of Utah
François	Labourie	Université Nice Sophia-Antipolis
Sean	Lawton	George Mason University
Etienne	Le Masson	Hebrew University
François	Ledrappier	University of Notre Dame
Gye-Seon	Lee	Ruprecht-Karls-Universität Heidelberg
Bernhard	Leeb	Ludwig-Maximilians-Universität München
Han	Li	University of Texas
Qionglng	Li	Rice University
Seonhee	Lim	Seoul National University
Elon	Lindenstrauss	Hebrew University
Michael	Lipnowski	Duke University
Anton	Lukyanenko	University of Michigan
Tue	Ly	Brandeis University
Michael	Magee	Institute for Advanced Study
Keivan	Mallahi Karai	Jacobs University Bremen
Kathryn	Mann	University of California, Berkeley
Albert	Marden	University of Minnesota Twin Cities
Gregory	Margulis	Yale University
Giuseppe	Martone	University of Southern California
Taylor	McAdam	University of Texas
Keith	Merrill	Brandeis University
Shahriar	Mirzadeh	Brandeis University
Maryam	Mirzakhani	Stanford University
Amir	Mohammadi	University of Texas
Shahar	Mozes	Hebrew University
Hee	Oh	Yale University
Wenyu	Pan	Yale University
Kyewon Koh	Park	Korea Institute for Advanced Study (KIAS)
Mark	Pollicott	University of Warwick
Jean-François	Quint	Université de Bordeaux I
Anthony	Quas	University of Victoria
Federico	Rodriguez Hertz	Pennsylvania State University
Alireza	Salehi Golsefidy	University of California, San Diego
Riddhi	Shah	Jawaharlal Nehru University (JNU)
Nimish	Shah	Ohio State University
Uri	Shapira	Technion---Israel Institute of Technology
Ronggang	Shi	Tel Aviv University
Lin	Shu	Beijing (Peking) University



<b>Participants</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Ralf	Spatzier	University of Michigan
Andreas	Strombergsson	Uppsala University
Roman	Sverdlov	University of Mississippi
George	Tomanov	Université Claude-Bernard (Lyon I)
Rodrigo	Treviño	New York University, Courant Institute
Jimmy	Tseng	University of Bristol
Corinna	Ulcigrai	University of Bristol
Joseph	Vandehey	University of Georgia
Peter	Varju	University of Cambridge
Kurt	Vinhage	Pennsylvania State University
Ilya	Vinogradov	University of Bristol
Polina	Vytnova	School of Mathematical Sciences, Queen Mary, University of London
Zhiren	Wang	Pennsylvania State University
Dale	Winter	Brown University
Joseph	Wolf	University of California, Berkeley
Maxime	Wolff	Institut de Mathématiques de Jussieu
Grace	Work	University of Illinois at Urbana-Champaign
Alexander	Wright	Stanford University
Chenxi	Wu	Cornell University
Lei	Yang	Yale University
Tengren	Zhang	University of Michigan
Cheng	Zheng	Ohio State University

## Officially Registered Participant Information

<b>Participants</b>		<b>110</b>
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<b>Gender</b>		<b>110</b>
<b>Male</b>	77.27%	85
<b>Female</b>	21.82%	24
<b>Declined to state</b>	0.91%	1

<b>Ethnicity*</b>		<b>119</b>
<b>White</b>	52.10%	62
<b>Asian</b>	25.21%	30
<b>Hispanic</b>	4.20%	5
<b>Pacific Islander</b>	0.00%	0
<b>Black</b>	1.68%	2
<b>Native American</b>	0.00%	0
<b>Mixed</b>	4.20%	5
<b>Declined to state</b>	12.61%	15

\* ethnicity specifications are not exclusive

# 60 responses

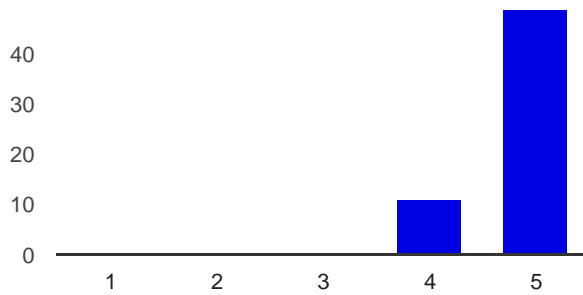
60 responses / 110 participants = 55% response rate

[View all responses](#)   [Publish analytics](#)

## Summary

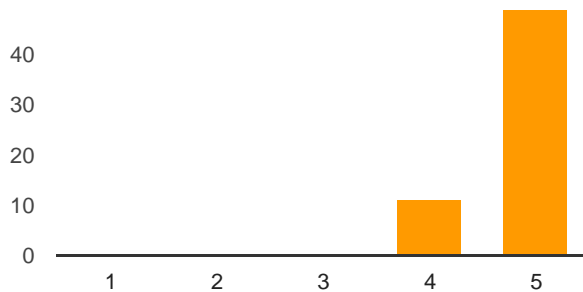
### Workshop assessment

#### The workshop was intellectually stimulating



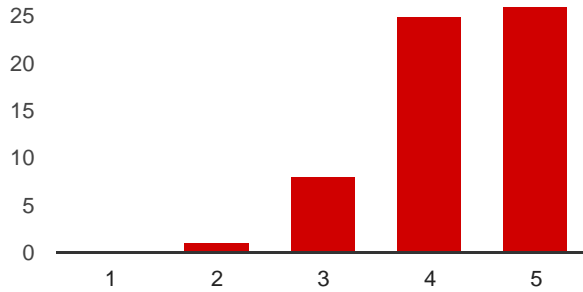
Not at all: 1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>0</b>	0%
4	<b>11</b>	18.3%
Very: 5	<b>49</b>	81.7%

#### The overall experience of the workshop was worthwhile



Not at all: 1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>0</b>	0%
4	<b>11</b>	18.3%
Very: 5	<b>49</b>	81.7%

### The time between lectures was adequate for discussion



Not at all: 1	<b>0</b>	0%
2	<b>1</b>	1.7%
3	<b>8</b>	13.3%
4	<b>25</b>	41.7%
Very: 5	<b>26</b>	43.3%

### Additional comments on the workshop organization

The talks were very interesting, but the schedule was a bit too busy.

The after-lunch talks were all very close together.

It would be better if the talks started later

it was a great idea to have the concert, but perhaps doing it after all the talks and not in the intermission would have been better

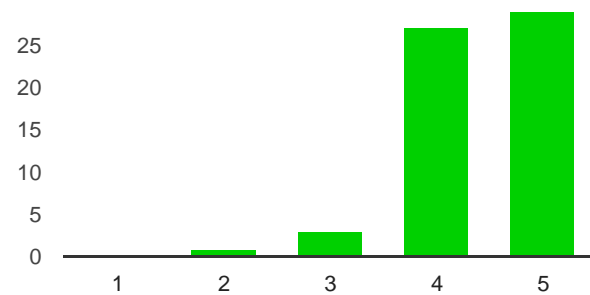
### Personal assessment

#### I was well prepared to benefit from the lectures



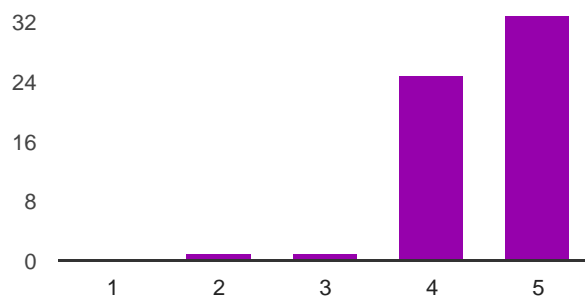
Not at all: 1	<b>1</b>	1.7%
2	<b>2</b>	3.3%
3	<b>9</b>	15%
4	<b>26</b>	43.3%
Very: 5	<b>22</b>	36.7%

**My interest in the subject matter was increased by the workshop**



Niot at all: 1	<b>0</b>	0%
2	<b>1</b>	1.7%
3	<b>3</b>	5%
4	<b>27</b>	45%
Very: 5	<b>29</b>	48.3%

**The workshop helped me meet people with similar scientific interests**



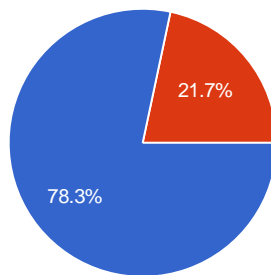
Not at all: 1	<b>0</b>	0%
2	<b>1</b>	1.7%
3	<b>1</b>	1.7%
4	<b>25</b>	41.7%
Very Much: 5	<b>33</b>	55%

### Additional comments on your personal assessment

I am only a second year graduate student, so there was a lot that I didn't understand in the lectures. However, I still feel like I benefitted from them and they increased my interest significantly.

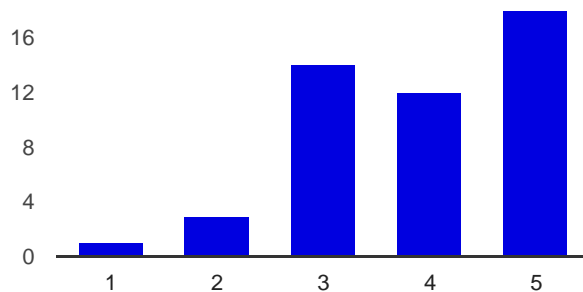
### Additional Activities

#### Did you attend the reception?



Yes	<b>47</b>	78.3%
No	<b>13</b>	21.7%

#### If you did attend the reception, did it help to solidify the contacts you made in the workshop?



Not at all: 1	<b>1</b>	2.1%
2	<b>3</b>	6.3%
3	<b>14</b>	29.2%
4	<b>12</b>	25%

Very much: 5 **18** 37.5%

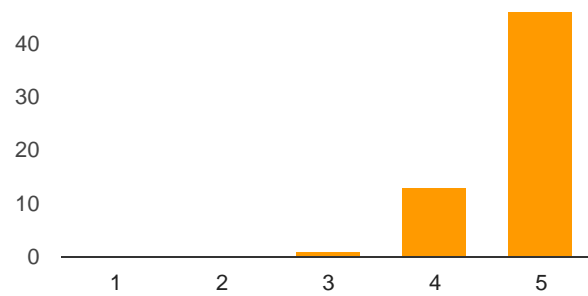
### Please provide any comments on the reception

food was terrible

great food!

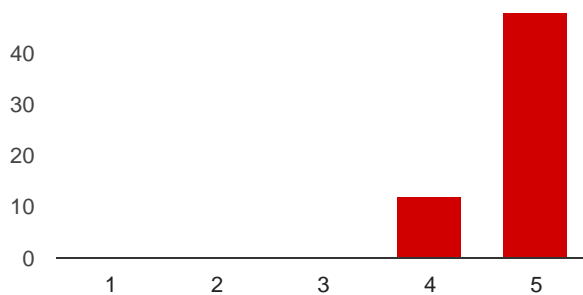
## Venue

### I found the MSRI staff helpful



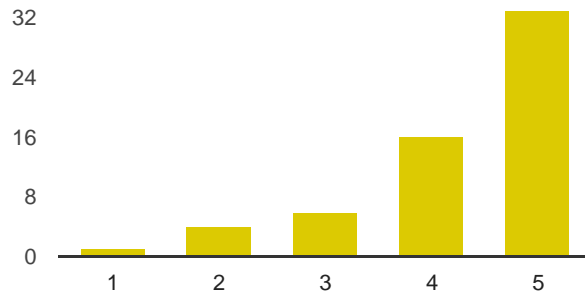
Not at all: 1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>1</b>	1.7%
4	<b>13</b>	21.7%
Very: 5	<b>46</b>	76.7%

### The MSRI physical facilities were conducive for such a workshop



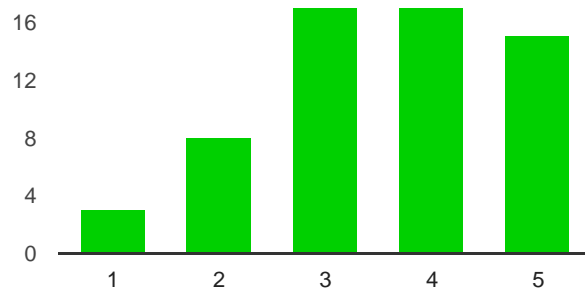
Not at all: 1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>0</b>	0%
4	<b>12</b>	20%
Very: 5	<b>48</b>	80%

**The MSRI computer facilities were adequate for such a workshop**



Not at all: 1	<b>1</b>	1.7%
2	<b>4</b>	6.7%
3	<b>6</b>	10%
4	<b>16</b>	26.7%
Very: 5	<b>33</b>	55%

**The MSRI lunch arrangements were satisfactory**

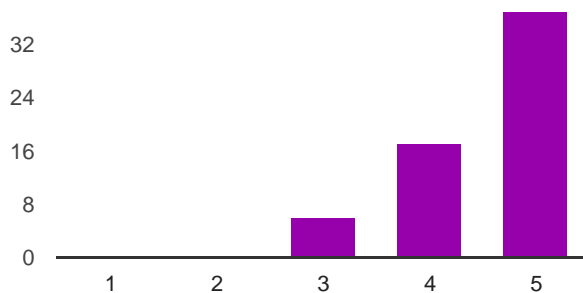


Not at all: 1	<b>3</b>	5%
2	<b>8</b>	13.3%
3	<b>17</b>	28.3%
4	<b>17</b>	28.3%



Very: 5    **15**    25%

### The MSRI tea arrangements were satisfactory



Not at all: 1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>6</b>	10%
4	<b>17</b>	28.3%
Very: 5	<b>37</b>	61.7%

### Additional comments on the venue

long queues were problems for snacks

Drinks should be allowed in library and lecture hall - caffeine increases productivity

The location of MSRI is absolutely beautiful, although a little out of the way. A few times the lunch providers ran out of vegetarian options fairly early into lunch, which was unfortunate for me, since I am vegetarian.

Transportation – many people complained that there were not enough buses in the morning, maybe it is possible too add a few buses in the future?

I already commented on the need to have hangers for jacket/swaters and/or lockers for participants without office in the previous survey. I also think that if the lunch could be paid for with credit cards instead of paypal account, it could be useful for overseas participants.

More fresh fruits please!

I attended the conference while breastfeeding my child. It would be useful to have a room where it is possible to breastfeed and have the baby stay with a nanny if needed

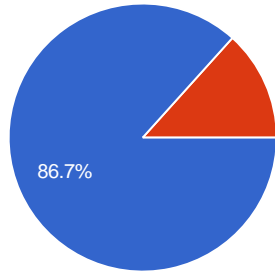
I have a suggestion: As there is no office for the workshop participants, if possible please provide a place to hang jackets/sweaters and also lockers if possible. It is difficult to carry warm clothes/laptops all the time including during the visit to the washroom. A simple rod with lots of hangers somewhere in the building would be useful for the participants without the office.

ordering lunch on Wednesdays via the MSRI website is really difficult: first you need to log in to your MSRI account, then select your food, then pay with a credit card. Overall it is a lot of work

for just a lunch. I spent half an hour on it (first getting a new password, then trying to remember my american billing address, etc..) It would be nice to be given the option to pay in cash at reception of the food.

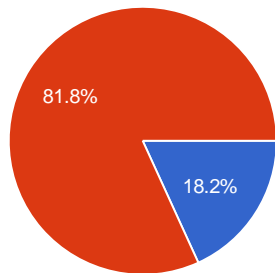
## MSRI Wireless Network

Did you use MSRI's wireless network?



Yes	52	86.7%
No	8	13.3%

Did you experience any difficulties with the network?



Yes	10	18.2%
No	45	81.8%

If you did experience difficulties with the network, please explain:

no connectivity

too slow

Reception weak in the main lecture hall.

The network was sometimes a bit slow, e.g. around noon.

Weak wireless signal in the main lecture hall

Too slow

the signal is not strong

slow periods

**Thank you for completing this survey**

**We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.**

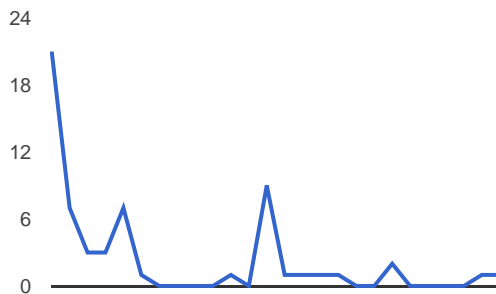
I enjoyed the concert. Hope this kind of activities continue

Wash the blackboard between the talks!

In an MSRI account, the only default image (unless of course you upload your own picture) is that of a (white) male. I would have liked the option to choose a female image.

To encourage women with young children to attend, it would be great to be able to offer partial help/reimbursement with additional childcare costs when traevelling. Certian institutes, for example the Newwton Institute, do this and I found it a great way to help and encourage women in similar situation to attend.

### Number of daily responses



**Connections for Women: Dynamics on  
Moduli Spaces of Geometric Structures**

January 15, 2015 - January 16, 2015

MSRI, Berkeley, CA, USA

Organizers:

**Virginie Charette (University of Sherbrooke)**

**Fanny Kassel (Université de Lille I (Sciences et Techniques de Lille  
Flandres Artois))**

**Karin Melnick (University of Maryland)**

**Anna Wienhard (Ruprecht-Karls-Universität Heidelberg)**

# REPORT ON THE WORKSHOP: CONNECTIONS FOR WOMEN, DYNAMICS ON MODULI SPACES OF GEOMETRIC STRUCTURES

15–16 JANUARY 2015

Organizers:

- Virginie Charette
- Fanny Kassel
- Karin Melnick
- Anna Wienhard

## 1. SCIENTIFIC DESCRIPTION

The workshop consisted of eight talks: two longer ones by successful, established female mathematicians (Alessandra Iozzi and Jing Tao) and six shorter ones by brilliant female postdocs (Youngju Kim, Qionglin Li, Evelyn Lamb, Sara Maloni, Kathryn Mann, Beatrice Pozzetti).

We asked all speakers, apart from Evelyn Lamb, to talk on topics that we chose, among the major themes of the program. We asked them to start at a very basic graduate level, and by the end, if possible, to give some indication of their own contributions to the subject and motivate current research in the field. We thought all talks were very successful in this respect. We asked Evelyn Lamb (a well-known and popular expositor) to give the last talk, on some more historical aspects of hyperbolic geometry.

Due to a last-minute emergency, Alessandra Iozzi unfortunately had to postpone her trip to Berkeley. However, she accepted to give a video conference from ETH Zürich at the originally scheduled time. Thanks to the excellent work of the IT staff at MSRI and ETH, the video conference went very well. Iozzi did a great job at introducing bounded cohomology in a very friendly way; this subject may often seem a bit technical to newcomers.

There was synergy between some talks of the Connections for Women Workshop and some talks of the Introductory Workshop, such as the talks on quasi-Fuchsian representations by Sara Maloni and Yair Minsky.

## 2. PROFESSIONAL DEVELOPMENT SESSION

Members of the panel:

- Richard Canary (University of Michigan),
- Indira Chatterji (Université de Nice Sophia-Antipolis, France),
- David Dumas (University of Illinois at Chicago),
- Karin Melnick (University of Maryland),
- Jing Tao (University of Oklahoma).

Moderator: Anna Wienhard.

There were about 40 people in the audience, including many young women and men, and a few more senior mathematicians.

The goal of the Professional Development Session was to discuss various aspects of academic careers in mathematics, and to present several points of view on them. We started by asking all panelists to answer the following two questions:

- (1) Why have you pursued a career in mathematics?
- (2) What does one need in order to have a successful career in mathematics?

The Professional Development Session was a real success, and many young women expressed their appreciation afterwards. We opted to invite two well-known and thoughtful male mathematicians on the panel. It was particularly interesting and helpful for young people to hear that all members of the panel, men and women, junior and senior, could relate to the ‘impostor syndrome’ that David Dumas mentioned. The atmosphere was very casual and open, and young people felt comfortable asking very concrete questions, such as how to choose good research problems, how to organize one’s time, when to start writing a paper and how to know when it is complete, etc.

Indira Chatterji was carrying her baby for the whole discussion, which was an illustration of the compatibility of a successful career in mathematics with a family life.

### 3. CONCLUSION

This Connections for Women workshop was a nice ramp up to the Introductory Workshop. It gave young people (in particular, young women) the chance to get to know one another in a relaxed atmosphere, to expand their professional network, and to learn some deep and interesting mathematics.

<b>Organizers</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Virginie	Charette	University of Sherbrooke
Fanny	Kassel	Université de Lille I (Sciences et Techniques de Lille Flandres Artois)
Karin	Melnick	University of Maryland
Anna	Wienhard	Ruprecht-Karls-Universität Heidelberg
<b>Speakers</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Alessandra	Iozzi	Eidgenössische TH Zürich-Hönggerberg
Youngju	Kim	Korea Institute for Advanced Study (KIAS)
Evelyn	Lamb	University of Utah
Qionglin	Li	Rice University
Sara	Maloni	Brown University
Kathryn	Mann	University of California, Berkeley
Maria Beatrice	Pozzetti	MSRI - Mathematical Sciences Research Institute
Jing	Tao	University of Oklahoma



**Connections for Women: Dynamics on Moduli Spaces of Geometric Structures**

January 15 to 16, 2015

**Schedule**

<b>Thursday, January 15, 2015</b>			
8:45AM - 9:00AM	Simons Auditorium		Welcome
9:00AM - 10:30AM	Simons Auditorium	Alessandra Iozzi	Introduction to bounded cohomology and applications to rigidity
10:30AM - 11:00AM	Atrium		Tea
11:00AM - 12:00PM	Simons Auditorium	Kathryn Mann	Groups acting on the circle
12:00PM - 2:00PM	Atrium		Lunch
2:00PM - 3:00PM	Simons Auditorium	Youngju Kim	An introduction to Lorentzian 3-manifold
3:00PM - 3:30PM	Atrium		Tea
3:30PM - 4:30PM	Simons Auditorium	Beatrice Pozzetti	Hermitian symmetric spaces
5:00PM - 6:30PM	Atrium		Professional Development Session
7:00PM - 8:30PM			Dinner at Taste of Himalayas

<b>Friday, January 16, 2015</b>			
9:00AM - 10:30AM	Simons Auditorium	Jing Tao	Introduction to Teichmuller spaces
10:30AM - 11:00AM	Atrium		Tea
11:00AM - 12:00PM	Simons Auditorium	Sara Maloni	Introduction to quasi-Fuchsian groups
12:00PM - 2:00PM	Atrium		Lunch
2:00PM - 3:00PM	Simons Auditorium	Qionglin Li	Harmonic Maps And Surface Group Representations
3:00PM - 3:30PM	Atrium		Tea
3:30PM - 4:30PM	Simons Auditorium	Evelyn Lamb	What we knew about hyperbolic geometry before we knew about hyperbolic geometry



<b>Participants</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Ilesanmi	Adeboye	Wesleyan University
Vanessa	Alderete	National Autonomous University of Mexico (UNAM)
Caleb	Ashley	Howard University
Shinpei	Baba	Ruprecht-Karls-Universität Heidelberg
Yves	Benoist	Université de Paris XI
Francis	Bonahon	University of Southern California
Sarah	Bray	Tufts University
C. Davis	Buenger	Ohio State University
Claire	Burrin	Eidgenössische TH Zürich-Hönggerberg
Virginie	Charette	University of Sherbrooke
Rex	Cheung	Yale University
Michelle	Chu	University of Texas
Corina	Ciobotaru	Université de Genève
Jeffrey	Danciger	University of Texas
Carlos Alberto	De la Cruz Mengual	Eidgenössische TH Zürich-Hönggerberg
Guillaume	Dreyer	University of Notre Dame
David	Dumas	University of Illinois at Chicago
Viveka	Erlandsson	Aalto University
Erica	Flapan	Pomona College
Charles	Fougeron	Université de Paris VII (Denis Diderot)
Selim	Ghazouani	École Normale Supérieure
Sourav	Ghosh	Université de Paris XI
William	Goldman	University of Maryland
Adriana	González	National Autonomous University of Mexico (UNAM)
Vesselin	Gueorguiev	California State University
Clément	Guérin	Université de Strasbourg I (Louis Pasteur)
Olivier	Guichard	Université de Strasbourg I (Louis Pasteur)
Subhojoy	Gupta	California Institute of Technology
Soon ki	Hong	Seoul National University
Alessandra	Iozzi	Eidgenössische TH Zürich-Hönggerberg
Fanny	Kassel	Université de Lille I (Sciences et Techniques de Lille Flandres Artois)
Youngju	Kim	Korea Institute for Advanced Study (KIAS)
Dong Han	Kim	Dongguk University
Marilyn	Koshlap	City College of San Francisco
Sanghoon	Kwon	Seoul National University
Evelyn	Lamb	University of Utah
Arielle	Leitner	University of California, Santa Barbara
Qionglng	Li	Rice University
Seonhee	Lim	Seoul National University
Sara	Maloni	Brown University
Kathryn	Mann	University of California, Berkeley
Stéphane	Marseglia	Université de Strasbourg I (Louis Pasteur)
Giuseppe	Martone	University of Southern California
Howard	Masur	University of Chicago

<b>Participants</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Karin	Melnick	University of Maryland
Kyewon Koh	Park	Korea Institute for Advanced Study (KIAS)
Ana	Peón-Nieto	Ruprecht-Karls-Universität Heidelberg
Raquel	Perales Aguilar	State University of New York, Stony Brook
Maria Beatrice	Pozzetti	MSRI - Mathematical Sciences Research Institute
David	Renardy	University of Michigan
Lorenzo	Ruffoni	Università di Bologna
Anna-Sofie	Schilling	Ruprecht-Karls-Universität Heidelberg
Lin	Shu	Beijing (Peking) University
Christina	Sormani	CUNY, Graduate Center
Jing	Tao	University of Oklahoma
Nicolaus	Treib	Ruprecht-Karls-Universität Heidelberg
Anna	Wienhard	Ruprecht-Karls-Universität Heidelberg
Maxime	Wolff	Institut de Mathématiques de Jussieu
Grace	Work	University of Illinois at Urbana-Champaign
Serena	Yuan	New York University, Courant Institute
Tengren	Zhang	University of Michigan
Cheng	Zheng	Ohio State University

## Officially Registered Participant Information

<b>Participants</b>		<b>62</b>
---------------------	--	-----------

<b>Gender</b>		<b>62</b>
<b>Male</b>	50.00%	31
<b>Female</b>	48.39%	30
<b>Declined to state</b>	1.61%	1

<b>Ethnicity*</b>		<b>68</b>
<b>White</b>	50.00%	34
<b>Asian</b>	25.00%	17
<b>Hispanic</b>	7.35%	5
<b>Pacific Islander</b>	0.00%	0
<b>Black</b>	2.94%	2
<b>Native American</b>	0.00%	0
<b>Mixed</b>	4.41%	3
<b>Declined to state</b>	10.29%	7

\* ethnicity specifications are not exclusive

# 40 responses

40 responses/62 participants = 64% response rate

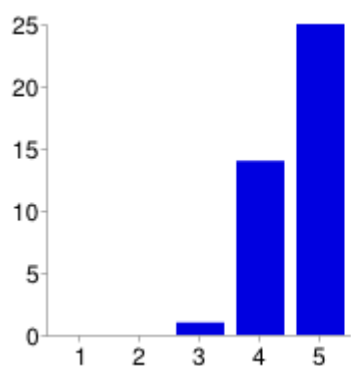
[View all responses](#)   [Publish analytics](#)

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## Summary

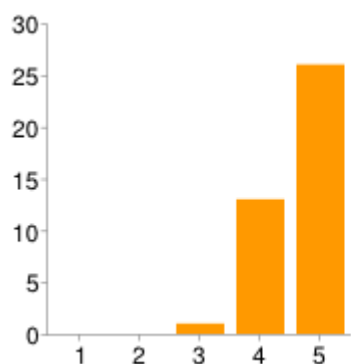
### Workshop assessment

#### The workshop was intellectually stimulating



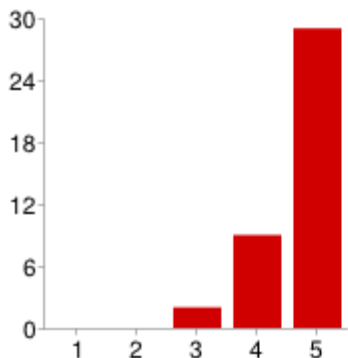
1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>1</b>	3%
4	<b>14</b>	35%
5	<b>25</b>	63%

#### The overall experience of the workshop was worthwhile



1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>1</b>	3%
4	<b>13</b>	33%
5	<b>26</b>	65%

#### The time between lectures was adequate for discussion



1	0	0%
2	0	0%
3	2	5%
4	9	23%
5	29	73%

### Additional comments on the workshop organization

1.5 hours talks are too long. They should be split into two 45 minute sections with a 5 minute break.

Thank you

Exceptionally friendly environment

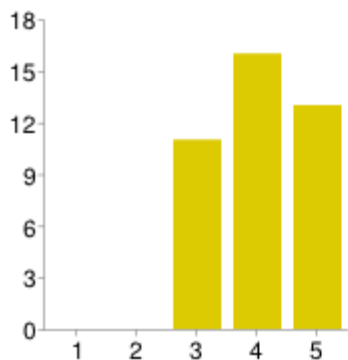
Very pleasant and well organized workshop!

Excellent pannel discussion

Good!

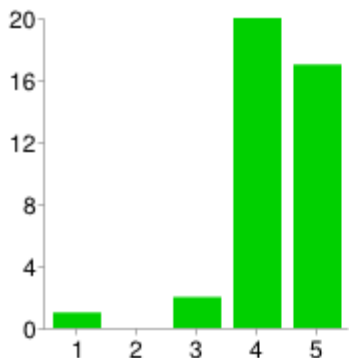
### Personal assessment

#### I was well prepared to benefit from the lectures



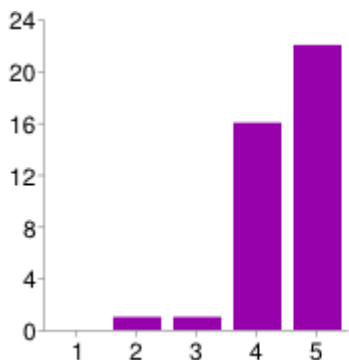
1	0	0%
2	0	0%
3	11	28%
4	16	40%
5	13	33%

#### My interest in the subject matter was increased by the workshop



1	1	3%
2	0	0%
3	2	5%
4	20	50%
5	17	43%

### The workshop helped me meet people with similar scientific interests



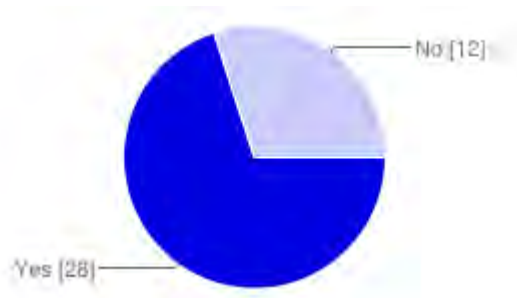
1	0	0%
2	1	3%
3	1	3%
4	16	40%
5	22	55%

### Additional comments on your personal assessment

Some of the talks were very close to my own research, while others were farther.

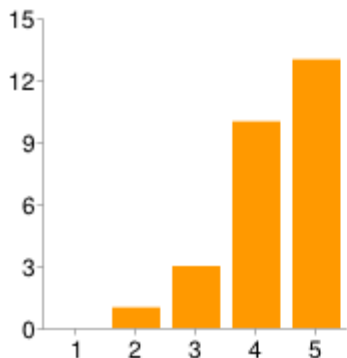
### Additional Activities

#### Did you attend the Professional Development Session?



Yes	28	70%
No	12	30%

If you did attend the Professional Development Session, did you find it worthwhile?



1	0	0%
2	1	3%
3	3	8%
4	10	25%
5	13	33%

### What other subjects should be addressed in future Professional Development Session?

Maybe less about why you became a mathematician and more about how

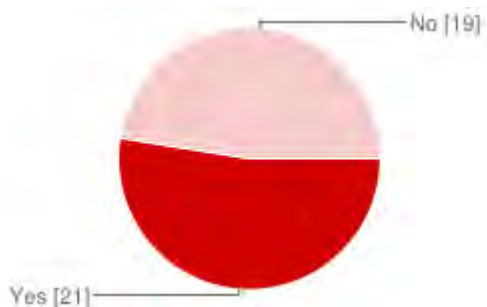
More details on how to prepare applications would be useful (from addressing eventual employers to how to structure it, to how to make it interesting t others...). The panel discussion was very interesting, as we heard about the experience of more established professionals, but most subjects treated were essentially subjective, so it would be nice to have a session on more practical aspects of professional development.

How to begin a career in mathematics.

Good strategies and choices for future developments.

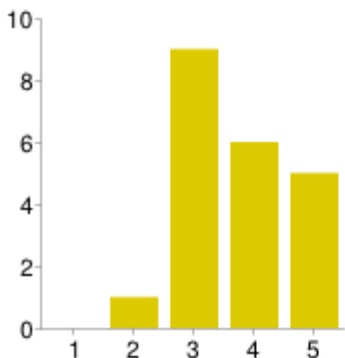
Hints for research applications,

### Did you attend the dinner?



Yes	21	53%
No	19	48%

### If you did attend the dinner, did it help to solidify the contacts you made in the workshop?



1	<b>0</b>	0%
2	<b>1</b>	3%
3	<b>9</b>	23%
4	<b>6</b>	15%
5	<b>5</b>	13%

### Please provide any comments on the dinner

I met some new people, which is as nice as "solidifying" contacts

I met some new people, which is as nice as "solidifying" contacts

I thought it was unnecessary to restrict to female participants only

food was not very good. rigid seating arrangement did not facilitate networking.

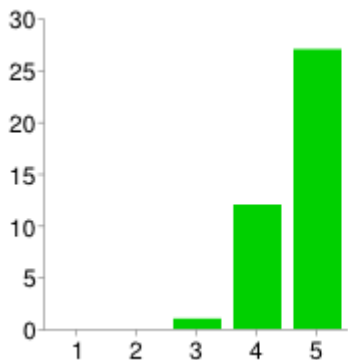
The restaurant was too noisy. There could have been more food.

Sitting on a too long table decreases the possibility of networking a lot, you end up talking with your neighbors only. The food was excellent

I talked to people I wouldn't have otherwise.

### Venue

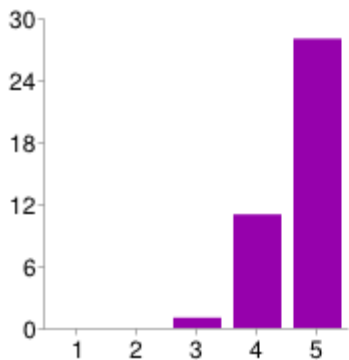
#### I found the MSRI staff helpful



1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>1</b>	3%
4	<b>12</b>	30%
5	<b>27</b>	68%

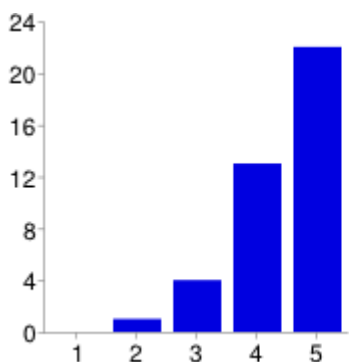
#### The MSRI physical facilities were conducive for such a workshop





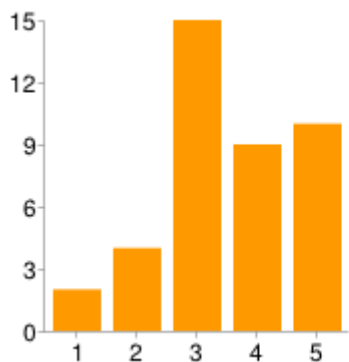
1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>1</b>	3%
4	<b>11</b>	28%
5	<b>28</b>	70%

**The MSRI computer facilities were adequate for such a workshop**



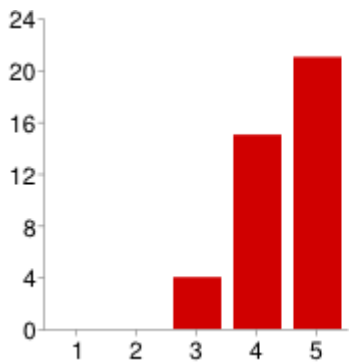
1	<b>0</b>	0%
2	<b>1</b>	3%
3	<b>4</b>	10%
4	<b>13</b>	33%
5	<b>22</b>	55%

**The MSRI lunch arrangements were satisfactory**



1	<b>2</b>	5%
2	<b>4</b>	10%
3	<b>15</b>	38%
4	<b>9</b>	23%
5	<b>10</b>	25%

**The MSRI tea arrangements were satisfactory**



1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>4</b>	10%
4	<b>15</b>	38%
5	<b>21</b>	53%

### Additional comments on the venue

wonderful!

Great!

is there any way to avoid using too many cups or plates during tea breaks? Why not have a marker for them so people can reuse their dishes again. They can be thrown at the end of the day.

It would be nice to have access to computers for guests (non members).

The lecture hall is beautiful but not perfect for a mathematical conference, only few seats can properly see the blackboards, maybe with smaller chairs would be better

hope to be able to buy bottles of water besides lunch time.

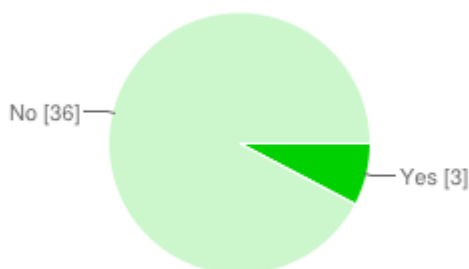
### MSRI Wireless Network

Did you use MSRI's wireless network?



Yes	<b>39</b>	98%
No	<b>1</b>	3%

Did you experience any difficulties with the network?



Yes	<b>3</b>	8%
No	<b>36</b>	90%

If you did experience difficulties with the network, please explain:

Its was pretty slow, and failed at times, but this could be my wifi system too, which tends to fail.

In the library, sometimes it doesn't work

very slow at times

## Thank you for completing this survey

**We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.**

thanks for making our stay at msri so pleasant.

Thank you so much!!

## Number of daily responses



**Introductory Workshop: Dynamics on  
Moduli Spaces of Geometric Structures**

January 20, 2015 - January 23, 2015

MSRI, Berkeley, CA, USA

Organizers:

**Richard Canary (University of Michigan)**

**William Goldman (University of Maryland)**

**Ursula Hamenstädt (Universität Bonn)**

**Alessandra Iozzi (ETHZ)**

**REPORT ON INTRODUCTORY WORKSHOP:  
DYNAMICS ON MODULI SPACES OF GEOMETRIC  
STRUCTURES  
20-23 JANUARY 2015**

Organizers

- Richard Canary (Michigan)
- William Goldman (Maryland)
- Ursula Hamenstädt (Bonn)
- Alessandra Iozzi (ETH Zürich)

1. SCIENTIFIC DESCRIPTION

The program focuses on geometric structures on manifolds defined by local coordinates into homogeneous spaces. Formally a subfield of differential geometry and topology, with a heavy infusion of Lie theory, its richness stems from close relations to dynamical systems, algebraic geometry, representation theory, Lie theory, partial differential equations, number theory, and complex analysis. These structures form moduli spaces whose algebraic properties contribute to rich geometric structures and symmetries themselves.

Hyperbolic structures on surfaces provide the first nontrivial examples, and the classical Fricke-Teichmüller space is the prototype of a deformation space of locally homogeneous structures. More general deformation spaces arise from the space of representations of the fundamental group of a manifold in a Lie group, which appears also as the moduli space of flat connections on the manifold. These *character varieties* have played an important role in developing topological invariants of manifolds, particularly in dimensions 3 and 4.

As this subject draws on several areas of mathematics which are not often taught together, entering this research area can be daunting. Hence one purpose of the workshop was to highlight parallels between the different areas. The talks in the *Connections for Women* workshop laid the foundations and provided motivation for the minicourses. The two workshops pleasantly complemented each other.

Both workshops benefitted from the NSF-funded *GEometric structures And Representation varieties* Research Network in the Mathematical Sciences. Network support enabled many participants to attend Institute activities. In particular a Network award provided travel and

local expenses for 10 international participants (including graduate students and postdocs) to the workshops. In addition, Network awards funded visits during the workshops to several established mathematicians (such as Steven Bradlow and Jeremy Kahn) collaborating with Network members in residence this semester at MSRI. The presence of these Network members enhanced the MSRI workshops.

## 2. PRESENTATIONS

The introductory workshop consisted of five minicourses touching on aspects of this theory. Burger's minicourse introduced Riemannian symmetric spaces, setting the stage, since the basic examples arise from symmetric spaces and their quotients. This classical material is absolutely fundamental for the geometric approach taken in our program.

Minsky's minicourse surveyed the state of the art of mapping class group actions and  $\text{Out}(F_n)$  actions on character varieties of surface groups and free groups respectively. Minsky's first lecture was an overview of character varieties and their automorphisms. His second lecture surveyed classical material from Kleinian groups. His talk complemented Tao's and Maloni's talks at the *Connections for Women* workshop. His third lecture united these two threads, and provided dynamical approach to more classical considerations in Kleinian groups.

Similarly, Benoist's minicourse dealt with a new perspective on conformal actions on the sphere, close in spirit to our program. Of course, classical Kleinian groups and Teichmüller theory form one of the important historical origins of the subject of our program. In his three lectures, Benoist approached these topics from the point of view of the action of the automorphism group  $\text{SO}(n, 1)$  on the space of compact subsets of  $S^{n-1}$  with the Hausdorff topology. This viewpoint shed new light on such classical objects as limit sets of convex cocompact groups, Schottky groups, quasicircles, degenerate Kleinian groups and symbolic dynamics of free groups.

Wright's minicourse dealt with the dynamics of translation surfaces. This fast-moving field, with origins in classical Teichmüller theory and 1-dimensional ergodic theory, involves a detailed understanding of a simple and fundamental class of geometric structures, with certain tame singularities. Rarely in mathematics does one expect to get such specific and thorough information about such basic mathematical objects. This theory is applied to the moduli of curves, which, for example, plays a fundamental role in modern mathematical physics. Furthermore his minicourse was perhaps the closest to the companion program, due

to the compelling and suggestive analogies between moduli spaces of geometric structures and homogeneous spaces of Lie groups.

Wienhard's lectures described new results on *Anosov representations*, a notion discovered by François Labourie in 2003, which seems to be the right generalization of convex cocompact Kleinian groups to higher rank Lie groups. Starting with basic examples, her lectures gradually advanced to describe a new viewpoint on this subject (which is currently being written up). We expect that these ideas will be one of the central themes for the semester's activities.

The synergy between our the two programs this semester is evidenced by the fact that Wright is officially a member of the *Geometric and Arithmetic Aspects of Homogeneous Dynamics* program, and Benoist is a member of both programs.

<b>Organizers</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Richard	Canary	University of Michigan
William	Goldman	University of Maryland
Ursula	Hamenstädt	Universität Bonn
Alessandra	Iozzi	ETHZ
<b>Speakers</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Yves	Benoist	Université de Paris XI
Marc	Burger	Eidgenössische TH Zürich-Hönggerberg
Yair	Minsky	Yale University
Anna	Wienhard	Ruprecht-Karls-Universität Heidelberg
Alexander	Wright	Stanford University





## Introductory Workshop: Dynamics on Moduli Spaces of Geometric Structures

January 20 to January 23, 2015

### Schedule

Tuesday, January 20, 2015			
9:15 AM - 9:30 AM	Simons Auditorium		Welcome
9:30 AM - 10:30 AM	Simons Auditorium	Yves Benoist	Conformal Dynamics
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00 PM	Simons Auditorium	Marc Burger	Introduction to the study of Riemannian Symmetric Spaces
12:00 PM - 2:00 PM	Atrium		Lunch
2:00 PM - 3:00 PM	Simons Auditorium	Anna Wienhard	Anosov representations
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:30 PM	Simons Auditorium	Alexander Wright	The $GL(2, \mathbb{R})$ action on moduli spaces of translation surfaces
4:30 PM - 6:20 PM	Atrium		Reception

Wednesday, January 21, 2015			
9:30 AM - 10:30 AM	Simons Auditorium	Yair Minsky	Dynamics on character varieties
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00 PM	Simons Auditorium	Yves Benoist	Conformal Dynamics
12:00 PM - 2:00 PM	Atrium		Lunch
2:00 PM - 3:00 PM	Simons Auditorium	Marc Burger	Introduction to the study of Riemannian Symmetric Spaces
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:30 PM	Simons Auditorium	Anna Wienhard	Anosov representations

Thursday, January 22, 2015			
9:30 AM - 10:30 AM	Simons Auditorium	Alexander Wright	The $GL(2, \mathbb{R})$ action on moduli spaces of translation surfaces
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00 PM	Simons Auditorium	Yair Minsky	Dynamics on character varieties
12:00 PM - 2:00 PM	Atrium		Lunch
2:00 PM - 3:00 PM	Simons Auditorium	Anna Wienhard	Anosov representations
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:30 PM	Simons Auditorium	Marc Burger	Introduction to the study of Riemannian Symmetric Spaces

Friday, January 23, 2015			
9:30 AM - 10:30 AM	Simons Auditorium	Marc Burger	Introduction to the study of Riemannian Symmetric Spaces
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00 PM	Simons Auditorium	Alexander Wright	The $GL(2, \mathbb{R})$ action on moduli spaces of translation surfaces
12:00 PM - 2:00 PM	Atrium		Lunch
2:00 PM - 3:00 PM	Simons Auditorium	Yair Minsky	Dynamics on character varieties
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:30 PM	Simons Auditorium	Yves Benoist	Conformal Dynamics

<b>Participants</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Ilesanmi	Adeboye	Wesleyan University
Khalid	Alammar	King Saud University
Vanessa	Alderete	National Autonomous University of Mexico (UNAM)
Ibraheem	Alolyan	King Saud University
Paul	Apisa	University of Chicago
Chris	Arettines	City University of New York (CUNY)
Caleb	Ashley	Howard University
Shinpei	Baba	Ruprecht-Karls-Universität Heidelberg
Ara	Basmajian	City University of New York (CUNY)
Yves	Benoist	Université de Paris XI
Francis	Bonahon	University of Southern California
Sarah	Bray	Tufts University
Martin	Bridgeman	Boston College
Marc	Burger	Eidgenössische TH Zürich-Hönggerberg
Claire	Burrin	Eidgenössische TH Zürich-Hönggerberg
Richard	Canary	University of Michigan
Virginie	Charette	University of Sherbrooke
Rex	Cheung	Yale University
Yitwah	Cheung	San Francisco State University
Suh Young	Choi	Korea Advanced Institute of Science and Technology (KAIST)
Michelle	Chu	University of Texas
Corina	Ciobotaru	Université de Genève
Brian	Collier	University of Illinois at Urbana-Champaign
Thomas	Crawford	Boston College
Jeffrey	Danciger	University of Texas
Ellie	Dannenberg	University of Illinois
Carlos Alberto	De la Cruz Mengual	Eidgenössische TH Zürich-Hönggerberg
Valentina	Disarlo	Indiana University
Kevin	Donoghue	University of California, Berkeley
Spencer	Dowdall	University of Illinois at Urbana-Champaign
Benjamin	Dozier	Stanford University
Guillaume	Dreyer	University of Notre Dame
David	Dumas	University of Illinois at Chicago
Matthew	Durham	University of Michigan
Eduard	Duryev	Harvard University
Viveka	Erlandsson	Aalto University
Alex	Eskin	University of Chicago
Ian	Frankel	University of Chicago
Selim	Ghazouani	École Normale Supérieure
Sourav	Ghosh	Université de Paris XI
alexis	gilles	École Normale Supérieure
William	Goldman	University of Maryland
Adriana	González	National Autonomous University of Mexico (UNAM)
Vesselin	Gueorguiev	California State University

<b>Participants</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Clément	Guérin	Université de Strasbourg I (Louis Pasteur)
Olivier	Guichard	Université de Strasbourg I (Louis Pasteur)
Subhojoy	Gupta	California Institute of Technology
Ursula	Hamenstädt	Universität Bonn
Robert	Haraway	Boston College
Yoe	Herrera	Universidad Autonoma de Bucaramanga
Soon ki	Hong	Seoul National University
Zheng	Huang	CUNY, Graduate Center
Alessandra	Iozzi	ETHZ
Dmitry	Jakobson	McGill University
Lien-Yung	Kao	University of Notre Dame
Fanny	Kassel	Université de Lille I (Sciences et Techniques de Lille Flandres Artois)
Steven	Kerckhoff	Stanford University
Dong Han	Kim	Dongguk University
Inkang	Kim	Korea Institute for Advanced Study (KIAS)
Sungwoon	Kim	Korea Institute for Advanced Study (KIAS)
Youngju	Kim	Korea Institute for Advanced Study (KIAS)
Dmitry	Kleinbock	Brandeis University
Kei	Kobayashi	The Institute of Statistical Mathematics
Kenji	Kozai	University of California, Berkeley
Sanghoon	Kwon	Seoul National University
François	Labourie	Université Nice Sophia-Antipolis
Michael	Landry	Yale University
Erwan	Lanneau	Université de Grenoble I (Joseph Fourier)
Andres	Larrain-Hubach	University of Arizona
François	Ledrappier	University of Notre Dame
Arielle	Leitner	University of California, Santa Barbara
Han	Li	University of Texas
Qionglng	Li	Rice University
Seonhee	Lim	Seoul National University
Joel	Louwsma	Smith College
Tue	Ly	Brandeis University
Tianyu	Ma	University of Maryland
Sara	Maloni	Brown University
Kathryn	Mann	University of California, Berkeley
Stéphane	Marseglia	Université de Strasbourg I (Louis Pasteur)
Giuseppe	Martone	University of Southern California
Howard	Masur	University of Chicago
Karin	Melnick	University of Maryland
Yair	Minsky	Yale University
Leonid	Monin	University of Toronto
Dave	Morris	University of Lethbridge
Duc-Manh	Nguyen	Université de Bordeaux I
Frederic	Palesi	Université d'Aix-Marseille (AMU)

<b>Participants</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Kyewon Koh	Park	Korea Institute for Advanced Study (KIAS)
Ana	Peón-Nieto	Ruprecht-Karls-Universität Heidelberg
Raquel	Perales Aguilar	State University of New York, Stony Brook
Mark	Pollicott	University of Warwick
Maria Beatrice	Pozzetti	MSRI - Mathematical Sciences Research Institute
Krista	Reimer	McGill University
David	Renardy	University of Michigan
Lorenzo	Ruffoni	Università di Bologna
Samuel	Saiki	University of Pittsburgh
Anna-Sofie	Schilling	Ruprecht-Karls-Universität Heidelberg
Nimish	Shah	Ohio State University
Yiwei	She	University of Chicago
Ronggang	Shi	Tel Aviv University
Lin	Shu	Beijing (Peking) University
Adam	Sikora	University at Buffalo (SUNY)
Lior	Silberman	University of British Columbia
Dmitriy	Slutskiy	Université de Strasbourg I (Louis Pasteur)
Yitzchak	Solomon	Brown University
Florian	Stecker	Ludwig-Maximilians-Universität München
Robert	Tang	University of Oklahoma
Samuel	Taylor	Yale University
Bo	Tian	University of Maryland
Nicolaus	Treib	Ruprecht-Karls-Universität Heidelberg
Anastasiia	Tsvietkova	University of California, Davis
Franco	Vargas Pallete	University of California, Berkeley
Nicholas	Vlamiš	Boston College
Nick	Wadleigh	Brandeis University
Yohsuke	Watanabe	University of Utah
Richard	Wentworth	University of Maryland
Christopher	Westenberger	University of California, Davis
Anna	Wienhard	Ruprecht-Karls-Universität Heidelberg
Dale	Winter	Brown University
Michael	Wolf	Rice University
Maxime	Wolff	Institut de Mathématiques de Jussieu
Grace	Work	University of Illinois at Urbana-Champaign
Alexander	Wright	Stanford University
Yunhui	Wu	Rice University
Lei	Yang	Yale University
Tian	Yang	Stanford University
Andrew	Yarmola	Boston College
Serena	Yuan	New York University, Courant Institute
Tengren	Zhang	University of Michigan
Zhiyong	Zhao	Duke University
Cheng	Zheng	Ohio State University

## Officially Registered Participant Information

<b>Participants</b>		<b>132</b>
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<b>Gender</b>		<b>132</b>
<b>Male</b>	75.76%	100
<b>Female</b>	23.48%	31
<b>Declined to state</b>	0.76%	1

<b>Ethnicity*</b>		<b>142</b>
<b>White</b>	52.82%	75
<b>Asian</b>	26.06%	37
<b>Hispanic</b>	5.63%	8
<b>Pacific Islander</b>	0.70%	1
<b>Black</b>	1.41%	2
<b>Native American</b>	0.00%	0
<b>Mixed</b>	3.52%	5
<b>Declined to state</b>	9.86%	14

\* ethnicity specifications are not exclusive

# 102 responses

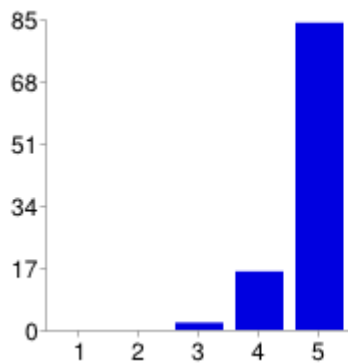
102 responses/132 participants = 77% response rate

[View all responses](#)   [Publish analytics](#)

## Summary

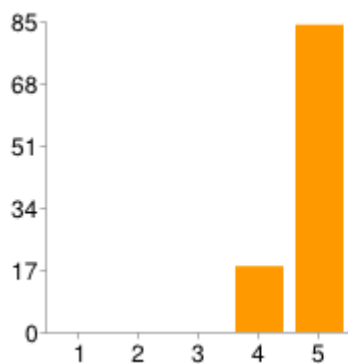
### Workshop assessment

#### The workshop was intellectually stimulating



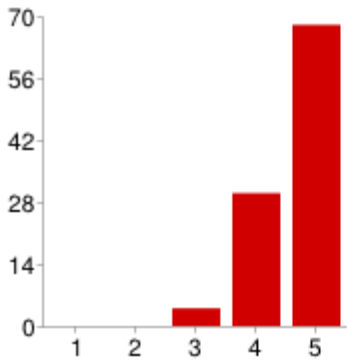
1	0	0%
2	0	0%
3	2	2%
4	16	16%
5	84	82%

#### The overall experience of the workshop was worthwhile



1	0	0%
2	0	0%
3	0	0%
4	18	18%
5	84	82%

#### The time between lectures was adequate for discussion



1	0	0%
2	0	0%
3	4	4%
4	30	29%
5	68	67%

## Additional comments on the workshop organization

Great job.

In my opinion the Introductory Workshop shouldn't be aimed at first year graduate students of UC Berkeley, but at a more advanced audience, since that is what is going to be there

The half hour breaks were wonderful and productive.

All the talks were excellent!!

Perhaps the talks could be schedule to end so people can catch the 4:25 bus?

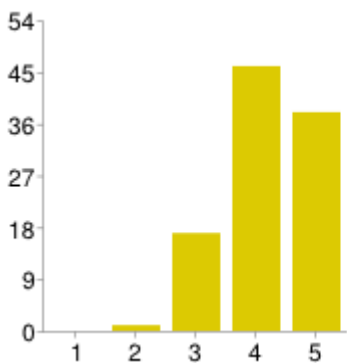
i would have liked longer breaks between talks, but I was the lead organizer, so I really shouldn't complain

The number and timing of the lectures was great. Also, the topics for the minicourses werexcellent

excellent choice of speakers!

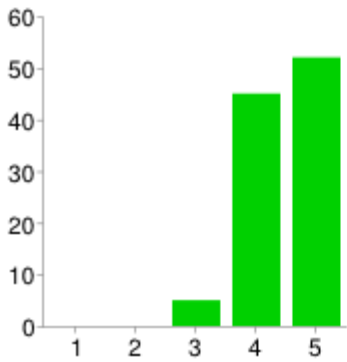
## Personal assessment

### I was well prepared to benefit from the lectures



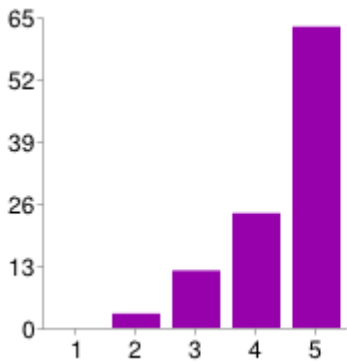
1	0	0%
2	1	1%
3	17	17%
4	46	45%
5	38	37%

### My interest in the subject matter was increased by the workshop



1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>5</b>	5%
4	<b>45</b>	44%
5	<b>52</b>	51%

### The workshop helped me meet people with similar scientific interests



1	<b>0</b>	0%
2	<b>3</b>	3%
3	<b>12</b>	12%
4	<b>24</b>	24%
5	<b>63</b>	62%

### Additional comments on your personal assessment

I was able to begin and work on some new collaborative projects

I expected the workshop to be more introductory

i was quite pleased with the activity

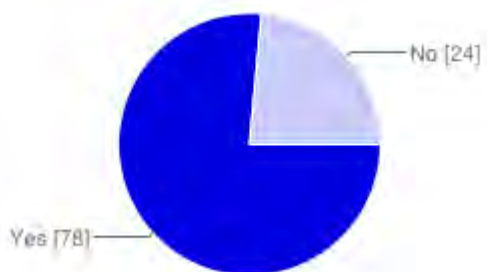
Awesome!

I particularly enjoyed the lectures of Minsky and Benoist

This workshop was a great opportunity to meet new people

### Additional Activities

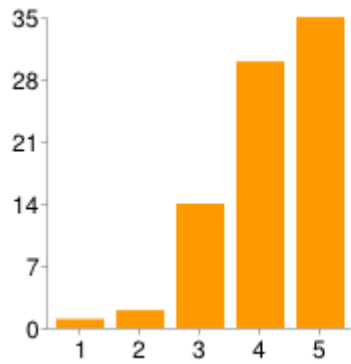
#### Did you attend the reception?



Yes	<b>78</b>	76%
No	<b>24</b>	24%



**If you did attend the reception, did it help to solidify the contacts you made in the workshop?**



1	1	1%
2	2	2%
3	14	14%
4	30	29%
5	35	34%

**Please provide any comments on the reception**

A bit crowded

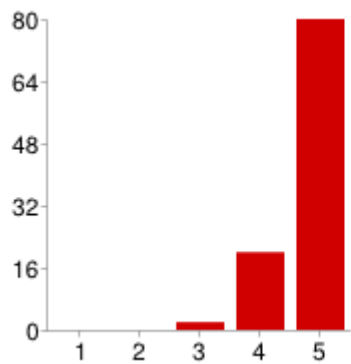
There was no reception

Great!

the reception was wonderful, it's probably too expensive to have more of them

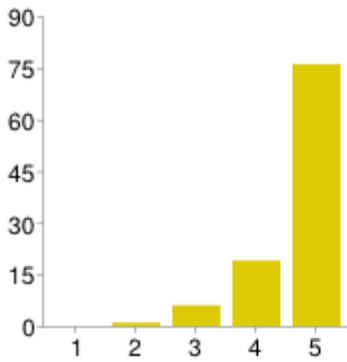
**Venue**

**I found the MSRI staff helpful**



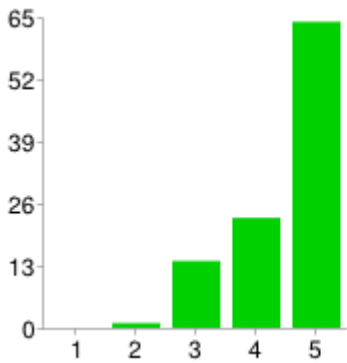
1	0	0%
2	0	0%
3	2	2%
4	20	20%
5	80	78%

**The MSRI physical facilities were conducive for such a workshop**



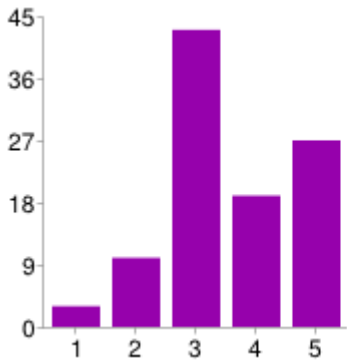
1	<b>0</b>	0%
2	<b>1</b>	1%
3	<b>6</b>	6%
4	<b>19</b>	19%
5	<b>76</b>	75%

**The MSRI computer facilities were adequate for such a workshop**



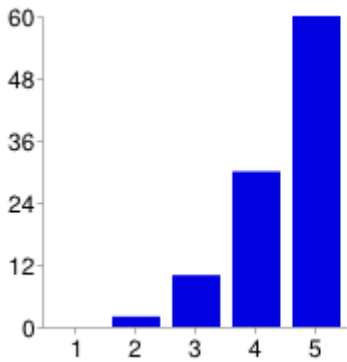
1	<b>0</b>	0%
2	<b>1</b>	1%
3	<b>14</b>	14%
4	<b>23</b>	23%
5	<b>64</b>	63%

**The MSRI lunch arrangements were satisfactory**



1	<b>3</b>	3%
2	<b>10</b>	10%
3	<b>43</b>	42%
4	<b>19</b>	19%
5	<b>27</b>	26%

**The MSRI tea arrangements were satisfactory**



1	<b>0</b>	0%
2	<b>2</b>	2%
3	<b>10</b>	10%
4	<b>30</b>	29%
5	<b>60</b>	59%

## Additional comments on the venue

see below; several people may have missed talks because the shuttles were too full

The lecture hall is not perfect for a mathematical conference (half of the audience cannot see the board), the lunch catering was rather poor, and in the first two days quite expensive

I did not use the computers, but the wireless was great

Healthy options at tea are appreciated

I'm bringing my own lunch my comment is about the support for that. I have no comment on the catered lunch. For tea perhaps more fruit and less cake

More frequent shuttle service would have been preferable.

A little bigger space is needed.

Maybe more fruits. :)

more fruit for tea would be nice

I didn't really eat lunch

line for lunch was too long; options were limited for those who don't arrive early, which can be a problem for people with dietary restrictions

The computers in room 205 are incredibly slow! It's almost impossible to do anything with them. Lunch on Wednesday was expensive and quite disappointing.

There could be better vegan options, for instance, some sort of vegetable protein on the sandwiches.

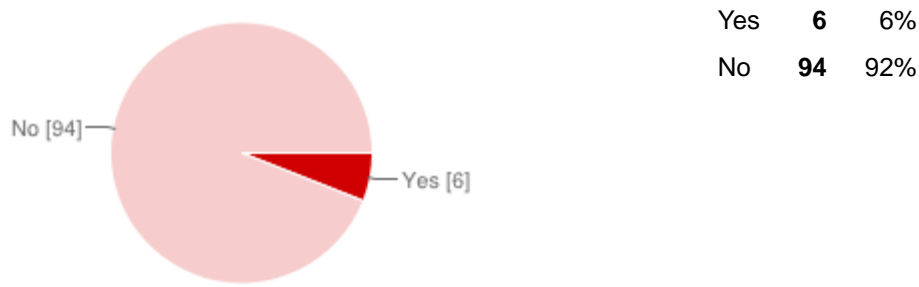
## MSRI Wireless Network

Did you use MSRI's wireless network?



Yes	<b>95</b>	93%
No	<b>7</b>	7%

Did you experience any difficulties with the network?



**If you did experience difficulties with the network, please explain:**

- Worked about 50% of the time
- The connection was spotty, and I had trouble downloading a paper
- A number of members could not figure out how to print.
- Problem setting up wireless printing... culprit was my laptop needed a restart
- The network is really great.
- Some areas of the Library are not well-covered. E.g. 3 seatings nearby the balcony.

**Thank you for completing this survey**

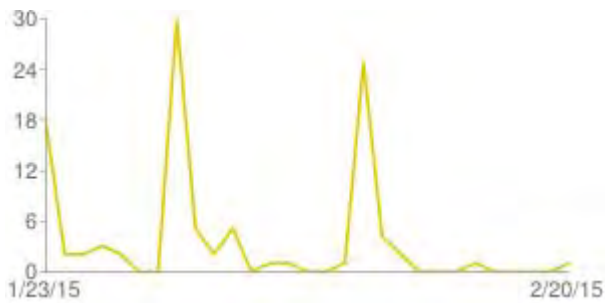
**We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.**

- Thank you!
- The bus to/from the venue is very crowded.
- Thank you very much for making possible my visit to the MSRI; it was really stimulating. Every thing was just perfect.
- I think it would have been nice if a large fraction of the participants were to stay at the same hotel - more possibilities for interaction with colleagues.
- should be able to get a bottle of water
- great experience, great talks, great staff, great place!
- one complaint i heard was that the shuttle from down the hill became very crowded and several people may have missed talks because they couldn't get seats. In the future, could larger buses (or more frequent buses) be arranged during the MSRI periods of intense activity?
- none
- Transit was a real problem. The shuttle was really inadequate for the number of people needing it, both in terms of space and in terms of the vehicle, itself. People waiting to go home from the Lawrence Hall of Science were sometimes unable to board because the shuttle was already too full.
- Speaking with a male workshop participant regarding the Connection for Women workshop which occurred in the week prior to the Introductory workshop, an interesting comment came up:

Concern was expressed over the dissemination of information regarding the position of women within the mathematics community to male members. Our conversation highlighted that, alongside the wonderful program of providing support to female researchers, more work could be done during the Connection for Women workshops to provide male participants with information regarding the difficulties pertinent to women in the field. By informing male participants, they may be more knowledgeable about the challenges still faced by women within the field, and thus more capable at aiding women in dissolving barriers.

Great opportunity for all participants!

## Number of daily responses



**Connections for Women: Geometric and  
Arithmetic Aspects of Homogeneous  
Dynamics**

January 29, 2015 - January 30, 2015

MSRI, Berkeley, CA, USA

Organizers:

**Elon Lindenstrauss (Hebrew University)**

**Hee Oh (Yale University)**

REPORT ON THE MSRI WORKSHOP: CONNECTIONS FOR  
WOMEN ON GEOMETRIC AND ARITHMETIC ASPECTS  
OF HOMOGENEOUS DYNAMICS, JAN 29-30, 2015

1. Organizers

- Elon Lindenstrauss (Hebrew University)
- Hee Oh (Yale University)

2. Scientific Description

The focus of the MSRI half-year program, Geometric and arithmetic aspects of homogeneous dynamics is on the study of homogeneous dynamical properties of natural algebraic actions on quotients of Lie groups by discrete subgroups. Such quotient spaces are interesting from many points of view and can be studied using a variety of tools, which explains the very rich interactions between homogeneous dynamics and other areas, in particular many branches of analytic and algebraic number theory, automorphic forms, geometry etc.

This Connections for Women workshop was the first event of the MSRI semester on Geometric and Arithmetic Aspects of Homogeneous Dynamics. The two-day event aimed to connect female graduate students and beginning researchers with established female researchers who work in the broad area of homogeneous dynamics and can serve as professional contacts and potential role-models. The workshop consisted of several mini-courses by established female mathematicians:

- Svetlana Katok (Penn State University)
- Tamar Ziegler (Hebrew University),
- Ursula Hamenstadt (Bonn University)
- Barbara Schapira (Universit de Picardie).

These lectures were interspersed with networking and social events over the course of the two days such as a panel discussion and a workshop dinner. Participants were encouraged to stay for the Introductory Workshop the following week. The mini courses were intended for graduate students, post-docs, and researchers in areas related to the program. This workshop was open to all mathematicians.

### 3. Presentations

Ursula Hamenstadt gave 2 lectures on The Weyl chamber flow and applications. She began her lecture series by introducing the surface subgroup conjecture solved by Kahn and Markovic. After describing how the exponential mixing of geodesic flow of compact hyperbolic manifolds was used in their proof as a crucial ingredient, she explained her ongoing work with Kahn how this idea can be extended to a higher rank group (e.g.,  $SL_3(\mathbb{R})$ ) in order to obtain a similar result. It was exciting to see a new application of homogeneous dynamics in understanding the geometric structure of hyperbolic manifolds.

Barbara Schapira gave 2 lectures on Ergodic properties of horocyclic flows on infinite volume hyperbolic surfaces. Although there is a quite rich theory of homogeneous dynamics in the finite volume quotient spaces, the infinite volume case is widely open. The study of horocyclic flows is one of the basic cases to be understood. In the case of geometrically finite surfaces, she explained the equidistribution of non-closed horocycles and measure classification results for locally finite measures invariant under horocycle flow, due to Roblin, Burger and herself. She gave beautiful introductory lectures while explaining key ideas in the proofs.

Tamar Ziegler gave 2 lectures on Patterns in primes and dynamics on nil-manifolds. She began her lecture by explaining Roth's theorem on 3 term progressions on prime numbers and Furstenberg's correspondence principle on the relation between ergodic theory and finding arithmetic progressions on sets of positive density. During only 2 lectures, she was able to give an almost complete overview of the recent exciting progress on the study of primes in arithmetic progression where the tools of ergodic theory were crucially used.

Svetlana Katok gave 2 lectures on Some number-theoretic tools used in homogeneous dynamics. She explained how closed tori orbits are related to important number theoretic concepts, such as class group, regulators, etc. She then explained how some results in number theory can be used to construct some examples of ergodic system with certain properties of entropies.



<b>Organizers</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Elon	Lindenstrauss	Hebrew University
Hee	Oh	Yale University
<b>Speakers</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Ursula	Hamenstädt	Universität Bonn
Svetlana	Katok	Pennsylvania State University
Barbara	Schapira	Université de Picardie (Jules Verne)
Tamar	Ziegler	Hebrew University



**Connections for Women:  
Geometric and Arithmetic Aspects of Homogeneous Dynamics**

January 29 - 30, 2015

**Schedule**

<b>Thursday, January 29, 2015</b>			
9:15AM - 9:30AM	Simons Auditorium		Welcome
9:30AM - 10:30AM	Simons Auditorium	Ursula Hamenstädt	The Weyl chamber flow and applications
10:30AM - 11:00AM	Atrium		Tea
11:00AM - 12:00PM	Simons Auditorium	Svetlana Katok	Some number-theoretic tools used in homogenous dynamics
12:00PM - 2:00PM	Atrium		Lunch
2:00PM - 3:00PM	Simons Auditorium	Tamar Ziegler	Patterns in primes and dynamics on nilmanifolds
3:00PM - 3:30PM	Atrium		Tea
3:30PM - 4:30PM	Simons Auditorium	Barbara Schapira	Ergodic properties of horocyclic flows on infinite volume hyperbolic surfaces
4:45PM - 5:30PM	Commons		Panel Discussion
6:30PM - 8:30PM	MSRI		Dinner at Taste of Himalayas Restaurant

<b>Friday, January 30, 2015</b>			
9:30AM - 10:30AM	Simons Auditorium	Svetlana Katok	Some number-theoretic tools used in homogenous dynamics
10:30AM - 11:00AM	Atrium		Tea
11:00AM-12:00PM	Simons Auditorium	Ursula Hamenstädt	The Weyl chamber flow and applications
12:00PM - 2:00PM	Atrium		Lunch
2:00PM-3:00PM	Simons Auditorium	Tamar Ziegler	Patterns in primes and dynamics on nilmanifolds
3:00PM-3:30PM	Atrium		Tea
3:30PM-4:30PM	Simons Auditorium	Barbara Schapira	Ergodic properties of horocyclic flows on infinite volume hyperbolic surfaces

<b>Participants</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Ilesanmi	Adeboye	Wesleyan University
Menny	Aka	ETH Zurich
Caleb	Ashley	Howard University
Maria	Avdeeva	Princeton University
Shinpei	Baba	Ruprecht-Karls-Universität Heidelberg
Francis	Bonahon	University of Southern California
Jennifer	Brown	Opower
Marc	Burger	ETH Zurich
Claire	Burrin	ETH Zurich
Jakub	Byszewski	Uniwersytet Jagiellonski
Rex	Cheung	Yale University
Kathryn	Dabbs	University of Texas
Jeffrey	Danciger	University of Texas
Carlos Alberto	De la Cruz Mengual	ETH Zurich
Nicolas	de Saxce	Université de Paris XIII (Paris-Nord)
Erica	Flapan	Pomona College
Sourav	Ghosh	Université Paris-Sud (Orsay)
Tom	Gilat	Hebrew University
William	Goldman	University of Maryland
Vesselin	Gueorguiev	California State University - Stanislaus
Subhojoy	Gupta	California Institute of Technology
Ursula	Hamenstädt	Universität Bonn
Jiyoung	Han	Seoul National University
Soon ki	Hong	Seoul national university
Tal	Horesh	Technion---Israel Institute of Technology
Lien-Yung	Kao	University of Notre Dame
Fanny	Kassel	Université de Lille I (Sciences et Techniques de Lille Flandres Artois)
Svetlana	Katok	Pennsylvania State University
Dmitry	Kleinbock	Brandeis University
Sanghoon	Kwon	Seoul National University
Tsviqa	Lakrec	Hebrew University
Or	Landesberg	Hebrew University
Therese	Landry	San Francisco State University
Etienne	Le Masson	MSRI - Mathematical Sciences Research Institute
François	Ledrappier	University of Notre Dame
Qionglng	Li	Rice University
Seonhee	Lim	Seoul National University
Elon	Lindenstrauss	Hebrew University
Tue	Ly	Brandeis University
Sara	Maloni	Brown University
Giuseppe	Martone	University of Southern California
Dave	Morris	University of Lethbridge
Hee	Oh	Yale University
Frederic	Palesi	Université d'Aix-Marseille (AMU)
Wenyu	Pan	Yale University

<b>Participants</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Mark	Pollicott	University of Warwick
Maria Beatrice	Pozzetti	MSRI - Mathematical Sciences Research Institute
Rene	Rühr	ETH Zurich
Barbara	Schapira	Université de Picardie (Jules Verne)
Ronggang	Shi	Tel Aviv University
Lin	Shu	Beijing (Peking) University
Lior	Silberman	University of British Columbia
Ralf	Spatzier	University of Michigan
Nicolaus	Treib	Ruprecht-Karls-Universität Heidelberg
Dale	Winter	Brown University
Philipp	Wirth	ETH Zurich
Maxime	Wolff	Institut de Mathématiques de Jussieu - PRG
Grace	Work	University of Illinois at Urbana-Champaign
Alexander	Wright	Stanford University
Lei	Yang	Yale University
Tengren	Zhang	University of Michigan
Cheng	Zheng	Ohio State University
Tamar	Ziegler	Hebrew University

## Officially Registered Participant Information

<b>Participants</b>		<b>63</b>
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<b>Gender</b>		<b>63</b>
<b>Male</b>	66.67%	42
<b>Female</b>	33.33%	21
<b>Declined to state</b>	0.00%	0

<b>Ethnicity*</b>		<b>67</b>
<b>White</b>	55.22%	37
<b>Asian</b>	26.87%	18
<b>Hispanic</b>	1.49%	1
<b>Pacific Islander</b>	0.00%	0
<b>Black</b>	2.99%	2
<b>Native American</b>	0.00%	0
<b>Mixed</b>	2.99%	2
<b>Declined to state</b>	10.45%	7

\* ethnicity specifications are not exclusive

# 25 responses

25 responses/63 participants = 40%

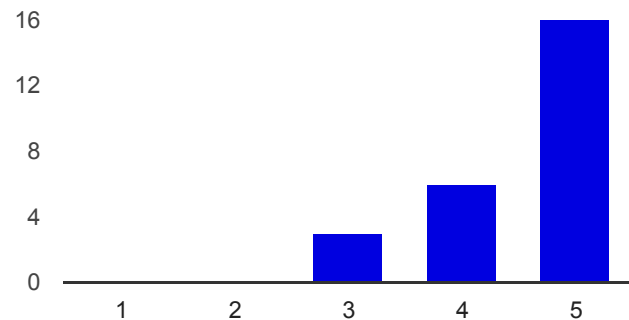
[View all responses](#)

[Publish analytics](#)

## Summary

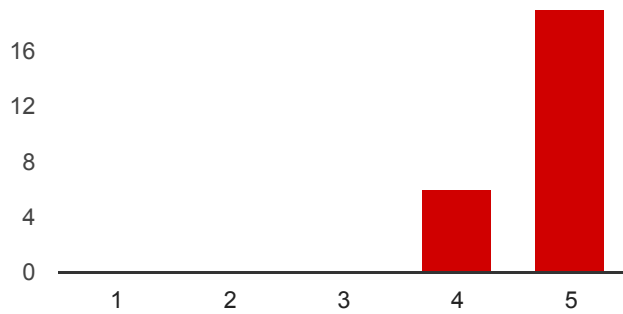
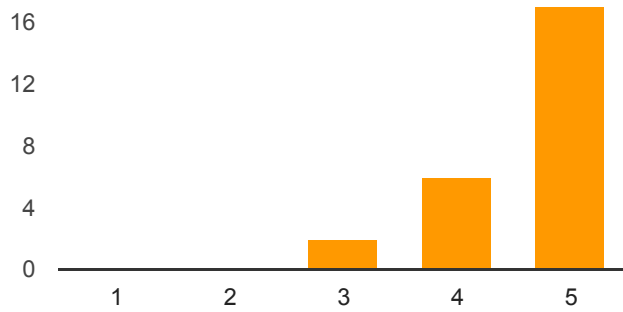
### Workshop assessment

The workshop was intellectually stimulating



Not at all: 1	0	0%
2	0	0%
3	3	12%
4	6	24%
Very: 5	16	64%

The overall experience of the workshop was worthwhile



Not at all:	1	0	0%
	2	0	0%
	3	0	0%
	4	6	24%
Very:	5	19	76%

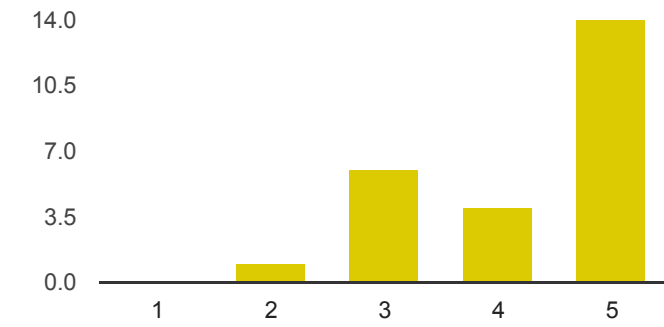
### Additional comments on the workshop organization

great!

the panel was interesting, I wish it was longer so there would be more time for questions.

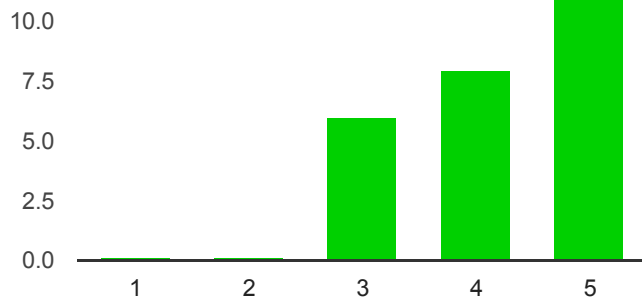
### Personal assessment

I was well prepared to benefit from the lectures



3	6	24%
4	4	16%
Very: 5	14	56%

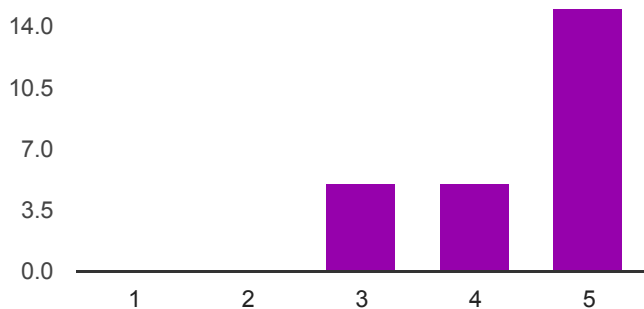
My interest in the subject matter was increased by the workshop



Niot at all: 1	0	0%
2	0	0%
3	6	24%
4	8	32%
Very: 5	11	44%

The workshop helped me meet people with similar scientific interests

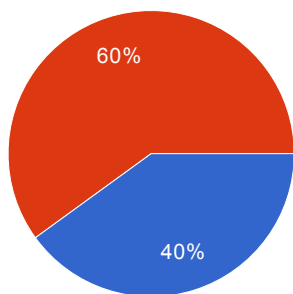




Additional comments on your personal assessment

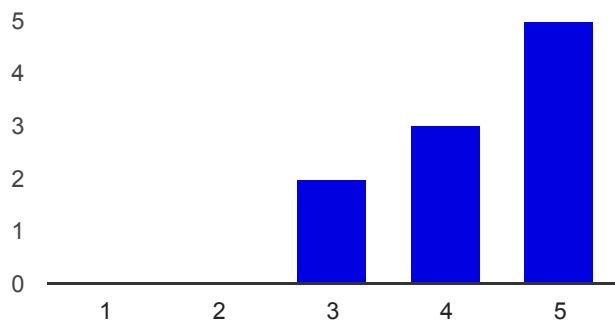
### Additional Activities

Did you attend the panel discussion?



Yes	10	40%
No	15	60%

If you did attend the panel discussion, did you find it worthwhile?



Not at all:	1	0	0%
	2	0	0%
	3	2	20%
	4	3	30%

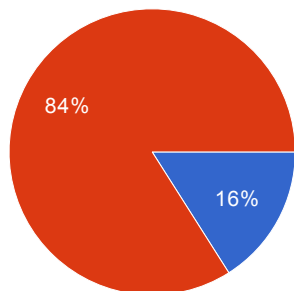
Very much: 5 5 50%

### What other subjects should be addressed in future panel discussions?

changing the last name after marriage, attending conferences around the world when the children are young

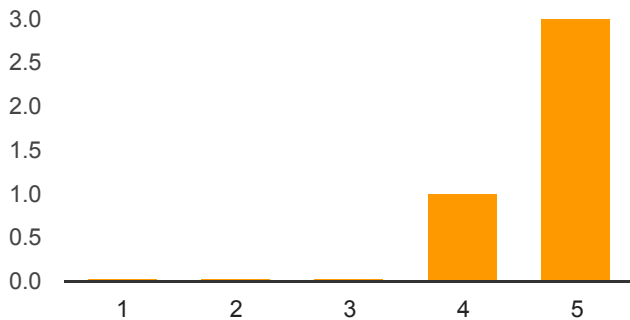
Questions not specific to women

### Did you attend the dinner?



Yes 4 16%  
No 21 84%

### If you did attend the dinner, did it help to solidify the contacts you made in the workshop?



Not at all: 1 0 0%  
2 0 0%  
3 0 0%

Very much: 5 3 75%

### Please provide any comments on the dinner

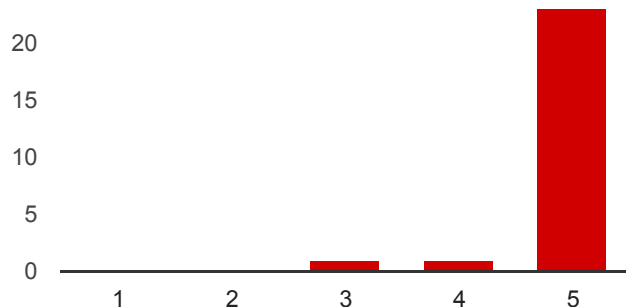
It was not clear whether the dinner was supposed to be for everybody or for women only.  
Perhaps this should be better explained next time.

Put on the public schedule a note saying the dinner is only for female participants

The food was much better than at the previous connections for women dinner.

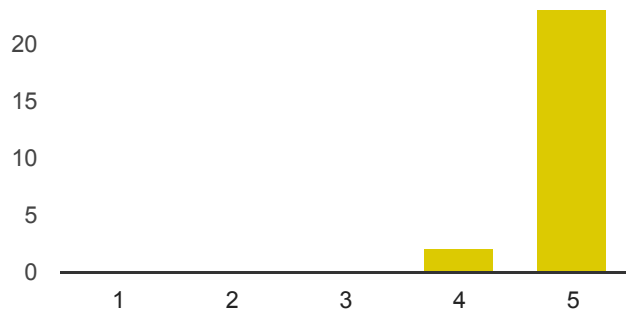
## Venue

I found the MSRI staff helpful



Not at all: 1	0	0%
2	0	0%
3	1	4%
4	1	4%
Very: 5	23	92%

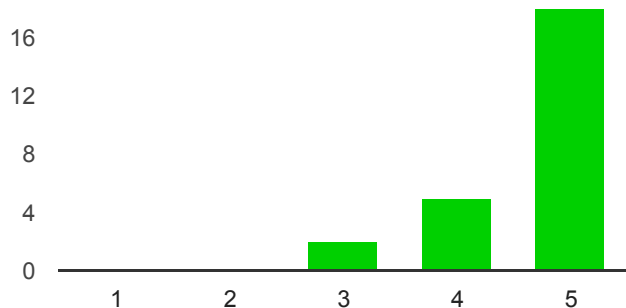
The MSRI physical facilities were conducive for such a workshop



Not at all: 1	0	0%
2	0	0%
3	0	0%

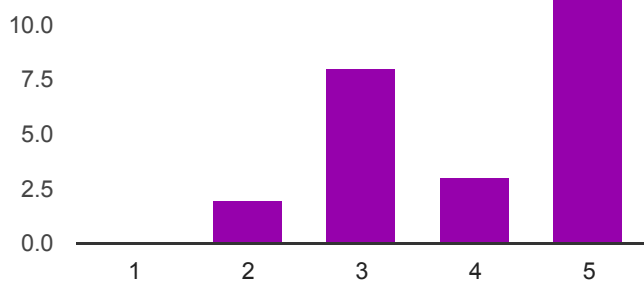
4 2 8%  
 Very: 5 23 92%

The MSRI computer facilities were adequate for such a workshop



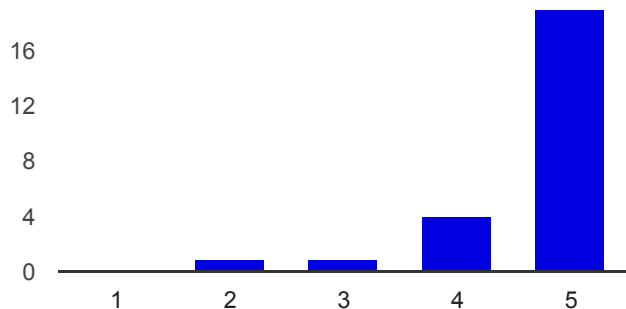
Not at all: 1 0 0%  
 2 0 0%  
 3 2 8%  
 4 5 20%  
 Very: 5 18 72%

The MSRI lunch arrangements were satisfactory



Not at all: 1 0 0%  
 2 2 8%  
 3 8 32%  
 4 3 12%  
 Very: 5 12 48%

### The MSRI tea arrangements were satisfactory



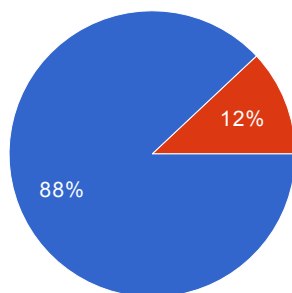
Not at all:	1	0	0%
	2	1	4%
	3	1	4%
	4	4	16%
Very:	5	19	76%

### Additional comments on the venue

Great arrangements for packing lunch from home

## MSRI Wireless Network

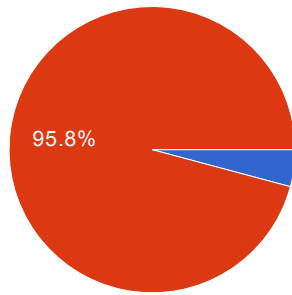
Did you use MSRI's wireless network?



Yes	22	88%
No	3	12%

Did you experience any difficulties with the network?

Yes	1	4.2%
No	23	95.8%



, please explain:

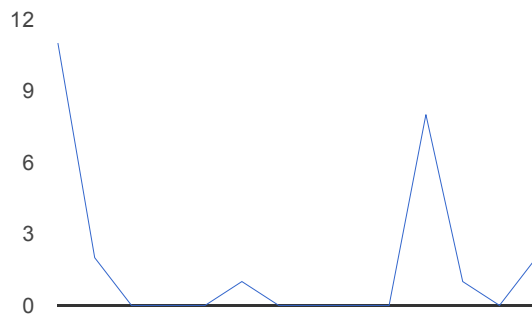
## Thank you for completing this survey

We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.

would be easier if everyone was in the same hotel, and there was a shuttle to the workshop and back.

Thank you!

## Number of daily responses



**Introductory Workshop: Geometric and  
Arithmetic Aspects of Homogeneous  
Dynamics**

February 02, 2015 - February 06, 2015

MSRI, Berkeley, CA, USA

Organizers:

**Manfred Einsiedler (Eidgenössische TH Zürich-Hönggerberg)**

**Jean-François Quint (Université de Bordeaux I)**

**Barbara Schapira (Université de Picardie (Jules Verne))**

## Report on the introductory workshop of the MSRI 2015 program, Geometric and Arithmetic Aspects of Homogeneous Dynamics

Manfred Einsiedler, Barbara Schapira and Jean-François Quint

The introductory workshop took place from February 2 until February 6, 2015, at MSRI. The lectures were delivered in Simons auditorium.

The main purpose of the workshop was to have senior researchers deliver courses on more or less recent developments on the theme of the program. There were six such courses. The total duration of the courses was 14 hours. Courses were delivered by Yves Benoist (CNRS – Universit Paris-Sud), Jens Markloff (University of Bristol), Amir Mohammadi (University of Texas at Austin), Dave Morris (University of Lethbridge), Hee Oh (Yale University) and Ashkay Venkatesh (Stanford University). We also asked other senior researchers as well as younger ones to give one hour talks on recent results. There were eight such talks.

The workshop was attended by about 100 people, among which 43 had asked for financial support. We attributed each of those 700 USD of support to cover their stay and travel expenses.

We consider that our goal in organizing the workshop was achieved in as much the courses were of an excellent scientific level and were really helpful for young researchers to get an introduction to the research area.

We made a mistake when organizing the schedule : we didn't realize that although MSRI opens at 8:30 am, lectures should only start at 9:00, in order to allow people who don't have a car to arrive with the 8:55 H-line bus.



<b>Organizers</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Manfred	Einsiedler	Eidgenössische TH Zürich-Hönggerberg
Jean-François	Quint	Université de Bordeaux I
Barbara	Schapira	Université de Picardie (Jules Verne)
<b>Speakers</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Yves	Benoist	Université de Paris XI
Francesco	Cellarosi	University of Illinois at Urbana-Champaign
Manfred	Einsiedler	Eidgenössische TH Zürich-Hönggerberg
Elena	Fuchs	University of Illinois at Urbana-Champaign
Anish	Ghosh	Tata Institute of Fundamental Research
Dmitry	Kleinbock	Brandeis University
Han	Li	University of Texas
Seonhee	Lim	Seoul National University
Jens	Marklof	University of Bristol
Amir	Mohammadi	University of Texas
Dave	Morris	University of Lethbridge
Hee	Oh	Yale University
Uri	Shapira	Technion---Israel Institute of Technology
Akshay	Venkatesh	Stanford University



## Introductory Workshop: Geometric and Arithmetic Aspects of Homogeneous Dynamics

February 2-6, 2015

### Schedule

Monday, February 2, 2015			
9:00 AM - 9:15 AM	Simons Auditorium		Welcome
9:15 AM - 10:30 AM	Simons Auditorium	Jens Marklof	Homogeneous flows and the statistics of directions
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00 PM	Simons Auditorium	Dave Morris	Introduction to Ratner's Theorems on Unipotent Flows
12:00 PM - 1:30 PM	Atrium		Lunch
1:30 PM - 2:30 PM	Simons Auditorium	Han Li	Masser's conjecture on equivalence of integral quadratic forms
2:40 PM - 3:25 PM	Simons Auditorium	Jens Marklof	Homogeneous flows and the statistics of directions
3:25 PM - 3:55 PM	Atrium		Tea
3:55 PM - 4:55 PM	Simons Auditorium	Hee Oh	Exponential decay of matrix coefficients
Tuesday, February 3, 2015			
9:00 AM - 10:00 AM	Simons Auditorium	Jens Marklof	Homogeneous flows and the statistics of directions
10:00 AM - 10:30 AM	Atrium		Tea
10:30 AM - 11:30 AM	Simons Auditorium	Dave Morris	Introduction to Ratner's Theorems on Unipotent Flows
11:40 AM - 12:40 PM	Simons Auditorium	Francesco Cellarosi	Quadratic Weyl Sums, Automorphic Functions, and Invariance Principles
12:40 PM - 2:10 PM	Atrium		Lunch
2:10 PM - 3:10 PM	Simons Auditorium	Manfred Einsiedler	Rigidity of higher rank diagonalisable actions
3:10 PM - 3:40 PM	Atrium		Tea
3:40 PM - 4:40 PM	Simons Auditorium	Hee Oh	Exponential decay of matrix coefficients
4:40 PM - 6:20 PM	Atrium		Reception
Wednesday, February 4, 2015			
8:40 AM - 10:10 AM	Simons Auditorium	Yves Benoist	Semigroups in semisimple groups
10:10 AM - 10:40 AM	Atrium		Tea
10:40 AM - 11:40 AM	Simons Auditorium	Dave Morris	Introduction to Ratner's Theorems on Unipotent Flows
11:45 AM - 12:45 PM	Simons Auditorium	Amir Mohammadi	Unipotent flows on infinite volume manifolds
Thursday, February 5, 2015			
8:40 AM - 10:10 AM	Simons Auditorium	Yves Benoist	Semigroups in semisimple groups
10:10 AM - 10:40 AM	Atrium		Tea
10:40 AM - 11:40 AM	Simons Auditorium	Amir Mohammadi	Unipotent flows on infinite volume manifolds
11:45 AM - 12:45 PM	Simons Auditorium	Akshay Venkatesh	Unipotent flows and L-functions
12:45 PM - 2:15 PM	Atrium		Lunch
2:15 PM - 3:15 PM	Simons Auditorium	Dmitry Kleinbock	Geometric and arithmetic aspects of bounded orbits on homogeneous spaces
3:15 PM - 3:45 PM	Atrium		Tea
3:45 PM - 4:45 PM	Simons Auditorium	Akshay Venkatesh	Unipotent flows and quadratic forms (after Linnik)
Friday, February 6, 2015			
08:40 AM - 09:40 AM	Simons Auditorium	Uri Shapira	Grids with dense values
09:40 AM - 10:10 AM	Atrium		Tea
10:10 AM - 11:10 AM	Simons Auditorium	Elena Fuchs	Thin groups: arithmetic and geometric viewpoints
11:20 AM - 12:20 PM	Simons Auditorium	Seonhee Lim	Martin boundary and local limit theorem of Brownian motion on negatively-curved manifolds
12:20 PM - 01:50 PM	Atrium		Lunch
01:50 PM - 02:50 PM	Simons Auditorium	Anish Ghosh	Diophantine approximation on group varieties

<b>Participants</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Ilesanmi	Adeboye	Wesleyan University
Ian	Agol	University of California, Berkeley
Menny	Aka	Eidgenössische TH Zürich-Hönggerberg
Hamid	Al-Saqban	University of Maryland
Paul	Apisa	University of Chicago
Caleb	Ashley	Howard University
Jayadev	Athreya	University of Illinois at Urbana-Champaign
Maria	Avdeeva	Princeton University
Shinpei	Baba	Ruprecht-Karls-Universität Heidelberg
Mohammad	Bardestani	University of Ottawa
Yves	Benoist	Université de Paris XI
Francis	Bonahon	University of Southern California
Martin	Bridgeman	Boston College
C. Davis	Buenger	Ohio State University
Marc	Burger	Eidgenössische TH Zürich-Hönggerberg
Claire	Burrin	Eidgenössische TH Zürich-Hönggerberg
Dongho	Byeon	Seoul National University
Jakub	Byszewski	Uniwersytet Jagiellonski
Francesco	Cellarosi	University of Illinois at Urbana-Champaign
Rex	Cheung	Yale University
Yitwah	Cheung	San Francisco State University
Suh Young	Choi	Korea Advanced Institute of Science and Technology (KAIST)
Kathryn	Dabbs	University of Texas
Jeffrey	Danciger	University of Texas
Yiftach	Dayan	Tel Aviv University
Carlos Alberto	De la Cruz Mengual	Eidgenössische TH Zürich-Hönggerberg
Nicolas	de Saxce	Université de Paris XIII (Paris-Nord)
Nedim	Degirmenci	Anadolu (Anatolia) University
Bunyamin	Demir	Anadolu (Anatolia) University
Changguang	Dong	Pennsylvania State University
Benjamin	Dozier	Stanford University
Samuel	Edwards	Uppsala University
Manfred	Einsiedler	Eidgenössische TH Zürich-Hönggerberg
Daniel	El-Baz	University of Bristol
Alex	Furman	University of Illinois
Anish	Ghosh	Tata Institute of Fundamental Research
Sourav	Ghosh	Université de Paris XI
Tom	Gilat	Hebrew University
alexis	gilles	École Normale Supérieure
William	Goldman	University of Maryland
Ilya	Gringlaz	Tel Aviv University
Olivier	Guichard	Université de Strasbourg I (Louis Pasteur)
Subhojoy	Gupta	California Institute of Technology
Jiyoung	Han	Seoul National University

<b>Participants</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Thomas	Hille	Yale University
Soon ki	Hong	Seoul National University
Tal	Horesh	Technion---Israel Institute of Technology
Alessandra	Iozzi	Eidgenössische TH Zürich-Hönggerberg
Lien-Yung	Kao	University of Notre Dame
Fanny	Kassel	Université de Lille I (Sciences et Techniques de Lille Flandres Artois)
Asaf	Katz	Hebrew University
Steven	Kerckhoff	Stanford University
Ilya	Khayutin	Hebrew University
Inkang	Kim	Korea Institute for Advanced Study (KIAS)
Sungwoon	Kim	Korea Institute for Advanced Study (KIAS)
Dmitry	Kleinbock	Brandeis University
Kenji	Kozai	University of California, Berkeley
Sanghoon	Kwon	Seoul National University
François	Labourie	Université Nice Sophia-Antipolis
Tsviqa	Lakrec	Hebrew University
Or	Landesberg	Hebrew University
Etienne	Le Masson	Hebrew University
François	Ledrappier	University of Notre Dame
Han	Li	University of Texas
Qionglng	Li	Rice University
Penghui	Li	University of California, Berkeley
Seonhee	Lim	Seoul National University
Elon	Lindenstrauss	Hebrew University
Benjamin	Linowitz	University of Michigan
Xiao-Chuan	Liu	IMPA-INSTITUTO NACIONAL DE MATEMÁTICA PURA E APLICADA
Brian	Longo	University of California, San Diego
Tue	Ly	Brandeis University
Alex	Maier	Eidgenössische TH Zürich-Hönggerberg
Sara	Maloni	Brown University
Kathryn	Mann	University of California, Berkeley
Jens	Marklof	University of Bristol
Giuseppe	Martone	University of Southern California
Howard	Masur	University of Chicago
Karin	Melnick	University of Maryland
JUNJIE	MIAO	East China Normal University
Shahriar	Mirzadeh	Brandeis University
Amir	Mohammadi	University of Texas
Dave	Morris	University of Lethbridge
Shahar	Mozes	Hebrew University
Hee	Oh	Yale University
Frederic	Palesi	Université d'Aix-Marseille (AMU)
Wenyu	Pan	Yale University
Mark	Pollicott	University of Warwick

<b>Participants</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Maria Beatrice	Pozzetti	MSRI - Mathematical Sciences Research Institute
Jean-François	Quint	Université de Bordeaux I
David	Renardy	University of Michigan
Florian	Richter	Ohio State University
Donald	Robertson	Ohio State University
Rene	Rühr	Eidgenössische TH Zürich-Hönggerberg
Barbara	Schapira	Université de Picardie (Jules Verne)
Nimish	Shah	Ohio State University
Uri	Shapira	Technion---Israel Institute of Technology
Ronggang	Shi	Tel Aviv University
Lin	Shu	Beijing (Peking) University
Adam	Sikora	University at Buffalo (SUNY)
Lior	Silberman	University of British Columbia
Yotam	Smilansky	Tel Aviv University
Ilia	Smilga	Université de Paris XI (Paris-Sud)
Omri	Solan	Tel Aviv University
Ralf	Spatzier	University of Michigan
Matthew	Stover	Temple University
Nicolaus	Treib	Ruprecht-Karls-Universität Heidelberg
Nick	Wadleigh	Brandeis University
Anna	Wienhard	Ruprecht-Karls-Universität Heidelberg
Dale	Winter	Brown University
Philipp	Wirth	Eidgenössische TH Zürich-Hönggerberg
Grace	Work	University of Illinois at Urbana-Champaign
Alexander	Wright	Stanford University
Lei	Yang	Yale University
Pengyu	Yang	Ohio State University
Tengren	Zhang	University of Michigan
Cheng	Zheng	Ohio State University
Tamar	Ziegler	Hebrew University

## Officially Registered Participant Information

<b>Participants</b>		<b>120</b>
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<b>Gender</b>		<b>120</b>
<b>Male</b>	82.50%	99
<b>Female</b>	16.67%	20
<b>Declined to state</b>	0.83%	1

<b>Ethnicity*</b>		<b>124</b>
<b>White</b>	55.65%	69
<b>Asian</b>	25.81%	32
<b>Hispanic</b>	0.81%	1
<b>Pacific Islander</b>	0.81%	1
<b>Black</b>	1.61%	2
<b>Native American</b>	0.00%	0
<b>Mixed</b>	1.61%	2
<b>Declined to state</b>	13.71%	17

\* ethnicity specifications are not exclusive

# 69 responses

69 responses/120 participants = 58% response rate

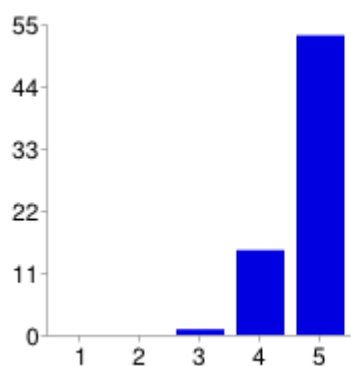
[View all responses](#)   [Publish analytics](#)

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## Summary

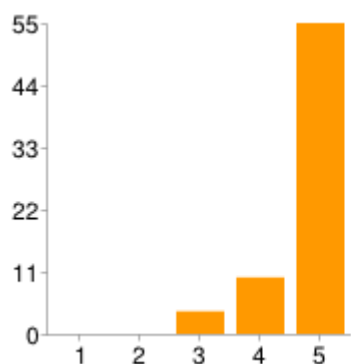
### Workshop assessment

#### The workshop was intellectually stimulating



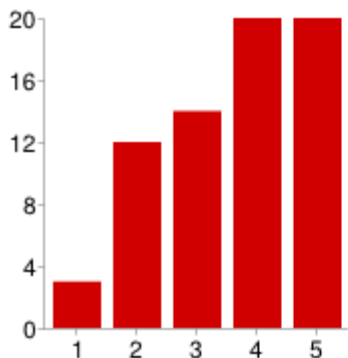
1	0	0%
2	0	0%
3	1	1%
4	15	22%
5	53	77%

#### The overall experience of the workshop was worthwhile



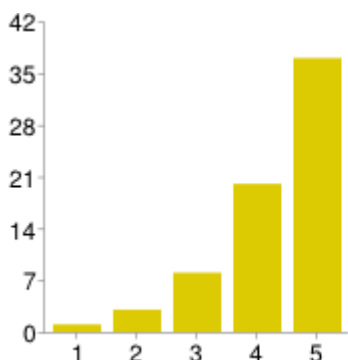
1	0	0%
2	0	0%
3	4	6%
4	10	14%
5	55	80%

The starting times of the first talks of the day were:



1	<b>3</b>	4%
2	<b>12</b>	17%
3	<b>14</b>	20%
4	<b>20</b>	29%
5	<b>20</b>	29%

### The time between lectures was adequate for discussion



1	<b>1</b>	1%
2	<b>3</b>	4%
3	<b>8</b>	12%
4	<b>20</b>	29%
5	<b>37</b>	54%

### Additional comments on the workshop organization

awesome

lunch catering is quite poor. bagels are great though!

should have coordinated shuttle service with ucb so that they would send larger vehicles

It ran seamlessly

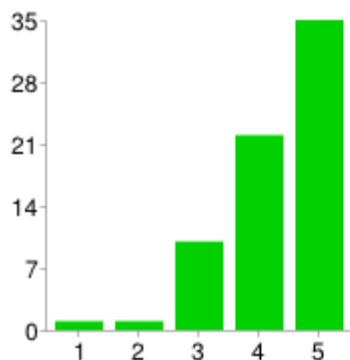
Excellent talks, and excellent selection of speakers

The workshop started way too early almost every day. There were too many talks and not enough time for discussion. I have never seen such a crazy schedule for a workshop.

### Personal assessment

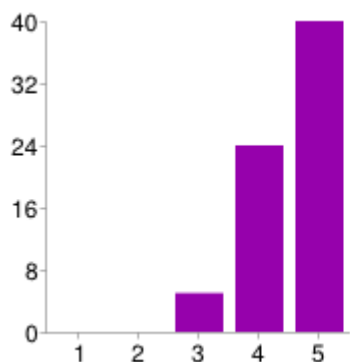
#### I was well prepared to benefit from the lectures





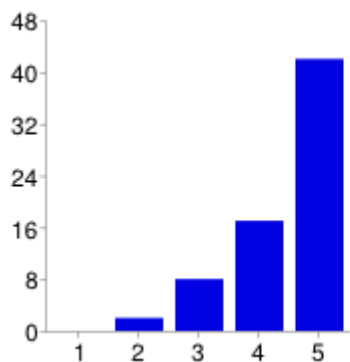
1	1	1%
2	1	1%
3	10	14%
4	22	32%
5	35	51%

### My interest in the subject matter was increased by the workshop



1	0	0%
2	0	0%
3	5	7%
4	24	35%
5	40	58%

### The workshop helped me meet people with similar scientific interests



1	0	0%
2	2	3%
3	8	12%
4	17	25%
5	42	61%

### Additional comments on your personal assessment

I enjoyed it greatly

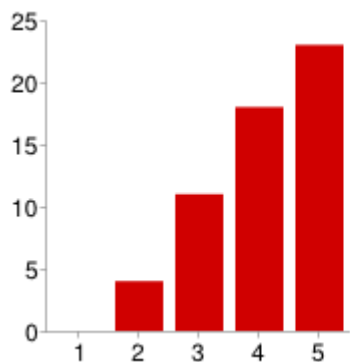
### Additional Activities

Did you attend the reception?



Yes	<b>56</b>	81%
No	<b>13</b>	19%

**If you did attend the reception, did it help to solidify the contacts you made in the workshop?**



1	<b>0</b>	0%
2	<b>4</b>	6%
3	<b>11</b>	16%
4	<b>18</b>	26%
5	<b>23</b>	33%

**Please provide any comments on the reception**

It was a bit too crowded in the atrium

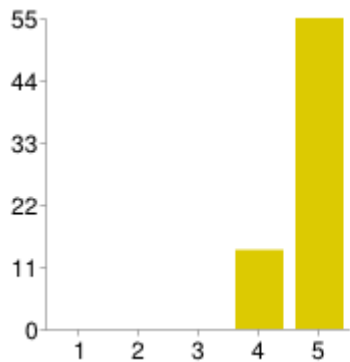
would have been very nice to have more chairs.

the reception was fantastic; since i'm so involved in administrative aspects these days, and couldn't attend that many of the talks, i found the reception extremely beneficial mathematically.

i'm mainly involved in the other program, but i met new people at the reception and had numerous stimulating mathematical discussions there.

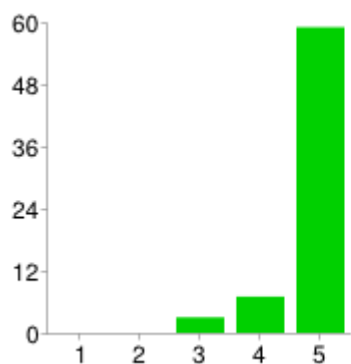
**Venue**

**I found the MSRI staff helpful**



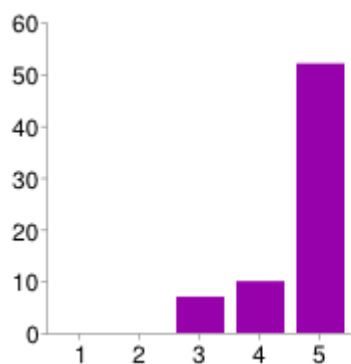
1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>0</b>	0%
4	<b>14</b>	20%
5	<b>55</b>	80%

**The MSRI physical facilities were conducive for such a workshop**



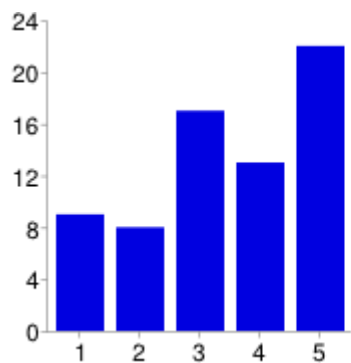
1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>3</b>	4%
4	<b>7</b>	10%
5	<b>59</b>	86%

**The MSRI computer facilities were adequate for such a workshop**



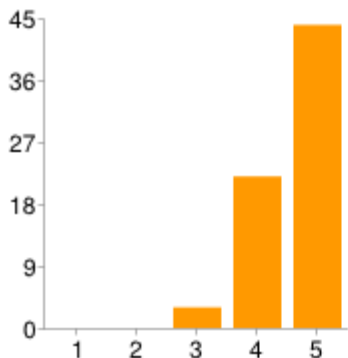
1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>7</b>	10%
4	<b>10</b>	14%
5	<b>52</b>	75%

**The MSRI lunch arrangements were satisfactory**



1	<b>9</b>	13%
2	<b>8</b>	12%
3	<b>17</b>	25%
4	<b>13</b>	19%
5	<b>22</b>	32%

**The MSRI tea arrangements were satisfactory**



1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>3</b>	4%
4	<b>22</b>	32%
5	<b>44</b>	64%

### Additional comments on the venue

Everything is excellent except lunch! I do not like the lunch at all!  
excellent.

Used the kitchen to reheat lunch from home

everyone was scattered in different hotels, and commuting to the MSRI was not completely trivial. I think it is much easier to bond when everyone is staying in the same hotel (or few hotels), and it would save a lot of time if there was a shuttle from the hotel/s to the MSRI and back.

The venue and conditions are fantastic. Really the only thing I would suggest to improve is the lunch, a better selection is needed with an option for a hot meal.

Maybe an online food ordering can be a good way to have varied food delivered. in any case, the lunch catering is not up to the standard of the other things.

I particularly liked the cinnamon rolls at the morning tea.

The Auditorium was top notch.

I did not like the pair of ladies who served lunch

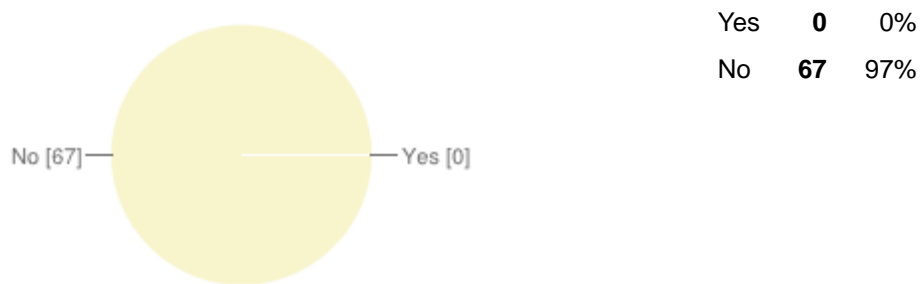
### MSRI Wireless Network

#### Did you use MSRI's wireless network?



Yes	<b>63</b>	91%
No	<b>6</b>	9%

#### Did you experience any difficulties with the network?



**If you did experience difficulties with the network, please explain:**

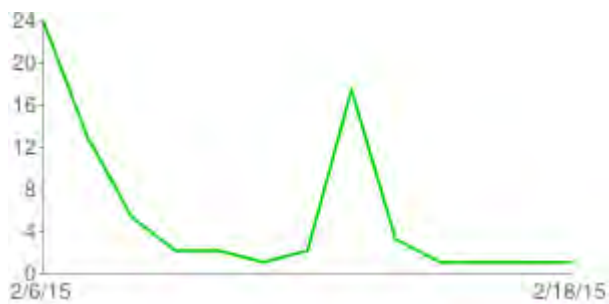
No responses yet for this question.

**Thank you for completing this survey**

**We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.**

Thank you!

**Number of daily responses**



**Dynamics on Moduli Spaces**  
April 13, 2015 - April 17, 2015  
MSRI, Berkeley, CA, USA

Organizers:

**Marc Burger (Eidgenössische TH Zürich-Hönggerberg)**

**David Dumas (University of Illinois at Chicago)**

**Olivier Guichard (Université de Strasbourg I (Louis Pasteur))**

**François Labourie (Université Nice Sophia-Antipolis)**

**Anna Wienhard (Ruprecht-Karls-Universität Heidelberg)**

REPORT ON THE MSRI WORKSHOP “DYNAMICS ON MODULI SPACES”,  
APRIL 13–17, 2015

ORGANIZERS

- Marc Burger (ETH Zurich)
- David Dumas (University of Illinois at Chicago)
- Olivier Guichard (Université de Strasbourg I)
- François Labourie (Université de Nice Sophia Antipolis)
- Anna Wienhard (Ruprecht-Karls-Universität Heidelberg).

1. SCIENTIFIC DESCRIPTION

The study of moduli spaces of geometric structures originated in classical nineteenth century differential geometry and geometric topology and centred around Riemann surfaces and Kleinian group theory. Over the last fifty years, the extensive development of this field has revealed deep connections to many other fields of mathematics. Relations to algebraic geometry, representation theory, differential equations, number theory, and mathematical physics are now well-established, and the cross fertilization of ideas and techniques from all these different fields has proved to be both very productive and challenging.

A central object of study in this area is the space of homomorphisms from the fundamental group of a given manifold to a Lie group. Surfaces, due to their flexibility, play a fundamental role here. For instance, classical Teichmüller theory considers the case of a surface fundamental group and the Lie group  $\mathrm{PSL}(2, \mathbb{R})$ , while in the study of Kleinian groups one considers 3-manifold groups (often described through their boundaries) mapping to  $\mathrm{PSL}(2, \mathbb{C})$ . In recent years there has been a surge of new activity in this field wherein key features of these classical instances have been shown to persist for certain families of representations into other Lie groups.

The wealth of techniques used to study these objects and their moduli spaces is already present in Teichmüller theory: dynamics and thermodynamics, complex and algebraic geometry, cohomological methods, combinatorics, etc.. One may describe Teichmüller theory as a dictionary, where, for instance, complex geometric features (associated to elliptic PDE) correspond to dynamical pictures (associated to hyperbolic flows): the paragon of these correspondences being Selberg trace formula. The progress of years seems to suggest some version of dictionary may persist for higher rank Lie groups (as opposed to  $\mathrm{PSL}(2, \mathbb{R})$ ).

The purpose of this research workshop was twofold, first ensuring the dissemination of the exciting new results produced these recent years, but also making the connection with classical and venerable subject such as Kleinian groups, Teichmüller theory, and the study of Shimura varieties. Furthermore, some talks were devoted to survey the corpus of results from nearby fields that the organizers feel may shape future research directions (such as WKB approximation, 3-manifolds, finitely generated subgroups of arithmetic groups)

## 2. HIGHLIGHTS OF PRESENTATIONS

Several workshop presentations described new results and perspectives on classical Teichmüller theory. For example, the workshop opened with Richard Canary’s engaging lecture about recent joint work with J. Brock, K. Bromberg, C. Lecuire and Y. Minsky which provides a complete characterization of subconvergent sequences of quasi-Fuchsian groups in terms of ending invariants. Ursula Hamenstaedt described results relating the measurable dynamics of the Teichmüller and Weil-Petersson geodesic flows. Ian Agol presented joint work with C. Leininger and D. Margalit which bounds the minimum dilatation of a pseudo-anosov as a function of genus and the dimension of its invariant homology, linearly interpolating between previous results on the Torelli group and on arbitrary pseudo-anosov mapping classes. Bertrand Deroin gave a compelling lecture about a new “transfer principle” (part of joint work with G. Calsamiglia and S. Francaviglia) for studying the dynamics of the isoperiodic foliation of the moduli space of abelian differentials; this foliation has attracted much attention recently as a natural structure on the moduli space which is transverse to the extensively-studied Teichmüller geodesic flow.

Another significant theme explored in the workshop was the use of techniques from dynamical systems to study properties of moduli spaces of geometric structures. In this direction, Andrés Sambarino described a recent breakthrough (in joint work with R. Potrie) whereby the thermodynamic formalism is used to establish an entropy rigidity result characterizing Fuchsian representations among Hitchin representations. Maryam Mirzakhani proposed an ambitious conjecture regarding the asymptotic growth rate of the number of closed curves on a surface whose intersection number with a fixed geodesic current is bounded by a constant, and she described her recent work which establishes this conjecture in the case of the Liouville current of a hyperbolic surface. Tengren Zhang presented a generalization of the classical collar lemma of hyperbolic geometry which applies to representations in the Hitchin component of  $\mathrm{PSL}(n, \mathbb{R})$ , a result of his joint project with G.-S. Lee.

A number of lecturers described work related to Anosov representations and Hitchin components of higher-rank Lie groups. Fanny Kassel’s lecture described a new method (developed in collaboration with F. Guéritaud, O. Guichard, and A. Wienhard) for constructing proper actions of hyperbolic groups on homogeneous spaces of semisimple Lie groups; as an application this technique allows one to construct non-Anosov representations of hyperbolic groups which nevertheless share some key properties of Anosov representations, for example admitting continuous, equivariant boundary maps into the flag variety. Francis Bonahon’s lecture introduced a coordinate system on the Hitchin component of a surface group which is adapted to understanding the action of a pseudo-Anosov homeomorphism on this moduli space. This joint project with G. Dreyer represents a broad generalization of Thurston’s shearing coordinate system for Teichmüller space, and builds on the Fock-Goncharov coordinates for the Hitchin component of a punctured surface.

Several speakers described different aspects of the problem of compactifying the Hitchin components. Pranav Pandit described a largely conjectural picture (jointly



developed with L. Katzarkov, A. Noll, and C. Simpson) which interprets compactification constructions in terms of categorical algebraic geometry. Its aim is ultimately to reconcile the Hitchin and building point of view. A different aspect was presented by Qiongling Li, who described the asymptotic behavior of harmonic metrics and of eigenvalues of holonomy of flat connections associated with families of cyclic Higgs bundles (a collaboration with B. Collier). In the same vein, namely of understanding the behavior of individual limits of Hitchin representations, Anne Parreau presented a construction of an explicit geometric object carrying a surface group action with given length function coming from an action on an affine building. Daniele Alessandrini gave an alternative construction of compactification in the spirit of Morgan-Shalen, by using a different family of semi-algebraic functions. The fundamental question he addresses is whether a reasonable compactification will provide a bordification by a sphere, as in the case of the Thurston compactification.

These lectures showed that this aspect of higher Teichmüller theory presents, despite an existing large body of work, considerable potential for future, unexpected developments.

The talk of A. Salehi-Golsefidy provided a beautifully clear introduction to the method of the affine sieve and some of the recent results (including his own work) that have been established by this method. This type of sieve, developed by J. Bourgain, A. Gamburd and P. Sarnak, allows one to study arithmetic properties of subgroups of  $SL(n, \mathbb{Z})$  that are Zariski dense but not of finite index. Such methods were not available before and have spurred an interest from number theory in Zariski dense subgroups of Lie groups that are not lattices. This new point of contact between number theory and the study of discrete subgroups of Lie groups (which are central to the program on Dynamics on Moduli spaces of geometric structures) opens intriguing possibilities for future research directions.

There are deep links between classical Teichmüller theory and three-manifolds on one hand, and on the other hand representations of surface groups into the group of homeomorphisms of the circle. Also, the maximal representation aspect of Teichmüller theory lends itself to natural generalizations to representations of fundamental groups of complex hyperbolic manifolds. Each of these themes, worth a workshop in itself, were represented; the talk by Christian Zickert presented a glimpse of the theory of  $SL(n, \mathbb{C})$ -representations of three-manifold groups, where the unipotent representations are singled out as having special geometric significance and are encoded in the Ptolemy coordinates. Kathryn Mann presented her work on representations of surface groups into the group of homeomorphisms of the circle and explained very delicate rigidity phenomena concerning geometric non-maximal representations. Maria Beatrice Pozzetti presented her work concerning the general theme of understanding maximal representations into groups of hermitian type of fundamental groups of finite volume complex hyperbolic manifolds; more specifically she established strong rigidity for such representations with values in non-tube type domain groups.

Overall these talks indicated excited new directions, from the thematic as well as from the methodological point of view.

<b>Organizers</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Marc	Burger	Eidgenössische TH Zürich-Hönggerberg
David	Dumas	University of Illinois at Chicago
Olivier	Guichard	Université de Strasbourg I (Louis Pasteur)
François	Labourie	Université Nice Sophia-Antipolis
Anna	Wienhard	Ruprecht-Karls-Universität Heidelberg
<b>Speakers</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Ian	Agol	University of California, Berkeley
Daniele	Alessandrini	Ruprecht-Karls-Universität Heidelberg
Francis	Bonahon	University of Southern California
Richard	Canary	University of Michigan
Bertrand	Deroin	École Normale Supérieure
Ursula	Hamenstädt	Universität Bonn
Fanny	Kassel	Universitü de Lille I (Sciences et Techniques de Lille Flandres Artois)
Qionglng	Li	Rice University
Kathryn	Mann	University of California, Berkeley
Maryam	Mirzakhani	Stanford University
Pranav	Pandit	University of Vienna
Anne	Parreau	Université de Grenoble I (Joseph Fourier)
Maria Beatrice	Pozzetti	MSRI - Mathematical Sciences Research Institute
Alireza	Salehi Golsefidy	University of California, San Diego
Andrés	Sambarino	Université de Paris Diderot et Université Pierre et Marie Curie
Tengren	Zhang	University of Michigan
Christian	Zickert	University of Maryland



## Dynamics on Moduli Spaces

April 13 to April 17, 2015

### Schedule

Monday, April 13, 2015			
9:15 AM - 9:30 AM	Simons Auditorium		Welcome
9:30 AM - 10:30 AM	Simons Auditorium	Richard Canary	Convergence of quasifuchsian hyperbolic 3-manifolds
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00 PM	Simons Auditorium	Andrés Sambarino	The (asymptotic) location of eigenvalues of a representation in the Hitchin component
12:00 PM - 2:00 PM	Atrium		Lunch
2:00 PM - 3:00 PM	Simons Auditorium	Anne Parreau	Non archimedean representations of surface groups in $PGL(3)$ and $A_2$ -Euclidean buildings
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:30 PM	Simons Auditorium	Maria Beatrice Pozzetti	Maximal representations of complex hyperbolic lattices
Tuesday, April 14, 2015			
9:30 AM - 10:30 AM	Simons Auditorium	Francis Bonahon	The action of a pseudo-Anosov on the Hitchin component
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00 PM	Simons Auditorium	Fanny Kassel	Anosov representations and proper actions
12:00 PM - 2:00 PM	Atrium		Lunch
2:00 PM - 3:00 PM	Simons Auditorium	Christian Zickert	Coordinates for representation varieties of 3-manifold groups
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:30 PM	Simons Auditorium	Pranav Pandit	Buildings, spectral networks, and the Riemann-Hilbert correspondence at infinity
4:30 PM - 6:20 PM	Atrium		Reception
Wednesday, April 15, 2015			
9:30 AM - 10:30 AM	Simons Auditorium	Kathryn Mann	Three proofs from dynamics of rigidity of surface group actions
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00 PM	Simons Auditorium	Ian Agol	Entropy of pseudo-Anosovs which fix homology
Thursday, April 16, 2015			
9:30 AM - 10:30 AM	Simons Auditorium	Tengren Zhang	A collar lemma for Hitchin representations
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00 PM	Simons Auditorium	Daniele Alessandrini	Degeneration of real projective structures on open surfaces
12:00 PM - 2:00 PM	Atrium		Lunch
2:00 PM - 3:00 PM	Simons Auditorium	Qiongliang Li	Asymptotic Behavior of Certain Families of Higgs bundles in Hitchin Components
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:30 PM	Simons Auditorium	Bertrand Deroin	A transfer principle: from periods to isoperiodic foliations
Friday, April 17, 2015			
9:30 AM - 10:30 AM	Simons Auditorium	Alireza Golesefidy	Affine sieve and expansion in linear groups
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00 PM	Simons Auditorium	Ursula Hamenstädt	Dynamics and geometry of the Weil Petersson metric
12:00 PM - 2:00 PM	Atrium		Lunch
2:00 PM - 3:00 PM	Simons Auditorium	Maryam Mirzakhani	Counting closed geodesics on a hyperbolic surface

<b>Participants</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Jorge	Acosta	Rice University
Ilesanmi	Adeboye	Wesleyan University
Ian	Agol	University of California, Berkeley
Vanessa	Alderete	National Autonomous University of Mexico (UNAM)
Daniele	Alessandrini	Ruprecht-Karls-Universität Heidelberg
Jorgen Ellegaard	Andersen	Aarhus University
Paul	Apisa	University of Chicago
Caleb	Ashley	Howard University
Jayadev	Athreya	University of Illinois at Urbana-Champaign
David	Aulicino	University of Chicago
Shinpei	Baba	Ruprecht-Karls-Universität Heidelberg
Yves	Benoist	Université de Paris XI
Francis	Bonahon	University of Southern California
Steven	Bradlow	University of Illinois at Urbana-Champaign
Martin	Bridgeman	Boston College
Jeffrey	Brock	Brown University
Andre	Broido	Andre Broido
Kenneth	Bromberg	University of Utah
C. Davis	Buenger	Ohio State University
Marc	Burger	Eidgenössische TH Zürich-Hönggerberg
Claire	Burrin	Eidgenössische TH Zürich-Hönggerberg
Gabriel	Calsamiglia	Fluminense Federal University
Richard	Canary	University of Michigan
Lei	Chen	University of Chicago
Yitwah	Cheung	San Francisco State University
Suh Young	Choi	Korea Advanced Institute of Science and Technology (KAIST)
Brian	Collier	University of Illinois at Urbana-Champaign
Daryl	Cooper	University of California, Santa Barbara
Jeffrey	Danciger	University of Texas
Ellie	Dannenberg	University of Illinois
Carlos Alberto	De la Cruz Mengual	Eidgenössische TH Zürich-Hönggerberg
Bertrand	Deroin	École Normale Supérieure
Valentina	Disarlo	Indiana University
Benjamin	Dozier	Stanford University
Guillaume	Dreyer	University of Notre Dame
David	Dumas	University of Illinois at Chicago
Maksym	Eingorn	North Carolina Central University
Federica	Fanoni	Université de Fribourg
Gianluca	Faraco	Università di Parma
Ian	Frankel	University of Chicago
Ser-Wei	Fu	Temple University
Jane	Gilman	Rutgers University
William	Goldman	University of Maryland
Elise	Goujard	Max-Planck-Institut für Mathematik

<b>Participants</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Vesselin	Gueorguiev	California State University
Francois	Gueritaud	Université de Lille I
Olivier	Guichard	Université de Strasbourg I (Louis Pasteur)
Funda	Gultepe	University of Illinois at Urbana-Champaign
Ursula	Hamenstädt	Universität Bonn
Aloysius	Helminck	North Carolina State University
Michael	Heusener	Université de Clermont-Ferrand II (Blaise Pascal)
Zheng	Huang	CUNY, Graduate Center
Andy	Huang	Rice University
Alessandra	Iozzi	Eidgenössische TH Zürich-Hönggerberg
Lizhen	Ji	University of Michigan
Lien-Yung	Kao	University of Notre Dame
Fanny	Kassel	Université de Lille I
Linda	Keen	CUNY, Graduate Center
Steven	Kerckhoff	Stanford University
Inkang	Kim	Korea Institute for Advanced Study (KIAS)
Youngju	Kim	Korea Institute for Advanced Study (KIAS)
Sungwoon	Kim	Korea Institute for Advanced Study (KIAS)
Kyle	Kinneberg	Rice University
Dmitry	Kleinbock	Brandeis University
Kenji	Kozai	University of California, Berkeley
Thilo	Kuessner	Korea Institute for Advanced Study (KIAS)
Sanghoon	Kwon	Seoul National University
Georgios	Kydonakis	University of Illinois at Urbana-Champaign
François	Labourie	Université Nice Sophia-Antipolis
Andres	Larrain-Hubach	University of Arizona
Sean	Lawton	George Mason University
Cyril	Lecuire	Institut de Mathématiques de Toulouse
François	Ledrappier	University of Notre Dame
Gye-Seon	Lee	Ruprecht-Karls-Universität Heidelberg
Arielle	Leitner	University of California, Santa Barbara
Qionglin	Li	Rice University
Han	Li	University of Texas
Seonhee	Lim	Seoul National University
Elon	Lindenstrauss	Hebrew University
Kathryn	Lindsey	University of Chicago
John	Loftin	Rutgers University
Sara	Maloni	Brown University
Kathryn	Mann	University of California, Berkeley
Giuseppe	Martone	University of Southern California
Howard	Masur	University of Chicago
Ian	McIntosh	University of York
Thomas	Mettler	Eidgenössische TH Zürich-Hönggerberg
Yair	Minsky	Yale University

<b>Participants</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Sebastien	Miquel	École Normale Supérieure
Babak	Modami	University of Illinois at Urbana-Champaign
Martin	Moeller	Johann Wolfgang Goethe-Universität Frankfurt
Frederic	Palesi	Université d'Aix-Marseille (AMU)
Pranav	Pandit	University of Vienna
Anne	Parreau	Université de Grenoble I (Joseph Fourier)
Frédéric	Paulin	Université de Paris XI
Julien	Paupert	Arizona State University
Bram	Petri	Brown University
Maria Beatrice	Pozzetti	MSRI - Mathematical Sciences Research Institute
Daniele	Rosmondi	Università di Pavia
Lorenzo	Ruffoni	Università di Bologna
Samuel	Saiki	University of Pittsburgh
Alireza	Salehi Golsefidy	University of California, San Diego
Andrés	Sambarino	Université de Paris Diderot et Université Pierre et Marie Curie
Laura	Schaposnik	University of Illinois at Urbana-Champaign
Nimish	Shah	Ohio State University
Lin	Shu	Beijing (Peking) University
Adam	Sikora	University at Buffalo (SUNY)
Ralf	Spatzier	University of Michigan
Marco	Spinaci	Max-Planck-Institut für Mathematik
Matthew	Stover	Temple University
Hongbin	Sun	University of California, Berkeley
Ser	Tan	National University of Singapore
Bo	Tian	University of Maryland
Nicolaus	Treib	Ruprecht-Karls-Universität Heidelberg
Manuel	Ucan	National Autonomous University of Mexico (UNAM)
Nicholas	Vlamiš	Boston College
Richard	Wentworth	University of Maryland
Anna	Wienhard	Ruprecht-Karls-Universität Heidelberg
Michael	Wolf	Rice University
Maxime	Wolff	Institut de Mathématiques de Jussieu
Scott	Wolpert	University of Maryland
Grace	Work	University of Illinois at Urbana-Champaign
Alexander	Wright	Stanford University
Yunhui	Wu	Rice University
Binbin	Xu	Université de Grenoble I (Joseph Fourier)
Lei	Yang	Yale University
Andrew	Yarmola	Boston College
Sarah	Yeakel	University of Illinois at Urbana-Champaign
Yuncheng	You	University of South Florida
Tengren	Zhang	University of Michigan
Zhiyong	Zhao	Duke University
Cheng	Zheng	Ohio State University

<b>Participants</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Christian	Zickert	University of Maryland
Anton	Zorich	Institut de Mathématiques de Jussieu

## Officially Registered Participant Information

<b>Participants</b>		<b>135</b>
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<b>Gender</b>		<b>135</b>
<b>Male</b>	79.26%	107
<b>Female</b>	20.74%	28
<b>Declined to state</b>	0.00%	0

<b>Ethnicity*</b>		<b>143</b>
<b>White</b>	58.04%	83
<b>Asian</b>	22.38%	32
<b>Hispanic</b>	5.59%	8
<b>Pacific Islander</b>	1.40%	2
<b>Black</b>	1.40%	2
<b>Native American</b>	0.00%	0
<b>Mixed</b>	2.80%	4
<b>Declined to state</b>	8.39%	12

\* ethnicity specifications are not exclusive



# 84 responses

84 responses / 135 participants = 62% response rate

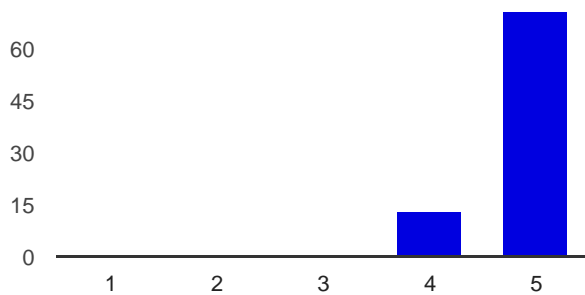
[View all responses](#)   [Publish analytics](#)

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## Summary

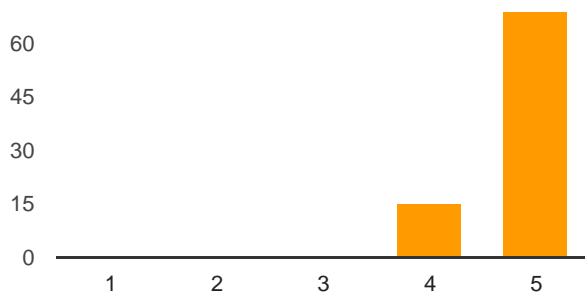
### Workshop assessment

#### The workshop was intellectually stimulating



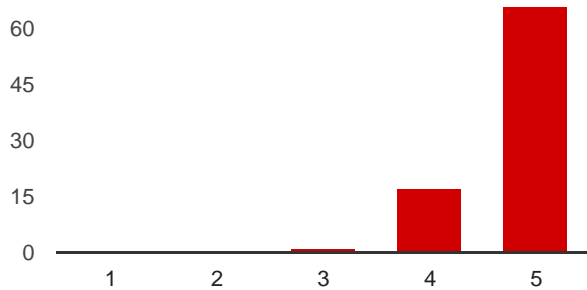
Not at all: 1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>0</b>	0%
4	<b>13</b>	15.5%
Very: 5	<b>71</b>	84.5%

#### The overall experience of the workshop was worthwhile



Not at all: 1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>0</b>	0%
4	<b>15</b>	17.9%
Very: 5	<b>69</b>	82.1%

### The time between lectures was adequate for discussion



Not at all: 1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>1</b>	1.2%
4	<b>17</b>	20.2%
Very: 5	<b>66</b>	78.6%

### Additional comments on the workshop organization

lunch catering was not so good

excellent workshop; only wish that i had more time to digest the many new ideas to which i was exposed

excellent

It was so amazing! I hope to participate in another workshop organized by the MSRI

Three talks per day maybe better.

The schedule and talks were great!

very professional

The workshop was very well organized.

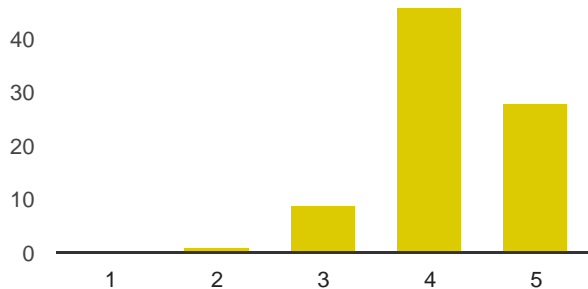
Perfectly organized!

Everything was excellent

great

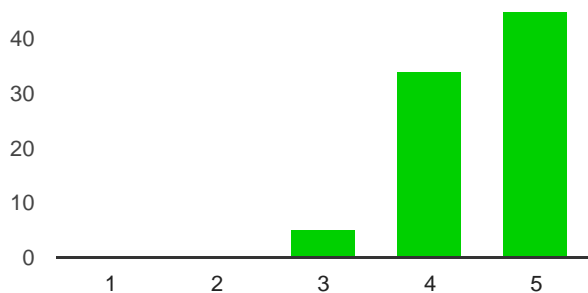
## Personal assessment

### I was well prepared to benefit from the lectures



Not at all: 1	<b>0</b>	0%
2	<b>1</b>	1.2%
3	<b>9</b>	10.7%
4	<b>46</b>	54.8%
Very: 5	<b>28</b>	33.3%

### My interest in the subject matter was increased by the workshop



Niot at all: 1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>5</b>	6%
4	<b>34</b>	40.5%
Very: 5	<b>45</b>	53.6%

### The workshop helped me meet people with similar scientific interests

Not at all: 1	<b>0</b>	0%
2	<b>1</b>	1.2%
3	<b>8</b>	9.5%
4	<b>26</b>	31%
Very Much: 5	<b>49</b>	58.3%

### Additional comments on your personal assessment

The large number of participants with similar interest as mine and great expertise in the subject was the biggest virtue of this seminar, I hope MSRI keeps organizing such wide and stimulating workshops!

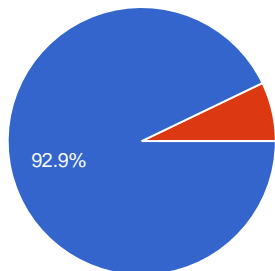
great opportunity

My interest in the subject matter was already at the highest, so I cannot say it was "very much" increased...

the large number of world experts in the subjects represented was truly impressive

### Additional Activities

#### Did you attend the reception?



Yes	<b>78</b>	92.9%
No	<b>6</b>	7.1%

**If you did attend the reception, did it help to solidify the contacts you made in the workshop?**

Not at all: 1	2	2.6%
2	1	1.3%
3	13	16.9%
4	24	31.2%
Very much: 5	37	48.1%

### **Please provide any comments on the reception**

Vary food over the semester, please

Great food!

too long lines

Very good opportunity to meet new people

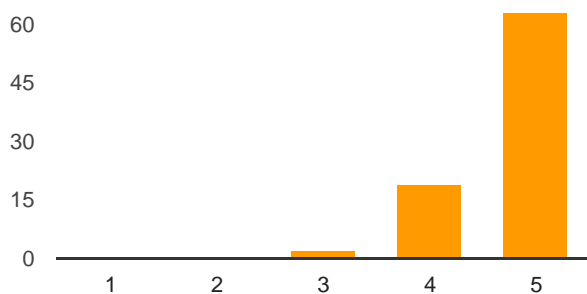
great!

maybe there could have been more food and wine given the extremely large number of participants in the workshop, but it was a wonderful social experience

Food wasn't enough

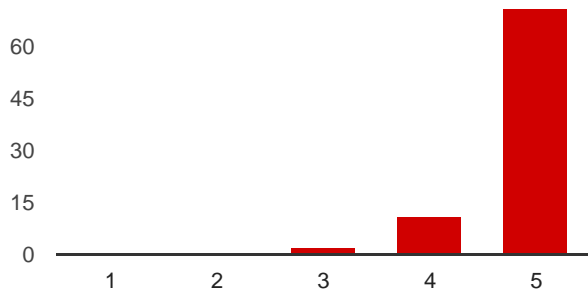
### **Venue**

#### **I found the MSRI staff helpful**



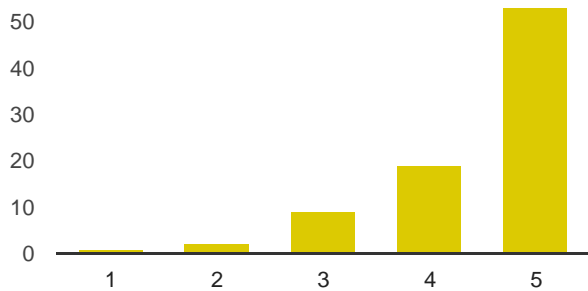
Not at all: 1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>2</b>	2.4%
4	<b>19</b>	22.6%
Very: 5	<b>63</b>	75%

**The MSRI physical facilities were conducive for such a workshop**



Not at all: 1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>2</b>	2.4%
4	<b>11</b>	13.1%
Very: 5	<b>71</b>	84.5%

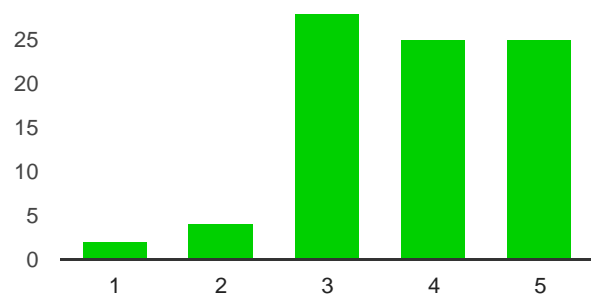
**The MSRI computer facilities were adequate for such a workshop**



Not at all: 1	<b>1</b>	1.2%
2	<b>2</b>	2.4%
3	<b>9</b>	10.7%
4	<b>19</b>	22.6%

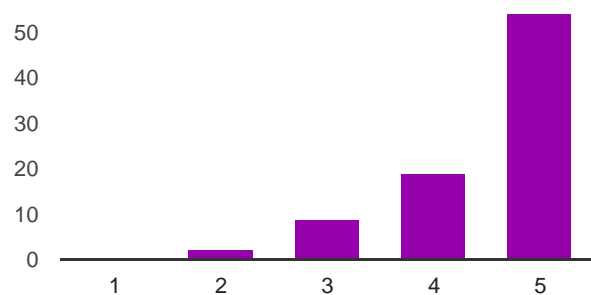
Very: 5 **53** 63.1%

### The MSRI lunch arrangements were satisfactory



Not at all: 1	<b>2</b>	2.4%
2	<b>4</b>	4.8%
3	<b>28</b>	33.3%
4	<b>25</b>	29.8%
Very: 5	<b>25</b>	29.8%

### The MSRI tea arrangements were satisfactory



Not at all: 1	<b>0</b>	0%
2	<b>2</b>	2.4%
3	<b>9</b>	10.7%
4	<b>19</b>	22.6%
Very: 5	<b>54</b>	64.3%

### Additional comments on the venue

Coffee/Tea should be allowed in the lecture hall and library. This would improve the productivity

of the workshop participants.

Lunch arrangements still are a bit haphazard.

more fresh fruits and less processed food on tea time please!

Didn't use lunch arrangements and computer facilities

perhaps more food could have been ordered, several times when I arrived late, the food had run out.

The Stuffed Inn catering (Thursday and Friday) was much better than earlier in the week.

A non-dairy milk option for tea/coffee would have been nice.

Fresher and healthier food in the morning coffee break could be introduced

I like all the facilities give to us!

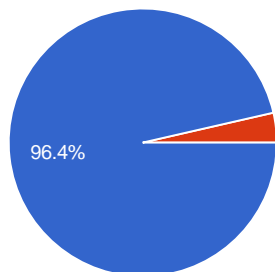
serving canned fruit is not great

The more places with a blackboard at which to discuss the better

Was not made aware that any computer facilities were available to participants.

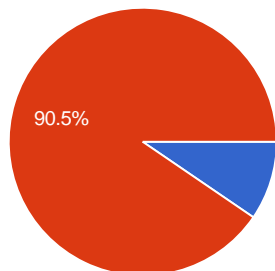
## MSRI Wireless Network

**Did you use MSRI's wireless network?**



Yes	<b>81</b>	96.4%
No	<b>3</b>	3.6%

**Did you experience any difficulties with the network?**



Yes	<b>8</b>	9.5%
No	<b>76</b>	90.5%

**If you did experience difficulties with the network, please explain:**

minor difficulties with the signal

sometime slow



Only used it to order lunch on Wed. Ddidn't remember my login info and the network was down for a while before the 10 AM deadline

The connection had some random lags, not very annoying per se but that often caused Skype to disconnect (and for European people as me daytime is the only available moment to call family...)

to slow when crowded

Even the secured network is very slow.

My wifi connection dropped out for half an hour just as I was trying to order lunch before the deadline. Might have just been my machine, and the library machines were free so it wasn't much of a problem.

Some connec problem appeared on Thursday, 16 April.

Network can be slow.

## Thank you for completing this survey

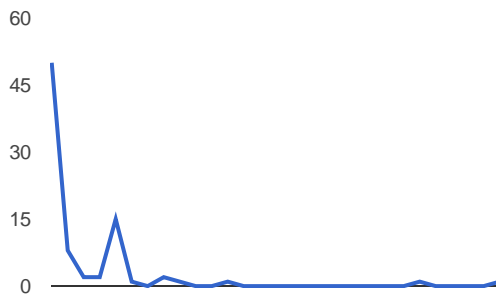
**We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.**

People who are in residence for the whole semester or part of it should wear NAME TAGS!

extremely inspiring and exciting event.

It would be nice if there is more choice for lunch...

## Number of daily responses



**Hot Topics: Kadison-Singer, Interlacing  
Polynomials, and Beyond**

March 09, 2015 - March 13, 2015

MSRI, Berkeley, CA, USA

Organizers:

**Sorin Popa (University of California, Los Angeles)**

**Daniel Spielman (Yale University)**

**Nikhil Srivastava (University of California, Berkeley)**

**Cynthia Vinzant (North Carolina State University)**

# Report for Hot Topics Workshop on Kadison-Singer, Interlacing Polynomials, and Beyond

March 9–13, 2015

Organizers: Sorin Popa (UCLA), Daniel Spielman (Yale), Nikhil Srivastava (UC Berkeley), Cynthia Vinzant (NC State).

## 1 Scientific Context and Objectives

The Kadison-Singer problem arose in operator algebras, was later reduced to several discrepancy type questions in finite dimensional linear algebra (including the “paving conjecture”), and was finally solved using techniques related to and motivated by questions in real algebraic geometry, algebraic/spectral graph theory, random matrix theory, and optimization. It therefore presents a natural opportunity to explore and make new connections between these fields. The broad objectives of the workshop were:

- To come up with future research directions and conjectures related to this interface and informed by all of these fields.
- To bring together researchers in the above fields to educate each other and potentially collaborate in this context.

Some of the more precise, mathematical objectives, detailed in the proposal were:

- To understand further applications of the method of interlacing polynomials to problems in combinatorics, graph theory, and linear algebra.
- To discuss applications and generalizations of paving in operator theory and operator algebras.
- To shed light on whether these methods can be used to solve other outstanding problems in discrepancy theory, such as the Komlos conjecture.
- To build a bridge between finite free convolutions, a device developed to study random graphs using interlacing families, and free probability theory.
- To potentially apply hyperbolic programming as an algorithmic tool in finding efficient constructive versions of matrix paving.

## 2 Summary

The workshop lasted for 5 days with four talks on each day, except for Wednesday, which had two talks.

The first talk was given by Petter Branden (Stockholm), who presented a generalization of the Marcus-Spielman-Srivastava theorem to the context of hyperbolic polynomials (the original theorem can be understood to be about determinants, which are a special case). This turns out to be a more natural context for many of the techniques, and also yields some new applications to combinatorics. Daniel Spielman (Yale) presented an outline of the method of interlacing families and used it to give a complete proof of the Bourgain-Tzafriri restricted invertibility theorem. Cynthia Vinzant (North Carolina State) gave a characterization of hyperbolicity cones in terms of interlacing, and presented partial results on the generalized Lax conjecture (which asks which hyperbolicity cones are spectrahedral) and when this condition can be checked using semidefinite programming. Chris Godsil (Waterloo) gave a gentle introduction to the theory of the matching polynomial, which figured prominently in the expansion of the method of interlacing polynomials to the construction of expander graphs.

Tuesday was centered around Free Probability theory and its connections with interlacing families. Dimitri Shlyakhtenko (UCLA) in the first half of his talk gave an introduction to the area, and then spoke on recent work which uses the machinery of free probability to calculate the spectral distributions of polynomials in freely independent operators. Alice Guionnet (MIT) talked about joint work with Shlyakhtenko on calculating the eigenvalue statistics of polynomials in Gaussian random matrices. In the afternoon, Adam Marcus (Princeton) and Nikhil Srivastava (Berkeley) gave talks on a finite-dimensional analogue of free convolution which appears in the analysis of random regular graphs. Marcus's talk ended with a conjecture relating this machinery to Voiculescu's infinite-dimensional free convolution.

Wednesday consisted of two talks on expander graphs. Alexandra Kolla (Illinois) spoke about eigenvalues of random covers of graphs, and Alain Valette (Neuchatel) presented work on infinite families of Cayley graph expanders which do not embed into each other metrically. The afternoon was formally scheduled to be free, but informal talks on hyperbolicity cones and sum-of-squares relaxations were organized by two of the participants (Bernd Sturmfels and Pablo Parrilo), and were attended by about half the participants.

Thursday began with two operator theory talks. William Johnson (Texas A & M) spoke on a characterization of commutators in  $L_p$  spaces, and Gideon Schechtman (Jerusalem) spoke on a quantitative version of the commutator theorem; notably, the best estimates for this problem are closely linked with the best estimates for paving, and improving one will lead to an improvement of the other. Stefan Vaes (KU Leuven) presented work with Popa on a generalization of the original Kadison-Singer paving problem to other MASAs and von Neumann algebras, and showed using the paving theorem that this more general notion holds in several cases of interest. He ended with an interesting conjecture on paving multiple matrices simultaneously which, is understood in the infinite-dimensional setting but open in finite dimensions. The last talk was a survey of combinatorial discrepancy theory by Nick

Harvey (UBC), which ended with a conjecture which simultaneously strengthens paving as well as several open questions in that area.

On Friday, Osman Guler (UMBC) gave a survey of optimization over hyperbolicity cones using interior point methods, and discussed the connections of this theory with the Lax conjecture. Shayan Oveis Gharan (Washington) spoke about his recent breakthrough result with Nima Anari on approximation algorithms for the asymmetric travelling salesman problem. The proof involves among other ingredients a generalization of the MSS theorem (which is concerned with sums of independent rank one random matrices) to certain negatively dependent distributions called Strongly Rayleigh Measures. He ended his talk with a conjectured “L1” version of Weaver’s  $KS_2$  conjecture, which if true would solve a number of outstanding problems in combinatorial optimization, including Goddyn’s Thin Tree conjecture. Nicole Tomczak-Jaegerman (Edmonton) gave a talk on concentration bounds for the extremal eigenvalues of empirical covariance matrices of log-concave distributions. The final talk was by Victor Vinnikov (Ben Gurion), and discussed determinantal representations (which were crucial to the resolution of the Lax conjecture in three dimensions) for certain lower-dimensional generalizations of hyperbolicity cones, for which the generalized Lax conjecture (in all dimensions) turns out to be true.

### 3 Outcomes and Anecdotes

The workshop turned out to be very lively with lots of interaction. The coffee breaks were pretty loud, and on several occasions conjectures were made and experimentally checked using MATLAB in the coffee area (typically by Dan Spielman). Shlyakhtenko and Guionnet made progress on Marcus’s question about finite vs. standard free probability during the workshop itself, and produced a small writeup before the week was over.

The interdisciplinary nature of the workshop and the diverse backgrounds of the participants were reflected in the rather creative questions (usually 5-15 minutes worth) asked during the talks and in the often opposing intuitions people had about them: for instance, Shlyakhtenko asked whether the orthogonal matrices in Marcus’s talk could be replaced by unitaries, and whether the volumes appearing in the universal barrier function in Guler’s could be interpreted as some kind of entropy; Branden suggested using a linear operator on polynomials to remove duplicate edges in the random graph model in Srivastava’s talk; Spielman asked whether there was an algebraic description of the central path for hyperbolic programs.

Several people remarked that they enjoyed the pedagogical nature of many of the talks, and learned something new and relevant — Harvey’s talk on discrepancy was a particularly big hit.

<b>Organizers</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Sorin	Popa	University of California, Los Angeles
Daniel	Spielman	Yale University
Nikhil	Srivastava	University of California, Berkeley
Cynthia	Vinzant	North Carolina State University
<b>Speakers</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Petter	Branden	Royal Institute of Technology (KTH)
Chris	Godsil	University of Waterloo
Alice	Guionnet	Massachusetts Institute of Technology
Osman	Guler	University of Maryland Baltimore County
Nicholas	Harvey	University of British Columbia
William	Johnson	Texas A & M University
Alexandra	Kolla	University of Illinois at Urbana-Champaign
Adam	Marcus	Yale University
Shayan	Oveis Gharan	University of Washington
Pablo	Parrilo	Massachusetts Institute of Technology
Sorin	Popa	University of California
Gideon	Schechtman	Weizmann Institute of Science
Dimitri	Shlyakhtenko	University of California, Los Angeles
Daniel	Spielman	Yale University
Nikhil	Srivastava	University of California, Berkeley
Nicole	Tomczak Jaegermann	University of Alberta
Stefaan	Vaes	Katholieke Universiteit Leuven
Alain	Valette	Université de Neuchâtel
Victor	Vinnikov	Ben Gurion University of the Negev
Cynthia	Vinzant	North Carolina State University



## Hot Topics: Kadison-Singer, Interlacing Polynomials, and Beyond

March 9 to March 13, 2015

### Schedule

Monday, March 9, 2015			
9:15 AM - 9:30 AM	Simons Auditorium		Welcome
9:30 AM - 10:30 AM	Simons Auditorium	Daniel Spielman	Introduction to Interlacing Polynomials, Barrier Functions, and Kadison-Singer
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00 PM	Simons Auditorium	Petter Branden	Hyperbolic polynomials, Strong Rayleigh matroids and the Marcus-Spielman-Srivastava theorem
12:00 PM - 2:00 PM	Atrium		Lunch
2:00 PM - 3:00 PM	Simons Auditorium	Cynthia Vinzant	Determinants, Hyperbolicity, and Interlacing
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:30 PM	Simons Auditorium	Chris Godsil	An overview of the Matching Polynomial
Tuesday, March 10, 2015			
9:30 AM - 10:30 AM	Simons Auditorium	Dimitri Shlyakhtenko	Laws of non-commutative polynomials in $n$ -tuples of free variables
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00 PM	Simons Auditorium	Alice Guionnet	Free probability, random matrices and transport maps
12:00 PM - 2:00 PM	Atrium		Lunch
2:00 PM - 3:00 PM	Simons Auditorium	Adam Marcus	Polynomial convolutions and connections to free probability
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:30 PM	Simons Auditorium	Nikhil Srivastava	Ramanujan graphs from finite free convolutions.
4:30 PM - 6:20 PM	Atrium		Reception
Wednesday, March 11, 2015			
9:30 AM - 10:30 AM	Simons Auditorium	Alexandra Kolla	Towards Constructing Expanders via Lifts: Hopes and Limitations
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00 PM	Simons Auditorium	Alain Valette	Expanders and box spaces
Thursday, March 12, 2015			
9:30 AM - 10:30 AM	Simons Auditorium	William Johnson	Commutators in $L(X)$ for some Banach spaces $X$
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00 PM	Simons Auditorium	Gideon Schechtman	A quantitative version of the commutator theorem for zero trace matrices
12:00 PM - 2:00 PM	Atrium		Lunch
2:00 PM - 3:00 PM	Simons Auditorium	Sorin Popa	Paving over arbitrary MASAs in von Neumann algebras
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:30 PM	Simons Auditorium	Nicholas Harvey	A survey of discrepancy theory
Friday, March 13, 2015			
9:30 AM - 10:30 AM	Simons Auditorium	Osman Guler	Hyperbolic Polynomials in Optimization
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00 PM	Simons Auditorium	Shayan Oveis Gharan	Effective-Resistance-Reducing Flows, Spectrally Thin Trees, and Asymmetric TSP
12:00 PM - 2:00 PM	Atrium		Lunch
2:00 PM - 3:00 PM	Simons Auditorium	Nicole Tomczak Jaegermann	Approximating the covariance matrix by the empirical covariance matrices; non-limiting random matrix approach
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:30 PM	Simons Auditorium	Victor Vinnikov	Hyperbolicity and determinantal representations for higher-codimensional subvarieties

<b>Participants</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Nima	Ahmadipouranari	University of California
Charles	Akemann	University of California, Santa Barbara
Jayadev	Athreya	University of Illinois at Urbana-Champaign
Benson	Au	University of California, Berkeley
Khodakhast	Bibak	University of Victoria
Jonathan	Block	University of Pennsylvania
Marcin	Bownik	University of Oregon
Petter	Branden	Royal Institute of Technology (KTH)
Ian	Charlesworth	University of California
Chris	Godsil	University of Waterloo
Alice	Guionnet	Massachusetts Institute of Technology
Osman	Guler	University of Maryland Baltimore County
Nicholas	Harvey	University of British Columbia
Nigel	Higson	Pennsylvania State University
Olga	Holtz	University of California, Berkeley
Chengjie	Huang	San Francisco State University
John	Jasper	University of Oregon
William	Johnson	Texas A & M University
Ilya	Kachkovskiy	University of California, Irvine
Steven	Karp	University of California, Berkeley
Alexandra	Kolla	University of Illinois at Urbana-Champaign
Michael	Luby	Qualcomm
Adam	Marcus	Yale University
Brent	Nelson	University of California, Los Angeles
Shayan	Oveis Gharan	University of Washington
Pablo	Parrilo	Massachusetts Institute of Technology
Robert	Pluta	University of Iowa
Sorin	Popa	University of California, Los Angeles
Gideon	Schechtman	Weizmann Institute of Science
Dimitri	Shlyakhtenko	University of California, Los Angeles
Ali	Sinop	University of California
Mahdi	Soltanolkotabi	University of Southern California
Daniel	Spielman	Yale University
Nikhil	Srivastava	University of California, Berkeley
Bernd	Sturmfels	UC Berkeley Math Faculty
Quang	Ta	Miami University
Nicole	Tomczak Jaegermann	University of Alberta
Levent	Tuncel	University of Waterloo
Stefaan	Vaes	Katholieke Universiteit Leuven
Alain	Valette	Université de Neuchâtel
Victor	Vinnikov	Ben Gurion University of the Negev
Cynthia	Vinzant	North Carolina State University
Mirkó	Visontai	Google, Inc.
Dan-Virgil	Voiculescu	University of California, Berkeley



<b>Participants</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Gary	Weiss	University of Cincinnati
Moor	Xu	University of California, Berkeley

## Officially Registered Participant Information

<b>Participants</b>		<b>46</b>
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<b>Gender</b>		<b>46</b>
<b>Male</b>	89.13%	41
<b>Female</b>	10.87%	5
<b>Declined to state</b>	0.00%	0

<b>Ethnicity*</b>		<b>46</b>
<b>White</b>	80.43%	37
<b>Asian</b>	13.04%	6
<b>Hispanic</b>	2.17%	1
<b>Pacific Islander</b>	0.00%	0
<b>Black</b>	0.00%	0
<b>Native American</b>	0.00%	0
<b>Mixed</b>	0.00%	0
<b>Declined to state</b>	4.35%	2

\* ethnicity specifications are not exclusive

# 20 responses

20 responses out of 46 participants = 43% response rate

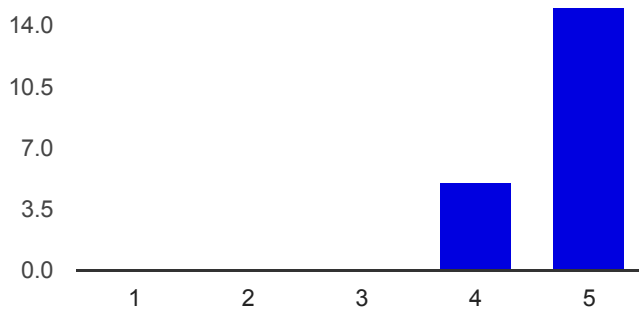
[View all responses](#)   [Publish analytics](#)

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## Summary

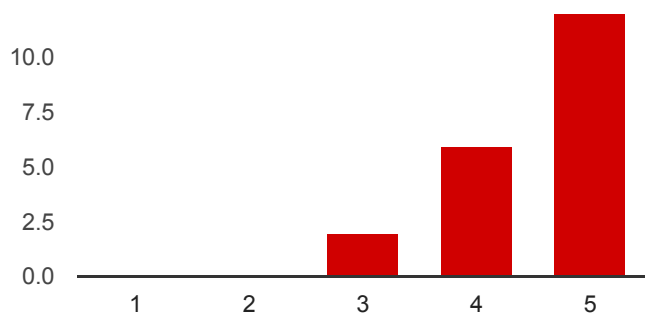
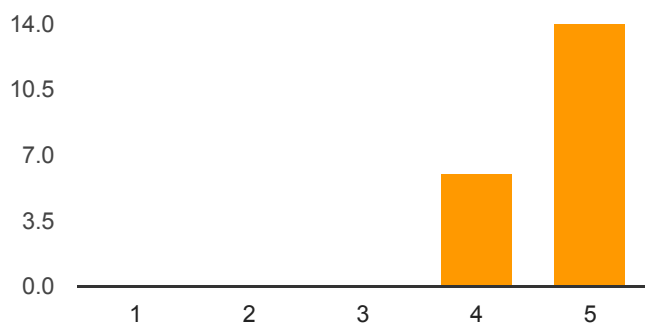
### Workshop assessment

The workshop was intellectually stimulating



Not at all: 1	0	0%
2	0	0%
3	0	0%
4	5	25%
Very: 5	15	75%

The overall experience of the workshop was worthwhile



Not at all:	1	0	0%
	2	0	0%
	3	2	10%
	4	6	30%
Very:	5	12	60%

### Additional comments on the workshop organization

very well organized

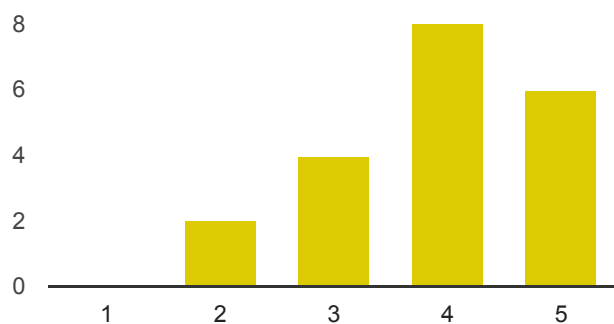
excellent

Everything was really great

Superb!

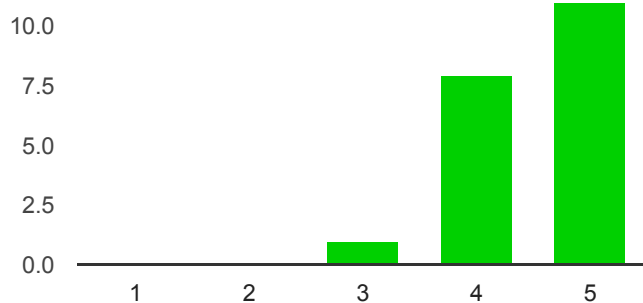
### Personal assessment

I was well prepared to benefit from the lectures



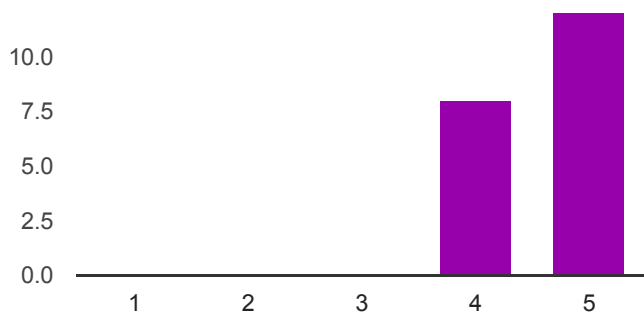
2	2	10%
3	4	20%
4	8	40%
Very: 5	6	30%

My interest in the subject matter was increased by the workshop

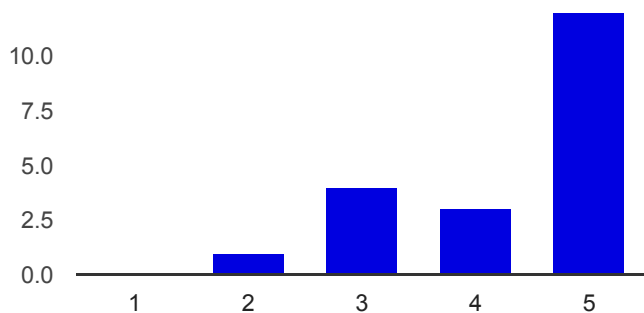


Niot at all: 1	0	0%
2	0	0%
3	1	5%
4	8	40%
Very: 5	11	55%

The workshop helped me meet people with similar scientific interests



The workshop helped me understand people with different scientific interests



Not at all: 1	0	0%
2	1	5%
3	4	20%
4	3	15%
Very Much: 5	12	60%

Additional comments on your personal assessment

extremely interesting workshop, was able to attend only in part because of my teaching duties this semester

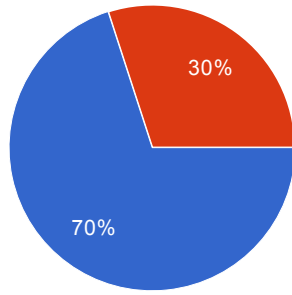
Everything was really great

## Additional Activities

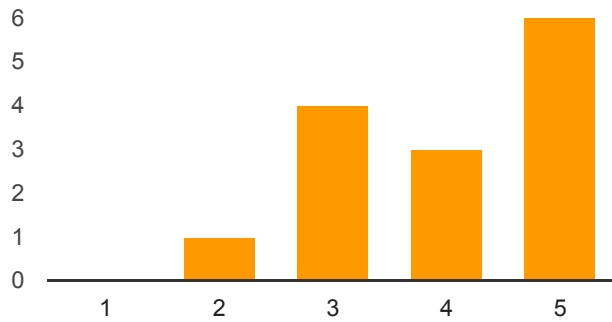
Did you attend the reception?

Yes 14 70%

No 6 30%



If you did attend the reception, did it help to solidify the contacts you made in the workshop?



Not at all: 1	0	0%
2	1	7.1%
3	4	28.6%
4	3	21.4%
Very much: 5	6	42.9%

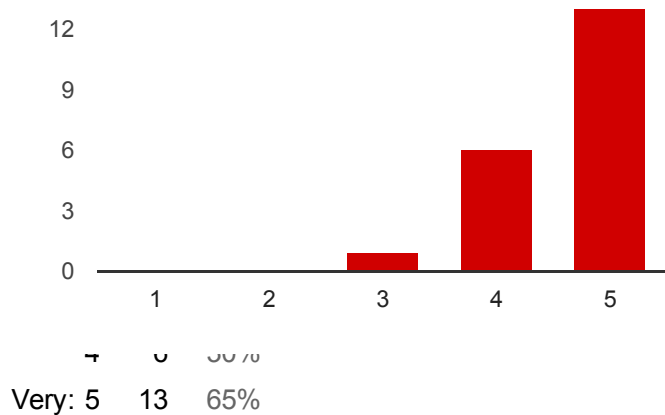
Please provide any comments on the reception

Salmon was oversalted.

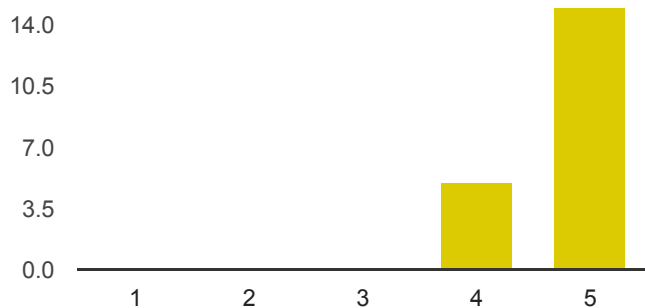
Everything was really great

## Venue

I found the MSRI staff helpful



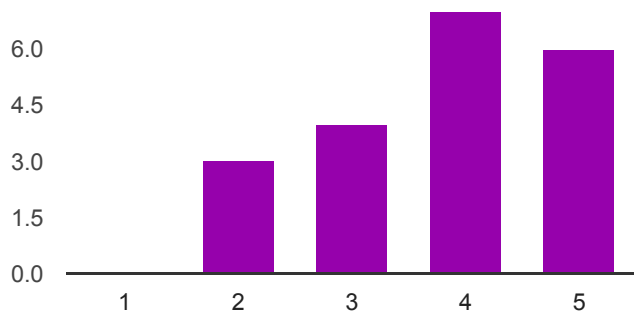
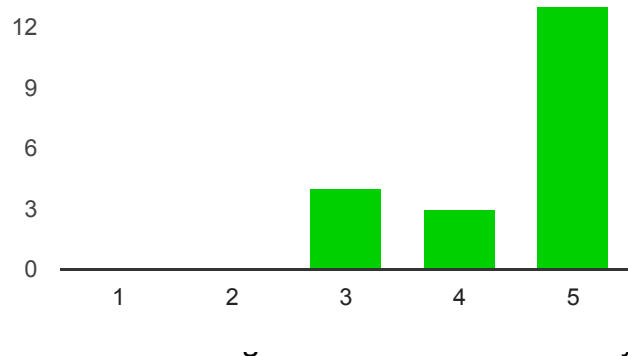
The MSRI physical facilities were conducive for such a workshop



Not at all:	1	0	0%
	2	0	0%
	3	0	0%
	4	5	25%
Very:	5	15	75%

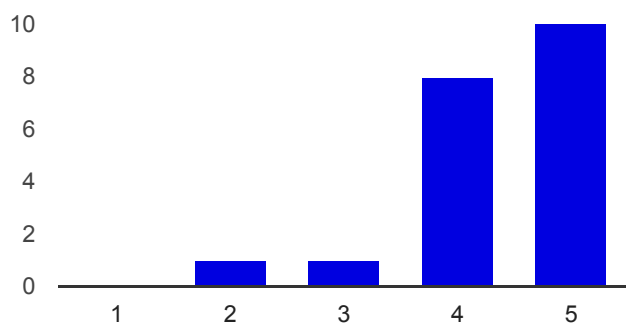
The MSRI computer facilities were adequate for such a workshop





Not at all:	1	0	0%
	2	3	15%
	3	4	20%
	4	7	35%
Very:	5	6	30%

The MSRI tea arrangements were satisfactory



Not at all:	1	0	0%
	2	1	5%

3 1 5%  
4 8 40%  
Very: 5 10 50%

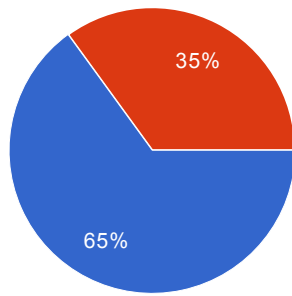
### Additional comments on the venue

Everything was really great

Great venue.

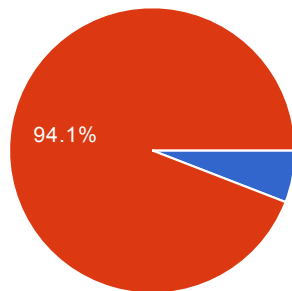
## MSRI Wireless Network

Did you use MSRI's wireless network?



Yes 13 65%  
No 7 35%

Did you experience any difficulties with the network?



Yes 1 5.9%  
No 16 94.1%

If you did experience difficulties with the network, please explain:

Occasionally slow dependent on the location.

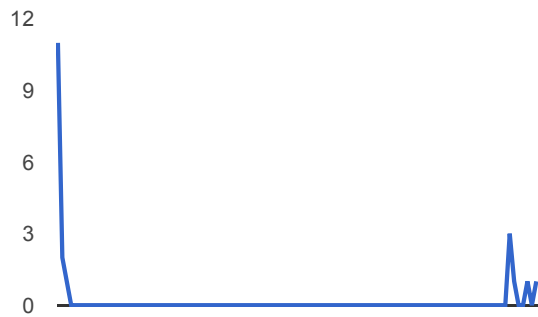
## Thank you for completing this survey

We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.

Everything was really perfect! Many thanks for organizing this amazing workshop!

Everything was really great

## Number of daily responses



**Summer Graduate School:  
Geometry and Analysis**

July 28, 2014 to August 8, 2014

MSRI, Berkeley, CA, USA

Organizers:

**Jacob Bernstein (Johns Hopkins University)**

**Hans-Joachim Hein (Imperial College, London)**

**Aaron Naber (Massachusetts Institute of Technology)**

# Summer Graduate Program in Geometry and Analysis, MSRI 2014

Jacob Bernstein, Otis Chodosh, Hans-Joachim Hein, Heather Macbeth, Aaron Naber

## 1 Introduction and Outline of Course

The purpose of the school was to provide students with some of the necessary background to understand and get involved in current research in geometric analysis, with an eye towards the 2016 geometry program at MSRI. In some areas of mathematics the best way to go about this will clearly be through hands-on research projects or presentations. In this regard the main issue with geometric analysis is the very large amount of background required. Often basic ideas that are second nature to workers in the field are not available from the usual textbooks. So we decided on a straightforward format of three lecture courses, set at different levels and geared towards different interests (Riemann Surfaces, Complex Geometry, and Geometric Analysis). Each class would meet for one hour each day of the school, and every day would be capped off with a tutorial and problem session. We were aiming for all three lecture series to start out with material familiar to a broad audience of graduate students, and to provide a shortest possible path from there to questions of current interest. Below are the testimonials of the teachers and TA's of this summer school, meant to outline the experience of each and analyze the success and failures of this summer school.

## 2 Introduction to Geometric Analysis, Naber

Let us begin with an outline of the course. The first week of the geometric analysis class consisted of a crash course of many basic objects in geometry and analysis. The week especially focused on Riemannian manifolds, estimates on heat flows and heat kernels, Harnack inequalities, and the Bakry-Emery-Ledoux estimates. The second week of the course consisted of more advanced topics, mostly related to Ricci curvature in one sense or another. This included a discussion of the splitting theorem and its effective versions, an introduction to the Gromov-Hausdorff metric, the structure theory of spaces with lower Ricci curvature bounds,  $\epsilon$ -regularity theorems for Einstein manifolds, and a less detailed overview of more recent results in the field.

The students themselves varied quite wildly in background and strength. My class was fairly well attended, though there were at most 4 or 5 students who I felt really engaged with the material and followed the technical details. In the other extreme, there were at least 10-15 who I felt had almost no background, and probably could have used a course on the basics of manifolds. Personally I found this quite challenging, in that there are conflicting urges to both lecture to as many as possible and to focus on those strong students which push the class forward. Of course in the end one tries to compromise between these two extremes. On a whole I felt the program was successful in that everyone seemed to learn something. The notes I developed during this course I continue to use and refine in both classes and other summer schools.

### 3 Introduction to Complex Geometry, Hein

The Complex Geometry class consisted of a rapid introduction to the subject in Week 1, assuming nothing more than basic complex analysis and manifold theory. In Week 2 we discussed some aspects of the Kähler-Einstein problem. My initial hopes of saying at least a few words about the Fano case turned out to be overly optimistic, but I did manage to prove much of the Calabi-Yau theorem (and a couple of students stuck around for an extra hour of lecture on the last day to see the proof of Yau's  $C^2$ -estimate). Some of the other highlights of the course were:

- the Weierstrass preparation theorem, "positivity of intersection", pathological analytic sets,
- points of indeterminacy of meromorphic functions, blowing up, resolution of singularities,
- positivity/negativity of line bundles = flexibility/rigidity of divisors = concavity/convexity of tubular neighborhoods,
- Kodaira embedding via peak sections and the use of cohomology vanishing to produce holomorphic objects,
- explicit examples of Calabi-Yau manifolds: tori and K3 surfaces, gluing constructions, Eguchi-Hanson and Taub-NUT.

Overall I tried hard to point out basic unifying principles and emphasize nontrivial concrete examples. I posted about 5 homework problems every day.

In conclusion the school was an intense, satisfying experience for me personally and has left me with a very useful set of notes and problems that I am sure others and I will use in the future - in fact I am using them right now to train my first graduate student at Maryland! I was especially pleased with one particular group of 5-6 students who appeared to be engaging deeply with the material right from the start. They were working hard on my problem sets every day (catching lots of mistakes in the process), stuck around for tutoring with either the TAs or myself, and kept sending me emails until late at night. While I did have a decent sized audience (my guess would be around 30) for the whole two weeks, and always got a couple of good questions during and after each lecture, I am less sure how engaged the other 25 really were. As a result, if I were to teach

such a school again in the future, I would probably consider toying with a more interactive format where students are assigned specific problems and presentation topics in advance.

## 4 Introduction to Riemann Surfaces, Bernstein

The course on Riemann surfaces consisted of ten lectures, one each day of the week. This was intended to be the most elementary of the three courses offered in the school and so I tried to assume as little background as possible. I mostly followed Simon Donaldson's book *Riemann Surfaces*, with the ultimate goal of presenting its proof, using complex analytic methods, of the uniformization theorem. For the last two lectures I supplemented the book with some applications of Riemann surfaces to classical minimal surface theory – for instance introducing the Weierstrass representation of a minimal surface in Euclidean three-space. This classical construction, which allows one give explicit parameterizations of any minimal surfaces in Euclidean three-space in terms of complex analytic data, continues to be extremely relevant to research in the field. For most of the lectures, I also wrote a few problems for the students that expanded on the material covered.

As this was the most elementary course, I spent the first several lectures reviewing basic concepts such as the definition of a Riemann surface as a one-dimensional complex manifold and the notion of a homomorphic map. I also briefly discussed the relationship to two-dimensional conformal geometry, but, following Donaldson, did not dwell much on this point. I next discussed calculus on a Riemann surface, in particular discussing the natural differential operators modeled on the Cauchy-Riemann operator. A notion of Poisson equation on a Riemann surface was introduced and some time was spent discussing some of the linear elliptic theory needed to analyze this equation. Using all the tools developed, I then sketched the proof of the uniformization theorem in the compact case. Finally, for the last two lectures I discussed some applications of Riemann surfaces to minimal surface theory. Specifically, I discussed the classical inequality between the energy of a map from a Riemann surface into Euclidean space and the area of its image and how this relate the variational theory of area to that of energy for surfaces. I concluded with a discussion of the classical Weierstrass representation of a minimal surface.

## 5 Problem and TA Session, Chodosh

As one of the two TA's for the MSRI summer school, my main role was to work with the students during the problem sessions, which was one hour each day. The three instructors would prepare problem sets and the students would try out the problems that they found challenging, or would simply review their notes from the day and ask questions about points where they were confused. We held the problem sessions in the large lecture hall, which allowed for several boards where

students/TA's/instructors could discuss the problems together. This format was good for allowing students to work at their own pace, but also encouraging people to discuss the problems with each other and the TA's when they were stuck.

This opportunity was crucial for several of the students, as the MSRI summer schools seem to end up with a group of students with very diverse backgrounds; as such, while some students would be interested in technical details of the lecture, there were other students who were struggling to learn basic concepts in Riemannian Geometry. The problem session format allows for students to discuss all of these topics, as well as to learn from the other students. Often, one or more of the instructors would also be around for the students to ask questions.

One of the stated goals of the summer school was to "provide graduate students with the necessary background to begin studies in the area." I feel that the problem sessions were crucial to achieving this goal; especially for students who are just starting out, it is essential to be able to work problems with immediate feedback. Moreover, several of the topics discussed in the summer school involved fields which are not usually taught at most of the student's home institutions, and are not easily learned from self-study from a book. As such, the problem sessions helped prepare the students for the study of geometric analysis.

Finally, on a personal note, I learned quite a bit myself from discussions with the lecturers, as well as several of the other students. I am sure that many of the other students also got a lot out of the program.

## 6 Problem and TA Session, Macbeth

Each day ended with a free-form problem session, generally attended by the more enthusiastic students. Exercises compiled by the instructors formed the basis for these problem sessions, and Otis Chodosh and I served as mentors.

During these sessions the students were actively studying the material from lectures, and so I had the pleasure of guiding them as they made the many small discoveries that together comprise the learning of a new subject. For instance: \* why the Poincaré-Lelong formula works \* how plurisubharmonic functions are "intermediate between" subharmonic functions and convex functions \* why the Fubini-Study metric is Einstein

Sometimes the problem session would spill over into the bus ride downhill and the dinner at Foothill, perhaps ending with a jubilant email to an instructor in the evening!

The students appeared to enjoy the lectures, and most remained engaged throughout the workshop. I myself found the workshop very rewarding, both as a mentor and as a student, and I look forward to returning to MSRI in Spring 2016 as a postdoc in the summer school's parent program.



### Organizers and Lecturers

First Name	Last Name	Institution
Jacob	Bernstein	Johns Hopkins University
Hans-Joachim	Hein	Imperial College, London
Aaron	Naber	Massachusetts Institute of Technology

### Teaching Assistants

First Name	Last Name	Institution
Otis	Chodosh	Stanford University
Heather	Macbeth	Princeton University



## Geometry and Analysis

July 28th-August 08, 2014

### Schedule

<b>Monday July 28, 2014</b>			
9:15 AM - 9:30 AM	Simons Auditorium		Intro to MSRI.
9:30 AM - 10:30 AM	Simons Auditorium	Aaron Naber	Lecture
10:30 AM - 11:00 AM	Atrium		Break
11:00 AM - 12:00 PM	Simons Auditorium	Jacob Bernstein	Lecture
12:00 PM - 2:00 PM	Atrium		Lunch Break
2:00 PM - 3:00 PM	Simons Auditorium	Jacob Bernstein	Lecture
3:00 PM - 3:30 PM	Atrium		Tea Break
3:30 PM - 4:30 PM	Simons Auditorium		TA Session

<b>Tuesday July 29, 2014</b>			
9:30 AM - 10:30 AM	Simons Auditorium	Aaron Naber	Lecture
10:30 AM - 11:00 AM	Atrium		Break
11:00 AM - 12:00 PM	Simons Auditorium	Jacob Bernstein	Lecture
12:00 PM - 2:00 PM	Atrium		Lunch Break
2:00 PM - 03:00 PM	Simons Auditorium	Joachim Heinze	Lecture
3:00 PM - 3:30 PM	Atrium		Tea Break
3:30 PM -4:30 PM	Simons Auditorium		TA Session

<b>Wednesday July 30, 2014</b>			
9:30 AM - 10:30 AM	Simons Auditorium	Aaron Naber	Lecture
11:30 AM -02:00 PM	Tilden Park		BBQ Lunch
2:00 PM - 03:00 PM	Simons Auditorium	Hans-Joachim Hein	Lecture
3:00 PM - 3:30 PM	Atrium		Tea Break
3:30 PM-4:30 PM	Simons Auditorium		TA Session

<b>Thursday July 31, 2014</b>			
9:30 AM - 10:30 AM	Simons Auditorium	Aaron Naber	Lecture
10:30 AM - 11:00 AM	Atrium		Break
11:00 AM - 12:00 PM	Simons Auditorium	Jacob Bernstein	Lecture
12:00 PM- 2:00 PM	Atrium		Lunch Break
2:00 PM - 3:00 PM	Simons Auditorium	Hans-Joachim Hein	Lecture
3:00 PM - 3:30 PM	Atrium		Tea Break
3:30 PM - 4:30 PM	Simons Auditorium		TA Session

<b>Friday Aug 01, 2014</b>			
9:30 AM - 10:30AM	Simons Auditorium	Aaron Naber	Lecture
10:30 AM - 11:00 AM	Atrium		Break
11:00 AM - 12:00 PM	Simons Auditorium	Jacob Bernstein	Lecture
12:00 PM - 2:00 PM	Atrium		Lunch Break
2:00 PM- 3:00 PM	Simons Auditorium	Hans-Joachim Hein	Lecture
3:00 PM -3:30 PM	Atrium		Tea Break
3:30 PM - 4:30 PM	Simons Auditorium		TA Session



## Geometry and Analysis

July 28th-August 08, 2014

### Schedule

<b>Monday Aug 4, 2014</b>			
9:30 AM - 10:30 AM	Simons Auditorium	Aaron Naber	Lecture
10:30 AM - 11:00 AM	Atrium		Break
11:00 AM - 12:00 PM	Simons Auditorium	Jacob Bernstein	Lecture
12:00 PM - 2:00 PM	Atrium		Lunch
2:00 PM - 3:00 PM	Simons Auditorium	Hans-Joachim Hein	Lecture
3:00 PM - 3:30 PM	Atrium		Tea Break
3:30 PM - 4:30 PM	Simons Auditorium		TA Session

<b>Tuesday Aug 5, 2014</b>			
9:30 AM - 10:30 AM	Simons Auditorium	Aaron Naber	Lecture
10:30 AM - 11:00 AM	Atrium		Break
11:00 AM - 12:00 PM	Simons Auditorium	Jacob Bernstein	Lecture
12:00 PM - 2:00 PM	Atrium		Lunch
2:00 PM - 3:00 PM	Simons Auditorium	Hans-Joachim Hein	Lecture
3:00 PM - 3:30 PM	Atrium		Tea Break
3:30 PM - 4:30 PM	Simons Auditorium		TA Session

<b>Wednesday Aug 6, 2014</b>			
9:30 AM - 10:30 AM	Simons Auditorium	Aaron Naber	Lecture
10:30 AM - 11:00 AM	Atrium		Break
11:00 AM - 12:00 PM	Simons Auditorium	Jacob Bernstein	Lecture
12:00 PM - 2:00 PM	Atrium		Lunch break
2:00 PM - 3:00 PM	Simons Auditorium	Hans-Joachim Hein	Lecture
3:00 PM - 3:30 PM	Atrium		Tea Break
3:30 PM - 4:30 PM	Simons Auditorium		TA Session

<b>Thursday Aug 7, 2014</b>			
9:30 AM - 10:30 AM	Simons Auditorium	Aaron Naber	Lecture
10:45 AM - 11:15 AM	Atrium		Break
11:00 AM - 12:00 PM	Simons Auditorium	Jacob Bernstein	Lecture
12:00 PM - 2:00 PM	Atrium		Lunch Break
2:00 PM - 3:00 PM	Simons Auditorium	Hans-Joachim Hein	Lecture
3:00 PM - 3:30 PM	Atrium		Tea Break
3:30 PM - 4:30 PM	Simons Auditorium		TA Session

<b>Friday Aug 8, 2014</b>			
9:30 AM - 10:30AM	Simons Auditorium	Aaron Naber	Lecture
10:30 AM - 11:00 AM	Atrium		Break
11:00 AM - 12:00 PM	Simons Auditorium	Jacob Bernstein	Lecture
12:00 PM - 2:00 PM	Atrium		Lunch Break
2:00 PM - 3:00 PM	Simons Auditorium	Hans-Joachim Hein	Lecture
3:00 PM - 3:30 PM	Atrium		Tea Break
3:30 PM - 4:00 PM	Simons Auditorium		TA Session

<b>Attending Students</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Niles	Armstrong	Kansas State University
Hussein	Awala	Temple University
Zach	Bailey	University of Delaware
Jacob	Bernstein	Johns Hopkins University
Armando	Cabrera Pacheco	University of Miami
Otis	Chodosh	Stanford University
John	Emanuello	Florida State University
Jonathan	Epstein	Dartmouth College
Dilan	Fernando	University of Missouri
Keegan	Flood	University of Waterloo
Stephen	Ge	University of California, Los Angeles
Curtis	Graham	Baylor University
Sheng	Guo	Ohio State University
Aldo	Guzmán Sáenz	Centro de Investigacion y de Estudios Avanzados del IPN
Chen	He	Northeastern University
Hans-Joachim	Hein	Imperial College, London
Lizzy	Huang	Duke University
Ryan	Hunter	University of Maryland
Joshua	Kaminsky	Washington State University
Jeremy	Lane	University of Toronto
Gregory	Laun	University of Maryland
Marius	Lemm	California Institute of Technology
Jennifer	Li	Louisiana State University
Jun	Li	University of Minnesota
Chris	Long	NSA - National Security Agency
Yucheng	Lu	University of California, Santa Cruz
Heather	Macbeth	Princeton University
Jeremy	Mann	University of Notre Dame
Mykola	Matviichuk	University of Toronto
Thomas	McCauley	Boston University
Isak	Mottelson	California Institute of Technology
Mayukh	Mukherjee	University of North Carolina
Aaron	Naber	Massachusetts Institute of Technology
Luca	Pallucchini	Temple University
Christopher	Policastro	University of California, Berkeley
Alberto	Raffero	Università di Torino
Daniel	Ramsay	Middle Tennessee State University
Carlos Andres	Rodriguez T.	Universidad de los Andes
Pam	Sargent	University of British Columbia
Lucius	Schoenbaum	Louisiana State University
Aleksandr	Smirnov	Louisiana State University
Selin	Taskent	State University of New York, Stony Brook
Wenda	Tu	Washington and Lee University
Changliang	Wang	University of California, Santa Barbara

<b>Attending Students</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Sean	Watson	University of California
Morgan	Weiler	University of California, Berkeley
Kwok Kin	Wong	University of Hong Kong
Chengfa	Wu	University of Hong Kong
Hang	Xu	University of California, Irvine
Yujia	Zhai	Cornell University
Boyu	Zhang	Harvard University
Ruobing	Zhang	Princeton University
Junyan	Zhu	Johns Hopkins University

## Student Statistics

<b>Total Students</b>		<b>48</b>
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<b>Gender</b>		<b>48</b>
<b>Male</b>	83.33%	40
<b>Female</b>	14.58%	7
<b>Declined to state</b>	2.08%	1

<b>Ethnicity*</b>		<b>51</b>
<b>White</b>	47.06%	24
<b>Asian</b>	37.25%	19
<b>Hispanic</b>	5.88%	3
<b>Pacific Islander</b>	0.00%	0
<b>Black</b>	0.00%	0
<b>Mixed</b>	1.96%	1
<b>Native American</b>	1.96%	1
<b>Declined to state</b>	5.88%	3

\* ethnicity specifications are not exclusive

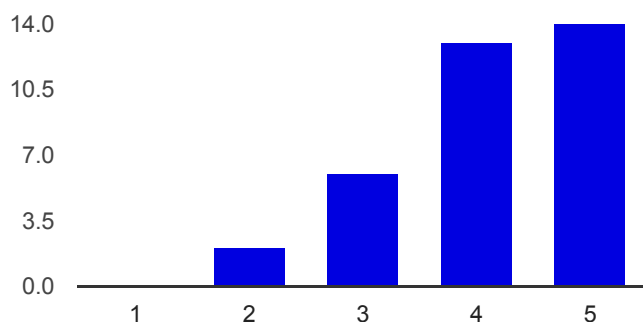
# 35 responses

35/53 = 66% response rate  
[View all responses](#)   [Publish analytics](#)

## Summary

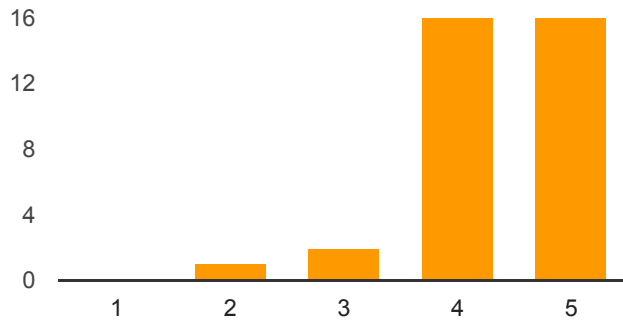
### Topic presentation and organization

The various topics within the summer school integrated into a coherent picture

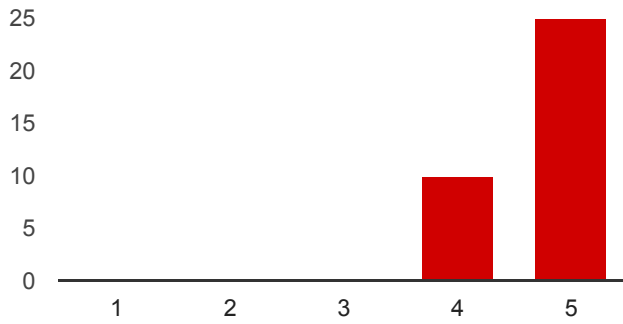


Not at all: 1	0	0%
2	2	5.7%
3	6	17.1%
4	13	37.1%
Very much: 5	14	40%

The faculty speakers were generally clear and well organized in their presentation

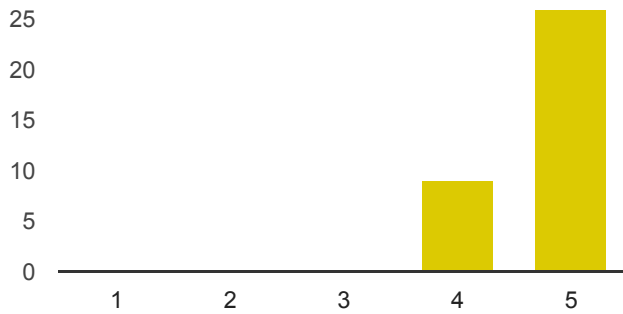


The school was intellectually stimulating



Not at all: 1	0	0%
2	0	0%
3	0	0%
4	10	28.6%
Very: 5	25	71.4%

The overall experience of the school was worthwhile

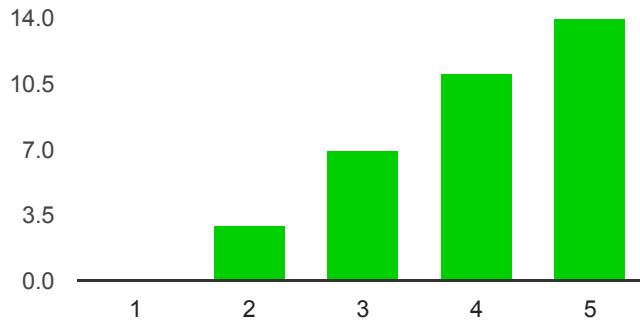


Not at all: 1	0	0%
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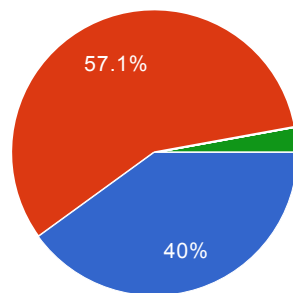
2	0	0%
3	0	0%
4	9	25.7%
Very: 5	26	74.3%

### The TA sessions were helpful



Not at all: 1	0	0%
2	3	8.6%
3	7	20%
4	11	31.4%
Very much: 5	14	40%

### The amount of material presented was:



Too much	14	40%
Just the right amount	20	57.1%
Not enough	0	0%
No opinion	1	2.9%

### Additional comments on the topic presentation and organization

n/a

none

Overall it is vary good and helpful for my study in this area.

The Riemann Surfaces course seemed to be at a much too elementary level. It did not even assume that one was familiar with the definition of a manifold, while the other two courses assumed extensive knowledge of differential geometry. This discrepancy seemed rather strange.

No

No comments here.

.

The topics were really interesting, I didn't have a great background on the subject, but I still benefited from the material presented.

I didn't expect a "Geometric Analysis" summer school will have so much focus on complex geometry, which was not my original purpose to come. I expected there will be more geometric analysis materials, but apparently there were too many complex geometry (which requires great amount of algebra knowledge). I didn't know what to choose in the last question,

None.

The TA session is very helpful! Thanks Otis a lot for his patient explanation.

Maybe we can combine with some advanced topics or organize a series of seminars in the meanwhile.

Profs. Naber and Hein were fantastic. Prof. Bernstein could use a great deal of improvement. His lectures were not nearly as polished as the others. His was supposed to be the most elementary but he seemed disinterested in presenting some of the material like the DeRahm Cohomology. Overall, it was a great program and I would recommend it to anyone.

NA

I thought the material covered was a great amount to cover in two weeks. Furthermore the Riemann Surfaces lecture was not well-prepared and the lecturer did not seem to be involved or considerably knowledgeable in that field. This lecture was supposed to be for beginners (only required a knowledge of complex analysis and basic graduate math) yet it called upon very advanced concepts to describe the material. There were also plenty of things skipped, like the fact that the syllabus listed De Rham cohomology as a days lecture. The only thing the lecturer really said about it was "If you don't know what this is, ask a friend". The other two talks were too advanced for me and I knew ahead of time that I would not really understand them. I realize now that the lectures all required much more of a foundation than I thought I had.

I felt that the Ricci curvature lectures were very well organized and presented, but didn't fit in with the other two that well. The complex geometry lectures got too advanced too

quickly, and the Riemann surfaces lecture was less well-organized than the other two.

The topics were very advanced and moved quickly. But overall, the presentations were very good.

The lectures were very well prepared, and the structure was set up in such a way as to encourage the students to discuss among themselves. Quite a good experience.

Very wonderful experience for me!

Aaron Naber was an excellent presenter!

The relationships of the three parallel sections are not emphasized.

It was great. The topics are very interesting. Personally, I think the Riemann surface course could be faster.

The course of Professor Hein was very helpful. I learnt a lot from it, the presentation was well organized, and the exercises were quite stimulating.

I enjoyed all of the lectures at this summer school. The TA sessions were helpful. I enjoyed working on the problem sets.

I think overall the topics were interesting and important. Nevertheless, even though some of us were advanced grad students, sometimes we were not familiar with the topics presented. I was expecting that the first week was going to be a complete introduction (basic notions and motivation) directed to those that are not familiar with the topics, and in the second week go faster and do things for those who are working on the field. Also, I think it is important to point out that I am disappointed by the course of Riemann Surfaces (which was supposed to be an introductory course). The lecturer seemed not to be very familiar with the topics, and sometimes, that he didn't even like the topics. At some point it seemed that he was just reading the book for us without being familiar with it. I was expecting a lot more from this course, at the end it turned out to be too informal for an advanced grad student and too confusing for a beginner grad student. I think the lecture in Riemannian Geometry was really good, the exposition was clear even for those who doesn't work in Riemannian Geometry and Analysis. The Complex Geometry lecture was also very good and I think it was perfect for someone that already knows complex geometry. In my case, this was my first formal exposition to this field, and although I learned many things the first days, I think I would have learned more if the topics were given slower or maybe avoiding some technical concepts. Sometimes the instructors assume we are familiar with the topics, but many of us don't. I suggest there should be more explanation and details. Some of the instructors speak too fast to follow by non-native speaker.

Professor Naber and Professor Hein were great. I thought Professor Bernstein was terrible. He mumbled through his lectures, he made numerous errors at the board, and his lectures just followed the text he assigned. Moreover, he consistently gave the impression that he did not want to give his lectures.

My answers are restricted to the topics that I was intending to benefit from, with the exception of the coherent picture question.

Thanks a lot

The topics were well presented.

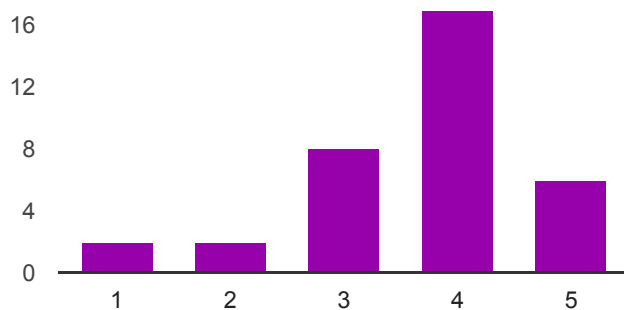
Aaron Naber's and Hans-Joachim Hein's lectures were extremely clear, well-paced and interesting.

N/A

Topic and presentation was great overall. I was impressed with the clarity of several of the lectures.

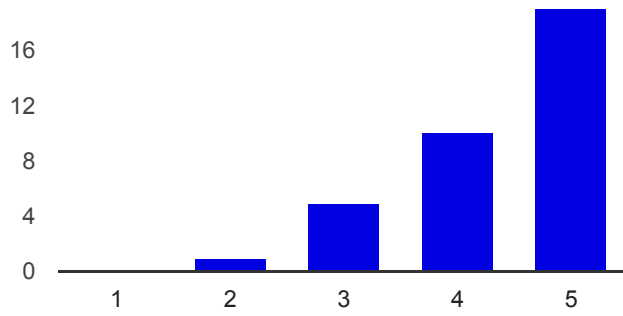
## Personal assessment

I was well prepared to benefit from the school

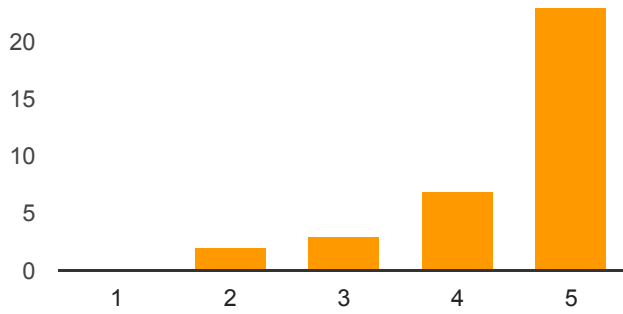


Not at all: 1	2	5.7%
2	2	5.7%
3	8	22.9%
4	17	48.6%
Very: 5	6	17.1%

My interest in the subject matter was increased by the school

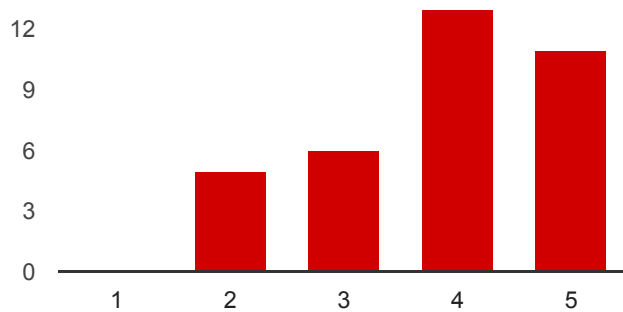


The center helped the most people with similar academic interests



Not at all: 1	0	0%
2	2	5.7%
3	3	8.6%
4	7	20%
Very much: 5	23	65.7%

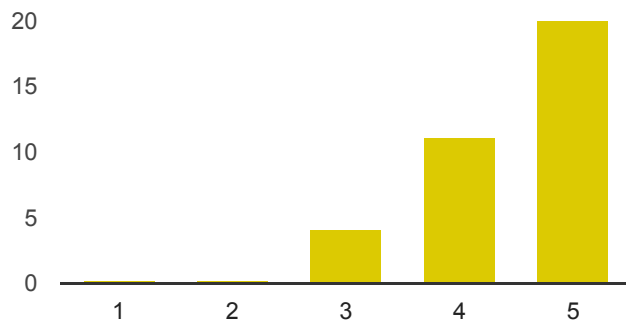
It is likely that I will work in the area of the school subject in the future



Not at all: 1	0	0%
2	5	14.3%

3	6	17.1%
4	13	37.1%
Very: 5	11	31.4%

How would you evaluate your interaction with other participants?



not satisfactory: 1	0	0%
2	0	0%
3	4	11.4%
4	11	31.4%
above satisfactory: 5	20	57.1%

### Additional comments on your personal assessment

No comment

I liked to meet with the other students. They are smart and interesting. I had a great time hanging out and discussing math with them.

None.

The people I met here were/are awesome. I was able to find out a lot more information about what kind of classes I should take, what books to buy and overall what sorts of things I can study/research. The guidance I received from the other students was unique to this sort of program because I find the people in my own department to be narrow-minded. Talking to people from all the other universities changed my perspective on graduate school, for the better.

I really enjoyed interacting with the other participants. It was great to meet a lot of other mathematicians.

I was surprised by the diversity found in this summer school. I was thinking that everyone was going to be an expert in the field but it seemed that most of the people were just somehow related to the fields but not actually working in it, which was a nice surprise and I think it adds important features to this summer schools. For the same

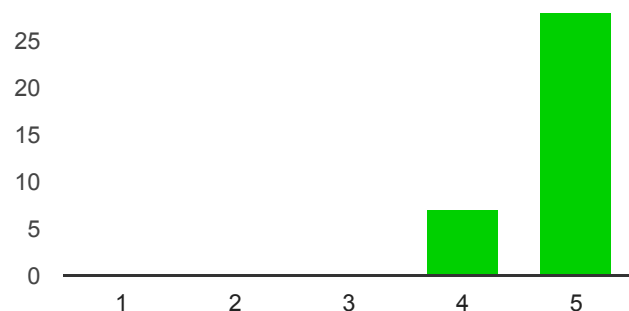
reason, I think the first week should be completely introductory. Even though we had seen some of the topics before, as a grad student, I don't mind at all to review some topics, we usually understand details that we missed before.

The above questions are answered with respect to all lectures.

I come from a different background and hoped to get a first almost-research level exposure to the field. This was what I got.

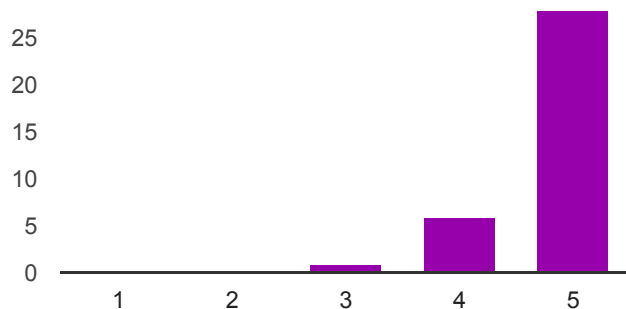
## MSRI Venue

I found the MSRI staff helpful



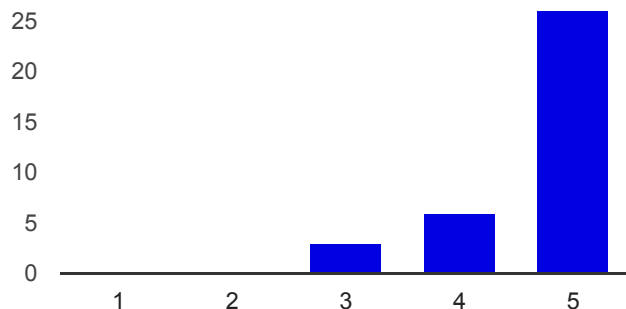
Not at all:	1	0	0%
	2	0	0%
	3	0	0%
	4	7	20%
Very:	5	28	80%

The MSRI physical facilities were conducive for such a school



Not at all: 1	0	0%
2	0	0%
3	1	2.9%
4	6	17.1%
Very: 5	28	80%

### The MSRI computer facilities were adequate for such a school



Not at all: 1	0	0%
2	0	0%
3	3	8.6%
4	6	17.1%
Very: 5	26	74.3%

### Additional comments on the MSRI venue

No comment.

None.

Thanks Linda for the nice library orientation.

The MSRI venue is excellent!

Everything was really great. The only thing which bothered me was that the last bus downhill was at 7.15, so I could not stay for longer to work. But I understand that there may be hard to do anything about it.

I enjoyed the MSRI facility very much. Without a doubt it is the nicest and most beautiful facility I have ever seen for mathematical research and dissemination. Right now on the MSRI calendar there is a program I plan to attend. Having gotten familiar with the facilities at MSRI during this summer school will help me focus on the mathematics I am studying when I come back. Thank you for having me!

The above are not full marks only because I didn't make use of the respective

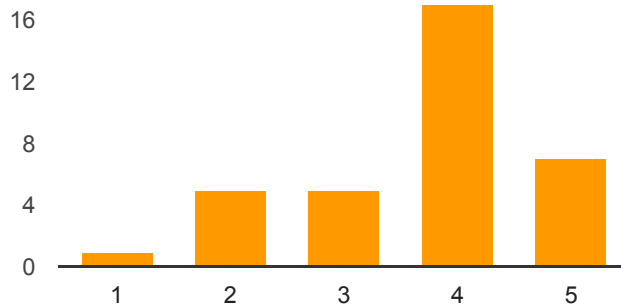


services/facilities

Perfection.

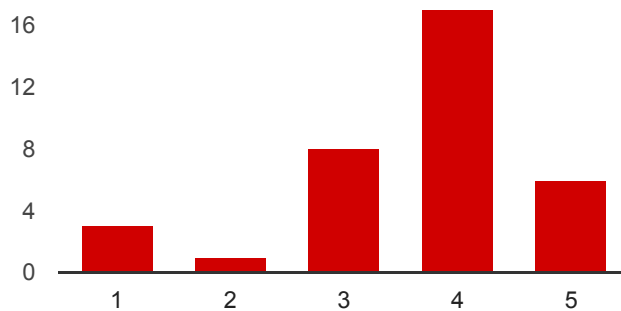
## Accommodation and Food

The summer school accommodation



not satisfactory:	1	1	2.9%
	2	5	14.3%
	3	5	14.3%
	4	17	48.6%
above satisfactory:	5	7	20%

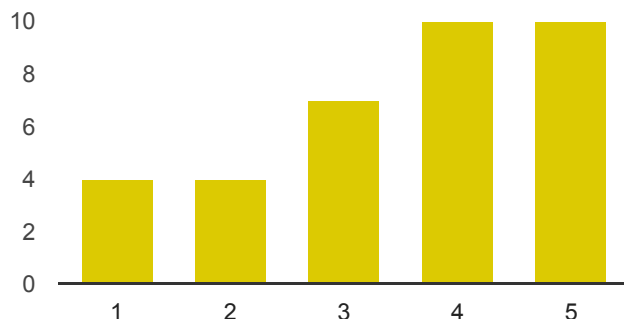
The food at the dormitories



not satisfactory:	1	3	8.6%
	2	1	2.9%
	3	8	22.9%

4 17 48.6%  
 above satisfactory: 5 6 17.1%

### The food provided at MSRI



not satisfactory: 1 4 11.4%  
 2 4 11.4%  
 3 7 20%  
 4 10 28.6%  
 above satisfactory: 5 10 28.6%

### Additional comments on accommodation and food

There is no other way to say this. The the food was shit.

No comment

None.

No food left if come fifteen minutes late for lunch at msri. Maybe providing more salads is better.

The dorms were fine, and fun to stay in. The food at the dining hall was miserable, as is to be expected from a college dining hall. The catering at MSRI on the other hand was kind of strange. I feel like the cooks chose strange dishes to serve or strange ways to prepare them. More often than not they would drench their dishes in grease and salt, making them unpalatable and often ran out of vegetarian/vegan options. I understand they need to cook for ~50 people but still, there are better ways to prepare the food and better options.

I really appreciate that MSRI provided vegetarian options daily. Also, the Foothill dorms and dining were very nice.

The food was mostly terrible and the dorms worse.

Usually I couldn't get enough food for lunch during the summer school, is it possible for

you to provide some more food in the future? Thanks!

The dormitory beds were very comfortable, however, there was no coffeemaker in the dormitory rooms. I asked the desk at Stern Hall if I could have a coffeemaker during my two-week stay but they said that none was available. The coffee in the cafeteria was not very good. The nearest coffeeshops and restaurants are a few blocks downhill on Euclid street. If I were ever to do this again, I will be sure to bring plenty of socks and good walking shoes. The food at MSRI was great. Good bread pudding and helpful service. Although I was expecting something more comfortable than college dorms, I think it is perfectly fine if this allows more students to enjoy this experience. The only complain I have is that the staff at the Foothill residences didn't seem to be taking care of the cleaning (of the bathrooms specially). They smelled really bad and the cleaning was really difficult to notice, I could only noticed that they took out the garbage from the bathroom. I am not used to share bathrooms, but I would expect that a bathroom with several users should be cleaned carefully everyday.

The dorms were pretty bad. The trash was never emptied. The linens were not changed. It was really inconvenient that the dorms did not have a refrigerator.

Please no too much spicy food

Thanks to MSRI for all the great food!

## **Thank you for completing this survey**

We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.

No comment.

I will appreciate that MSRI could provide more summer schools on analysis in the future. I remember the last time MSRI provided analysis summer school (on MSRI) were 3 years ago. And I actually have been waiting for 3 years for this summer school.

None.

Aside from the food this is one of the best trips I've been on.

I really enjoyed this program. Although the lecture material was very fast-paced, the lecturers were enthusiastic and it was exciting to see several areas in math come together. Many thanks to Christine Marshall, Jacari Scott, and the other program staff who helped make this a great two week stay!

MSRI is an amazing place! I really hope to come back again soon.

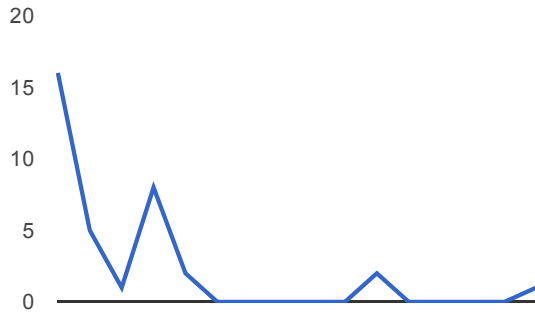
It would be nice to have the list of students (and e-mails) available online. It helps to communicate with each other during and after the school.

I liked this experience very much and for sure I will return if I have the chance. I think there are some details that could be improved, but in general it was a really nice

experience. Thank you to the MSRI organization for all this effort to give us this opportunities.

I had a great time, thanks! The dorms were a little grungy, but nothing too bad.

## Number of daily responses



**Summer Graduate School:  
Dispersive Partial Differential  
Equations**

June 16, 2014 to June 27, 2014

MSRI, Berkeley, CA, USA

Organizers:

**Natasa Pavlovic (University of Texas)**

**Nikolaos Tzirakis (University of Illinois at Urbana-Champaign)**

**FINAL REPORT ON THE MSRI SUMMER SCHOOL  
“DISPERSIVE PARTIAL DIFFERENTIAL EQUATIONS”,  
JUNE 16-27, 2014**

NATAŠA PAVLOVIĆ AND NIKOLAOS TZIRAKIS

We present a report on the summer school that we organized at the MSRI in the period June 16-27, 2014. In particular, after describing the goals of the summer school, we discuss the organization of the activities that took place during the school, followed by a description of the scientific content that was covered. We finish the report by discussing accomplishments.

1. GOALS OF THE SUMMER SCHOOL

The purpose of the summer school was to introduce graduate students to recent developments in the area of dispersive partial differential equations (PDE). Dispersive PDE is a very active area of Mathematical Analysis and PDE and has received a lot of attention from mathematicians due to its various applications to nonlinear optics, water wave theory and plasma physics to name a few. The main goal of the summer school was to present important but introductory results that were achieved in the last 30 years in the area. We tried to accommodate the interest of students who were at different stages in their studies and were working on different fields of Analysis and PDE. Although many students were working on dispersive PDE already, a sizable number of students had research interests that were not directly related to disperse PDE. We were prepared for this fact since we were told that the participants will have different mathematical backgrounds - this information was very helpful to us when we designed the activities and scientific content of the summer school. In order to accommodate such a diverse audience, we also presented some recent developments in the area and described the main challenges in the field. Our idea here was to inspire more advanced students who were already working on disperse PDE, to help them tackle some hard questions in their current and future research activities.

Our hope was that after participating in the summer school, students might express interest in attending some of the scientific activities related the program “*Deterministic and Probabilistic Challenges in Nonlinear Dispersive Equations*” that will take place at the MSRI in the Fall of 2015.

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*Date:* July 27, 2014.

The work of N.P. is supported in part by NSF grant DMS-1101192.

The work of N.T. is supported in part by University of Illinois Research Board Grant RB-14054. Both authors are thankful to the MSRI staff for all help in organizing the workshop.

## 2. STRUCTURE OF THE SCHOOL

The school consisted of the following three types of activities:

(1) **Lectures:**

Every day of the summer school started with two lectures, taught by either Pavlović or Tzirakis. The content of the lectures was split in the following three courses:

- Part I on basic theory for local and global analysis of the semi-linear Schrödinger equation.
- Part II on local and global theory for the Korteweg de Vries equation.
- Part III on a derivation of nonlinear dispersive equations from quantum many body systems.

We describe scientific content of each part in Section 3. Each part was accompanied by lecture notes that Pavlović and Tzirakis prepared and made available to participants of the school.

(2) **Problem sessions:**

They were organized and taught by teaching assistants Seckin Demirbas (of the University of Illinois at Urbana-Champaign) and Zhihui Xie (of the University of Texas at Austin). Each session was an hour long and took place in the afternoon on a daily basis (except on the last day of the summer school). The content was closely related to the material that was covered in lectures. The TAs worked out details of the relevant classical problems. However they encouraged students to actively participate, to ask questions and give suggestions about methods and techniques that were to be used.

(3) **Group work:**

On the first day of the school, we split students into six groups. There were approximately eight students in each group. The splitting was pretty random, using the alphabetic order of last names, which contributed to diversity of student's scientific interests in each group. Each group was assigned one topic from the attached list of topics/papers. They met on a daily basis to study the assigned topic (we reserved an hour in the schedule, however that was just a fraction of the time that each group devoted for the group work; they also met during breaks as well as in the evenings). We encouraged students to first understand the relevance of the paper and the context in which it appears, and then to focus on details. The goal was to understand the paper well enough so that each group can present a 15 minute talk and prepare a poster on the paper. All four of us (instructors and TAs) were available to answer questions related to papers. While we were happy to offer suggestions, and answer questions, we tried not to influence the structure of presentations/posters that groups prepared. The presentations took place in the afternoon of the last day of the summer school, and were followed by the poster session. The group work component of the summer school contributed significantly to the success of the summer school (more details are provided in Section 4) to the effect that we plan

to incorporate such a component to every summer school/program that we plan to organize in the future!

### 3. SCIENTIFIC CONTENT

Here we outline the scientific content of the summer school, that was covered in lectures, problem sessions and which was related to topics that students studied in groups. As we mentioned above, the material was divided in the following three courses:

#### **Part I** - 10 lectures

This was the introductory part of the course that focused on presenting questions of interest when studying dispersive PDE. We basically described important but basic techniques that answer some of those questions. However along the way we offered comments on how this material relates to current research directions, in an effort to keep the attention of the students who were already working in the field. We started by discussing what dispersion means, followed by a study of the Cauchy problem for the Schrödinger equation. After deriving the explicit formula for the solution to the linear equation, we discussed basis properties of the solution to the linear equation, including dispersive and Strichartz estimates. That was followed by an introduction to the semi-linear Schrödinger equation - in that context we reviewed symmetries of the equation, with an emphasis on scaling symmetry and its interpretations. Then we presented global well-posedness of classical solutions, followed by a detailed discussion of well-posedness in the energy space for energy sub-critical problems, followed by brief discussions of well-posedness results for respectively  $L^2$ -subcritical and critical equations. Morawetz type estimates were presented in detail, including both one particle and two particle interaction estimates. We concluded this part of the course by offering some applications of the virial and Morawetz estimates. In particular, we discussed blow-up results for the energy sub-critical and mass super-critical focusing problem, global well-posedness for the  $L^2$ -critical problem (defocusing problem under the finite variance assumption and a criteria that gives global well-posedness for the focusing problem) and quantum scattering in the energy space for the defocusing  $L^2$ - supercritical problem.

#### **Part II** - 8 lectures

In the second part of the lectures we studied dispersive PDE having nonlinearities of derivative type. For pedagogical reasons and in order to make our presentation self contained we focused on the Korteweg de Vries (KdV) equation which shares a bilinear derivative nonlinearity. We should note that the methods we developed can be employed in a large class of dispersive PDE. In this section we also discussed in details the initial value problem with periodic boundary conditions. Our first lecture described local existence and uniqueness results for smooth solutions of the KdV equation. Our approach did not distinguish between problems posed on the real line



or the torus. We employed the energy method which is based on a priori bounds that a formal solution satisfies along with ideas from standard parabolic regularization theory. Next we specialized on the real line where the equations are strongly dispersive and obtained well-posedness results for rough initial data, combining techniques from Part I (Strichartz estimates), smoothing dispersive estimates and maximal function estimates from Harmonic Analysis. This method is well adapted to nonlinearities of arbitrary order that include derivatives. For bilinear nonlinearities (which is the KdV case) we introduced a new scale of spaces and a new method which is called the restricted norm method of Bourgain. We proved almost optimal results for both the real line and the circle (periodic problem). Finally we introduced the method of normal forms which somehow simplifies the well-posedness theory of the periodic KdV. In particular we showed how one can obtain unconditional uniqueness for rough solutions by eliminating the derivative nonlinearity in some sense. The method is based on a careful analysis of the resonant and the non resonant nonlinear terms of the equation. In the last lecture we offered some recent applications of the previously developed theory. We showed for example the connections between periodic dispersive PDE and some questions coming from number theory and physics while in particular we discussed smoothing estimates, dispersive quantization effects and the Talbot phenomenon.

### Part III - 2 lectures

The derivation of nonlinear dispersive PDE, such as the nonlinear Schrödinger or nonlinear Hartree equations, from many body quantum dynamics is central topic in mathematical physics, which has been approached by many authors in a variety of ways. In particular, one way to derive NLS is via the Gross-Pitaevskii (GP) hierarchy, which is an infinite system of coupled linear non-homogeneous PDE. The most involved part in such a derivation of NLS consists in establishing uniqueness of solutions to the GP. That was achieved in the seminal papers of Erdős-Schlein-Yau. Recently, Chen, Hainzl, Pavlović and Seiringer gave a new, simpler proof of the unconditional uniqueness of solutions to the cubic Gross-Pitaevskii hierarchy in  $\mathbb{R}^3$  based on the quantum de Finetti theorem.

In this part of the course, we discussed the derivation of NLS via the GP, including a brief review of the work of Erdős-Schlein-Yau and of the work of Klainerman-Machedon on uniqueness for the GP via PDE techniques, and then described main ideas of the new proof of uniqueness of solutions to the GP via the quantum de Finetti theorem. In this proof, the quantum de Finetti theorem was employed as a bridge between the NLS and the GP hierarchy and hence, in such a way, we connected our exposition to the Part I of the course.

## 4. ACCOMPLISHMENTS

We interpret as a success the fact that students showed strong interest in the ideas we discussed and were actively engaged during the entire two weeks of the summer school. They had many questions related to the material that was presented in the

lectures and problem sessions. Also students asked questions beyond the material discussed in the course, and wanted to investigate research directions that relate dispersive PDE with topics of their PhD theses, some of which are in different areas (e.g. kinetic equations, equations of fluid dynamics).

The group work was a huge success and helped the students to deepen their knowledge on concrete research topics in dispersive PDE. Students worked very hard and spent numerous hours understanding not only the paper that was assigned to their group but also references and the context in which the paper appeared. The emphasis was on the “global picture”, however technical details were mastered too. Their presentations on the last day of the summer school were superb. Many senior researchers could envy them on how well they prepared their 15 minutes presentations. Often they used posters to complement what was discussed in presentations, which was quite useful.

Although all of us (organizers, TAs as well as every single participant) invested serious efforts in the summer school, the atmosphere of the summer school was cheerful. The staff members at the MSRI were amazing and made all our wishes come true - for example the help they offered to students in preparing the poster session was instrumental.

At the end let us mention that both Pavlović and Tzirakis were quite surprised to receive “thank you” cards signed by all students at the last day of the summer school. Although each of us was involved with organizing other summer schools in the past, we have never witnessed such an enthusiasm and the sense of community among graduate students participating at a summer school.

N. PAVLOVIĆ, DEPARTMENT OF MATHEMATICS, UNIVERSITY OF TEXAS AT AUSTIN.

*E-mail address:* `natasa@math.utexas.edu`

N. TZIRAKIS, UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN.

*E-mail address:* `tzirakis@math.uiuc.edu`

<b>Organizers and Lecturers</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Natasa	Pavlovic	University of Texas
Nikolaos	Tzirakis	University of Illinois at Urbana-Champaign

<b>Teaching Assistants</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Seckin	Demirbas	University of Illinois at Urbana-Champaign
Zihui	Xie	University of Texas



## Dispersive Partial Differential Equations

June 16-June 27, 2014

### Schedule

Monday June 16, 2014			
9:30 AM - 10:00 AM	Simons Auditorium		Intro to MSRI. Intro to the summer school
10:00 AM - 10:45 AM	Simons Auditorium	Natasa Pavlovic	What is a dispersive PDE. The fundamental solution to the linear Schrödinger equation. Dispersive estimates
10:45 AM - 11:15 AM	Atrium		Break
11:15 AM - 12:00 PM	Simons Auditorium	Natasa Pavlovic	Strichartz estimates
12:00 PM - 2:00 PM	Atrium		Lunch
2:00 PM - 3:00 PM	Simons Auditorium		TA Session
3:00 PM - 3:30 PM	Atrium		Tea Break
3:30 PM - 4:30 PM	Simons Auditorium		Intro to Group Work

Tuesday June 17, 2014			
10:00 AM - 11:30 AM	Simons Auditorium	Natasa Pavlovic	Intro to NLS: what is a solution; symmetries of the NLS
10:45 AM - 11:15 AM	Atrium		Break
11:15 AM - 12:00 AM	Simons Auditorium	Natasa Pavlovic	Local well-posedness for smooth solutions
12:00 PM - 2:00 PM	Atrium		Lunch
02:00 AM - 03:00 PM	Simons Auditorium		TA Session
3:00 PM - 3:30 PM	Atrium		Tea Break
3:30 PM - 4:30 PM	Simons Auditorium		Group Work

Wednesday June 18, 2014			
10:00 AM - 10:30 AM	Simons Auditorium	Natasa Pavlovic	Local well-posedness for the energy subcritical problem in the energy space
11:30 AM - 02:00 PM	Tilden Park		BBQ Lunch
02:00 PM - 03:00 PM	Simons Auditorium		TA Session
3:00 PM - 3:30 PM	Atrium		Tea Break
3:30 PM - 4:30 PM	Simons Auditorium		Group Work

Thursday June 19, 2014			
10:00 AM - 10:45 AM	Simons Auditorium	Nikolaos Tzirakis	The defocusing NLS. Introduction to energy scattering. Virial Identities
10:45 AM - 11:45 AM	Atrium		Break
11:15 AM - 12:00 PM	Simons Auditorium	Nikolaos Tzirakis	Interaction Morawetz estimates.
12:00 PM - 2:00 PM	Atrium		Lunch
2:00 PM - 3:00 PM	Simons Auditorium		TA Session
3:00 PM - 3:30 PM	Atrium		Tea Break
3:30 PM - 4:30 PM	Simons Auditorium		Group Work

Friday June 20, 2014			
10:45 AM - 10:45 AM	Simons Auditorium	Natasa Pavlovic	The focusing NLS. Blow-up of solutions. A criteria for the existence of global-in-time solutions
10:45 AM - 11:15 AM	Atrium		Break
11:15 AM - 12:00 PM	Simons Auditorium	Nikolaos Tzirakis	Scattering in the energy space for the energy sub-critical problem. Scattering in other spaces
12:00 PM - 2:00 PM	Atrium		Lunch
2:00 PM - 3:00 PM	Simons Auditorium		TA Session
3:00 PM - 3:30 PM	Atrium		Tea Break
3:30 PM - 4:30 PM	Simons Auditorium		Group Work

<b>Monday June 23, 2014</b>			
10:00 AM - 10:45 AM	Simons Auditorium	Nikolaos Tzirakis	The initial value problem for the KdV equation. The energy method
10:45 AM - 11:15 AM	Atrium		Break
11:15 AM - 12:00 PM	Simons Auditorium	Nikolaos Tzirakis	The Keing-Ponce-Vega method on R
12:00 PM - 2:00 PM	Atrium		Lunch
2:00 PM - 3:00 PM	Simons Auditorium		TA Session
3:00 PM - 3:30 PM	Atrium		Tea Break
3:30 PM - 4:30 PM	Simons Auditorium		Group Work

<b>Tuesday June 24, 2014</b>			
10:00 AM - 10:45 AM	Simons Auditorium	Nikolaos Tzirakis	The restricted norm method of Bourgain
10:45 AM - 11:15 AM	Atrium		Break
11:15 AM - 12:00 PM	Simons Auditorium	Nikolaos Tzirakis	The restricted norm method of Bourgain continued. Local and global well posedness in $L^2$
12:00 PM - 2:00 PM	Atrium		Lunch
2:00 PM - 3:00 PM	Simons Auditorium		TA Session
3:00 PM - 3:30 PM	Atrium		Tea Break
3:30 PM - 4:30 PM	Simons Auditorium		Group Work

<b>Wednesday June 25, 2014</b>			
10:00 AM - 10:45 AM	Simons Auditorium	Nikolaos Tzirakis	The periodic KdV. Periodic Strichartz estimates
10:45 AM - 11:15 AM	Atrium		Break
11:15 AM - 12:00 PM	Simons Auditorium	Nikolaos Tzirakis	Local Well-Posedness for rough data. The $X_{s,b}$ function space
12:00 PM - 2:00 PM	Atrium		Lunch break
2:00 PM - 3:00 PM	Simons Auditorium		TA Session
3:00 PM - 3:30 PM	Atrium		Tea Break
3:30 PM - 4:30 PM	Simons Auditorium		Group Work

<b>Thursday June 26, 2014</b>			
10:00 AM - 10:45 AM	Simons Auditorium	Nikolaos Tzirakis	Normal form methods and nonlinear smoothing on T
10:45 AM - 11:15 AM	Atrium		Break
11:15 AM - 12:00 PM	Simons Auditorium	Nikolaos Tzirakis	Dispersive Quantization and the Talbot effect
12:00 PM - 2:00 PM	Atrium		Lunch
2:00 PM - 3:00 PM	Simons Auditorium		TA Session
3:00 PM - 3:30 PM	Atrium		Tea Break
3:30 PM - 4:30 PM	Simons Auditorium		Group Work

<b>Friday June 27, 2014</b>			
10:00 AM - 10:45 AM	Simons Auditorium	Natasa Pavlovic	Derivation of the NLS from quantum many body systems
10:45 AM - 11:15 AM	Atrium		Break
11:15 AM - 12:00 PM	Simons Auditorium	Natasa Pavlovic	On the uniqueness of solutions to the Gross-Pitaevskii hierarchy
12:00 PM - 1:30 PM	Atrium		Lunch
1:30 PM - 3:30 PM	Simons Auditorium		Poster Session
3:30 PM - 4:00 PM	Simons Auditorium		Tea Break

<b>Attending Students</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Diana	Atanasova	Boston University
Marc	Carnovale	Ohio State University
Xianghong	Chen	University of Wisconsin
Laura	Cladek	University of Wisconsin
Erin	Compaan	University of Illinois at Urbana-Champaign
Eric	Cooper	Boston University
Simon	Dieckmann	Universitat Bielefeld
Emily	Fagerstrom	University at Buffalo (SUNY)
Wen	Feng	University of Kansas
Peng	He	University of Pittsburgh
Jin Woo	Jang	University of Pennsylvania
Estapraq	Kahlil	University of Oklahoma
Yeon Eung	Kim	National Institute for Mathematical Sciences
Dohyun	Kwon	National Institute for Mathematical Sciences
Ruomeng	Lan	Texas A & M University
Nathan	Lanfear	Arizona State University
Grace	Liu	University of California, Berkeley
Bingying	Lu	University of Michigan
Chenyun	Luo	Johns Hopkins University
Vincent	Martinez	Indiana University
Kevin	Mather	University of British Columbia
Domonic	Mei	University of Massachusetts, Amherst
Matthew	Michal	New Jersey Institute of Technology
Michael	Music	University of Kentucky
Pei	Pei	Earlham College
Monika	Pichler	University at Buffalo (SUNY)
Dimitrios	Roxanas	University of British Columbia
Kevin	Schenthal	University of California, Davis
Alessandro	Selvitella	McMaster University
Beniada	Shabani	Stanford University
Yusuke	Shimabukuro	McMaster University
Brian	Streit	Baylor University
Nils	Strunk	Universität Bielefeld
Katie	Switzer	Texas A & M University
Changhui	Tan	University of Maryland
Ryan	Thompson	University of Notre Dame
Patrick	Torres	Washington State University
Jeremy	Trageser	University of Nebraska
Son	Van	Miami University
Xiang	Wan	University of Virginia
Klaus	Widmayer	New York University, Courant Institute
Samantha	Xu	University of California, Los Angeles
Kazuo	Yamazaki	Oklahoma State University
Kai	Yang	University of Iowa
Zihui	Zhao	University of Washington
Changwei	Zhou	Binghamton University (SUNY)

## Student Statistics

<b>Total Students</b>		<b>46</b>
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<b>Gender</b>		<b>46</b>
<b>Male</b>	69.57%	32
<b>Female</b>	30.43%	14
<b>Declined to state</b>	0.00%	0

<b>Ethnicity*</b>		<b>48</b>
<b>White</b>	50.00%	24
<b>Asian</b>	45.83%	22
<b>Hispanic</b>	0.00%	0
<b>Pacific Islander</b>	2.08%	1
<b>Black</b>	0.00%	0
<b>Mixed</b>	2.08%	1
<b>Native American</b>	0.00%	0
<b>Declined to state</b>	0.00%	0

\* ethnicity specifications are not exclusive

# 38 [responses](#)

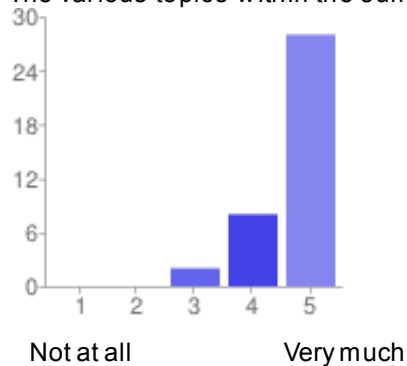
38 responses / 46 students = 83% response rate

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## Summary [See complete responses](#)

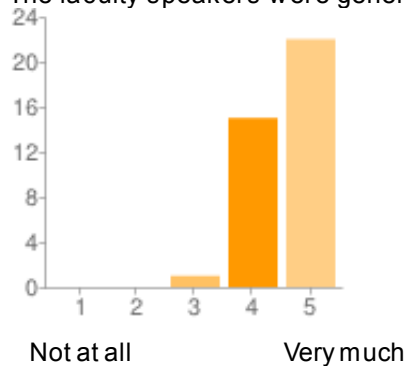
### Topic presentation and organization

The various topics within the summer school integrated into a coherent picture



1 - Not at all	0	0%
2	0	0%
3	2	5%
4	8	21%
5 - Very much	28	74%

The faculty speakers were generally clear and well organized in their presentation

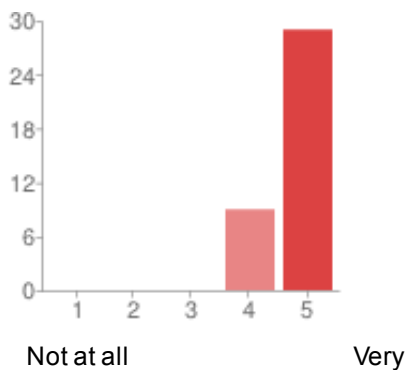


1 - Not at all	0	0%
2	0	0%
3	1	3%
4	15	39%
5 - Very much	22	58%

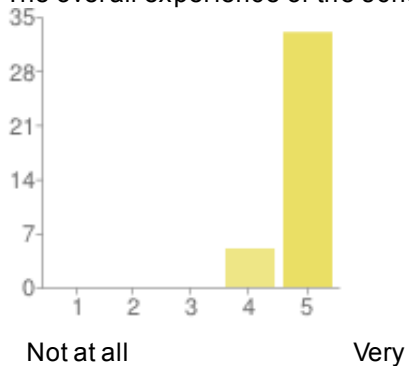
The school was intellectually stimulating

1 - Not at all	0	0%
2	0	0%
3	0	0%
4	9	24%
5 - Very	29	76%



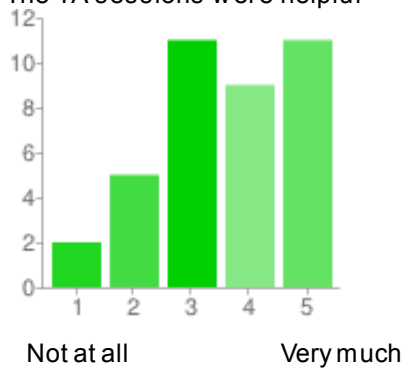


The overall experience of the school was worthwhile



1 - Not at all	0	0%
2	0	0%
3	0	0%
4	5	13%
5 - Very	33	87%

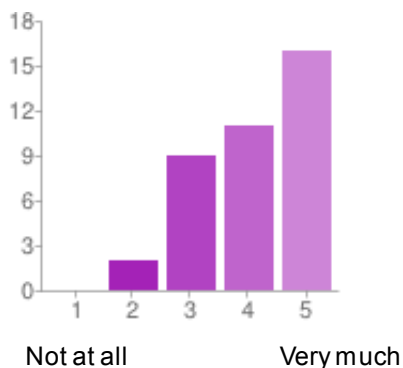
The TA sessions were helpful



1 - Not at all	2	5%
2	5	13%
3	11	29%
4	9	24%
5 - Very much	11	29%

The group work / poster session was a beneficial component of the program

1 - Not at all	0	0%
2	2	5%
3	9	24%
4	11	29%
5 - Very much	16	42%



The amount of material presented was:



Too much	1	3%
Just the right amount	31	82%
Not enough	6	16%
No opinion	0	0%

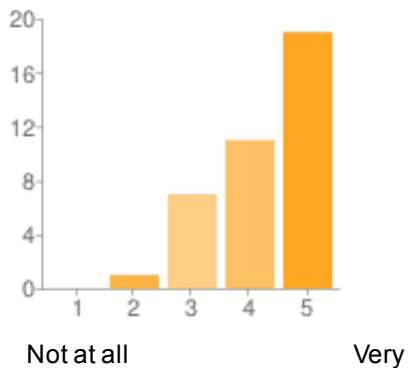
### Additional comments on the topic presentation and organization

It was good Very nice summer school. I learned a lot. Thanks a lot to Natasa and Nicolaos. \* The time allowed for student presentation is relatively small. N/A One of the best summer schools/workshops I have ever attended. The lectures were incredible; they were well-prepared, insightful, wonderfully motivated, and presented at a gratefully approachable level. The security of having lecture notes provided as well as recordings of the lectures was also very reassuring and something I will undoubtedly take advantage of in the future. Don't cover up blackboards Notes very helpful I think break tim ...

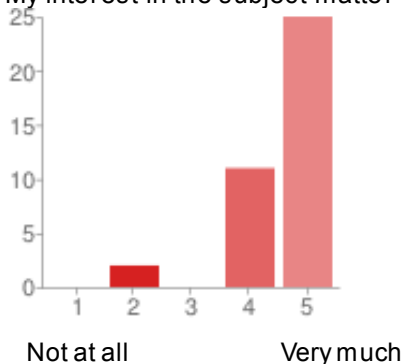
### Personal assessment

I was well prepared to benefit from the school

1 - Not at all	0	0%
2	1	3%
3	7	18%
4	11	29%
5 - Very	19	50%

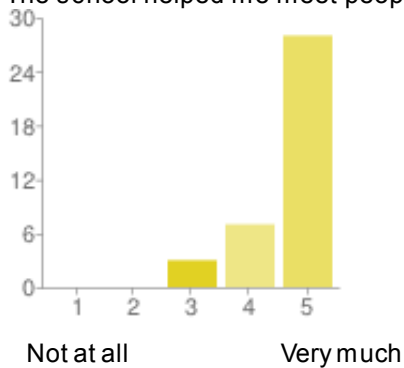


My interest in the subject matter was increased by the school



1 - Not at all	0	0%
2	2	5%
3	0	0%
4	11	29%
5 - Very much	25	66%

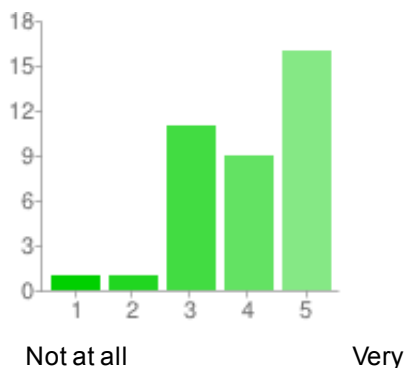
The school helped me meet people with similar scientific interests



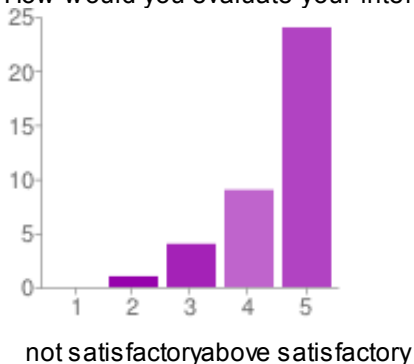
1 - Not at all	0	0%
2	0	0%
3	3	8%
4	7	18%
5 - Very much	28	74%

It is likely that I will work in the area of the school subject in the future

1 - Not at all	1	3%
2	1	3%
3	11	29%
4	9	24%
5 - Very	16	42%



How would you evaluate your interaction with other participants?



1 -not satisfactory	0	0%
2	1	3%
3	4	11%
4	9	24%
5 -above satisfactory	24	63%

### Additional comments on your personal assessment

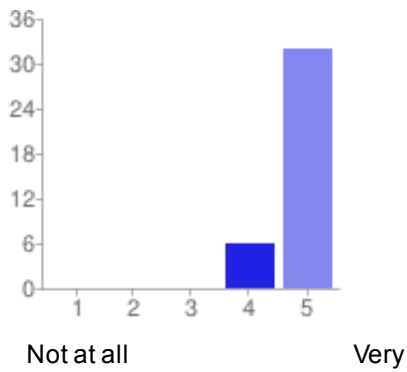
I think the group work and poster presentation was a nice touch to the summer school. It forced us to work together and, for some, find a way to quickly acclimate to reading material at the research level. I think the older students may have benefited more from this portion, however. I also feel that this forced us to compromise between the time allotted to studying the actual course material and studying the research paper. All in all, I think it was the right decision to incorporate group work into the program though. It would have been nice to have a participants list with institutions/ ...

### MSRI Venue

Please rate the different categories

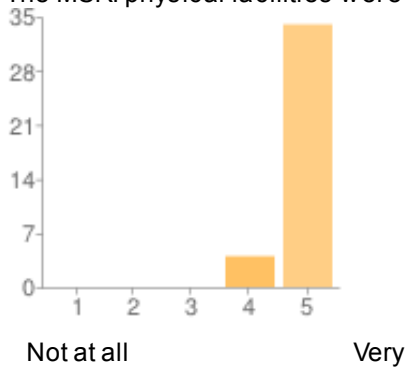
I found the MSRI staff helpful

1 - Not at all	0	0%
2	0	0%
3	0	0%
4	6	16%



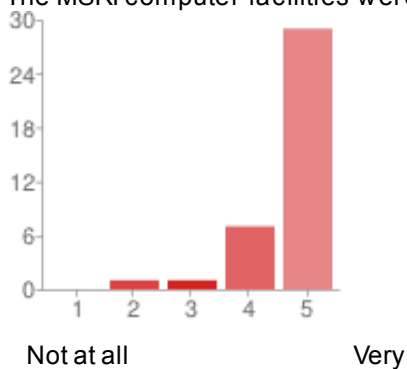
5 - Very 32 84%

The MSRI physical facilities were conducive for such a school



1 - Not at all 0 0%  
 2 0 0%  
 3 0 0%  
 4 4 11%  
 5 - Very 34 89%

The MSRI computer facilities were adequate for such a school



1 - Not at all 0 0%  
 2 1 3%  
 3 1 3%  
 4 7 18%  
 5 - Very 29 76%

**Additional comments on the MSRI venue**

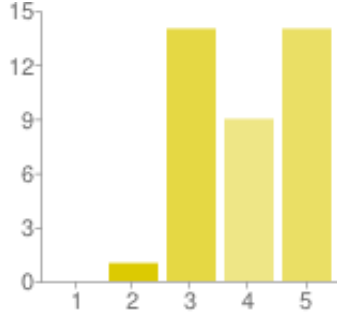
more chalkboards and meeting rooms could be beneficial A bit far from the dorms, but beautifully placed in the mountains. Has a wonderful library and plenty of room to move about and find space away from others if needed. Very comfortable for studying a little past the schedule of the summer school as well. Very nice view, lunch, and library. Specially, thanks to Chris for providing good accommodation options. Very nice view, lunch, and library. Specially, thanks to Chris for providing good accommodation options. I think the

computers weren't enough and kind of old. Also, the school closes too ...

## Accommodation and Food

Please rate the different categories

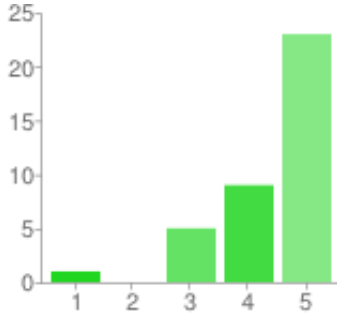
The summer school accommodation



not satisfactory above satisfactory

1 -not satisfactory	0	0%
2	1	3%
3	14	37%
4	9	24%
5 -above satisfactory	14	37%

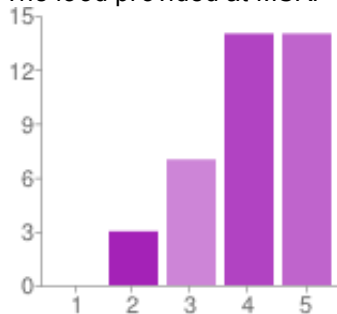
The food at the dormitories



not satisfactory above satisfactory

1 -not satisfactory	1	3%
2	0	0%
3	5	13%
4	9	24%
5 -above satisfactory	23	61%

The food provided at MSRI



not satisfactory above satisfactory

1 -not satisfactory	0	0%
2	3	8%
3	7	18%
4	14	37%
5 -above satisfactory	14	37%

### Additional comments on accommodation and food

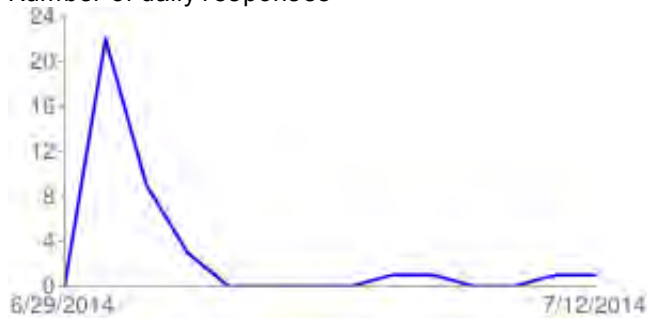
The accommodations provided by the MSRI were wonderful. Although the hours for the dining hall were somewhat restrictive, i.e., couldn't eat later than 8pm and no lunch provided on the weekends (though this forced one to explore the surrounding area, which was nice). On the other hands, the dorms being next to a big concert venue made it quite difficult to relax or study in the dorms on the weekend, but most students went downtown or to San Francisco then anyway. The food was fine and the caterers kind. I haven't been staying at the dorms and I haven't eaten at the dorms. I have had trouble get ...

### Thank you for completing this survey

We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.

A wonderful, wonderful summer school. I wouldn't hesitate to go again given the right topic and opportunity. Thank you for organizing this workshop. It was hard to see words in blackboard since the lecture room is not much light. It would be helpful if there is more lighting over the blackboard. I was really enjoying this workshop and happy to meet colleagues with many different background. I am thankful all the organizers and staffs. Thank you for organizing this workshop. It was hard to see words in blackboard since the lecture room is not much light. It would be helpful if there is ...

Number of daily responses



## Summer Graduate School: Dispersive Partial Differential Equations June 16 - 27, 2014

### Additional Survey Responses

#### Additional comments on your personal assessment

- I think the group work and poster presentation was a nice touch to the summer school. It forced us to work together and, for some, find a way to quickly acclimate to reading material at the research level. I think the older students may have benefited more from this portion, however. I also feel that this forced us to compromise between the time allotted to studying the actual course material and studying the research paper. All in all, I think it was the right decision to incorporate group work into the program though.
- It would have been nice to have a participants list with institutions/subject areas. By the end of the workshop, I knew the backgrounds of those that I most interacted with, but with such a large number of participants, I was not confident that I had not merely failed to discover the background or somebody working on topics of direct interest to me.
- I also felt that more than just 2 sets of 45 minute lectures may have made the school more worthwhile; this is also the reason why I wrote that the material presented was slightly not enough.
- The dorm room assignments were alphabetical as were the groups for the group work. I did not have a great experience with my suite mates and it was only made worse by having to work in their group. Different ways of randomizing would have made my experience better.
- This was one of the best experiences of my life (and I've gone to plenty of summer schools / workshops / conferences before). The environment was quite stimulating, the breaks created a lot of opportunities to interact with the other participants, and the lectures were not overwhelming to completely drain your energy!
- I love it!
- I thought this was a great way to meet other students in mathematics. Ample time was given to get to know other people at the school. I made a lot of new friends and contacts which I greatly appreciate.
- Great experience overall.

#### Additional comments on the MSRI venue

- more chalkboards and meeting rooms could be beneficial
- A bit far from the dorms, but beautifully placed in the mountains. Has a wonderful library and plenty of room to move about and find space away from others if needed. Very comfortable for studying a little past the schedule of the summer school as well.
- Very nice view, lunch, and library. Specially, thanks to Chris for providing good accommodation options.
- I think the computers weren't enough and kind of old. Also, the school closes too early. I have always remained much after the closure (5pm). I think an important institution like MSRI should be open till 7pm at least.
- The location of MSRI is amazing, and the building has plenty of spaces to work, all with great views!!!
- The venue was nice and comfortable for me.



**We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.**

- A wonderful, wonderful summer school. I wouldn't hesitate to go again given the right topic and opportunity.
- Thank you for organizing this workshop. It was hard to see words in blackboard since the lecture room is not much light. It would be helpful if there is more lighting over the blackboard. I was really enjoying this workshop and happy to meet colleagues with many different background. I am thankful all the organizers and staffs.
- Thank you very much for organizing the workshop, and for making it quite pleasant and not at all stressful!

**Additional comments on accommodation and food**

- The accommodations provided by the MSRI were wonderful. Although the hours for the dining hall were somewhat restrictive, i.e., couldn't eat later than 8pm and no lunch provided on the weekends (though this forced one to explore the surrounding area, which was nice). On the other hands, the dorms being next to a big concert venue made it quite difficult to relax or study in the dorms on the weekend, but most students went downtown or to San Francisco then anyway.
- The food was fine and the caterers kind.
- I haven't been staying at the dorms and I haven't eaten at the dorms.
- have had trouble getting water hot enough for showering the whole time staying. broken shower never fixed.
- Showers never got hot.
- The first week's caterers were great, the second week's: not that good...
- This is the worst part of the summer school. I want to suggest the following: Students should all be assigned to single rooms with more amenities, rather than undergraduate dorms.
- The food was great!
- I found the food to be great. I liked the catering for lunch better the second week, but both were good. As for accommodations, they were fine; however, the concerts that were happening right outside my window were quite distracting. My roommate and I both left our rooms during the concerts.
- I lived in my apartment during summer school.
- It's very helpful for the participants to live in the same suite and have dinner in the same dining hall. It helps strengthen the connection.
- The food is fine, but somehow in the middle of the session they changed the diner, and I do not know why.

**Additional comments on the topic presentation and organization**

- It was good
- Very nice summer school. I learned a lot. Thanks a lot to Natasa and Nicolaos.
- The time allowed for student presentation is relatively small.
- One of the best summer schools/workshops I have ever attended. The lectures were incredible; they were well-prepared, insightful, wonderfully motivated, and presented at a gratefully approachable level. The security of having lecture notes provided as well as recordings of the lectures was also very reassuring and something I will undoubtedly take advantage of in the future.
- Don't cover up blackboards, Notes very helpful

- I think break time is too much in this workshop. Before noon, we had two 45min lectures, 30min break, and 2h lunch time. It would be better if there are two 1h lectures, 15min break, and 1.5h lunch.
- There could have been a bit more material.
- Concerning the poster session. I think it's a good idea, but preparing the poster removed time from studying the content of the lectures. I would suggest to give in advance the topics one has to study for the poster (maybe 1 month before), so as soon as the summer school starts, students can start with the poster with already in mind the topic.
- The group work/poster session was an interesting idea. On one hand, it forces all participants to learn the material very well. On the other hand, some students who are more advanced in their research may have come to the Program just to get an idea of the topic of "Dispersive PDE" and had much work of his/her own (such as finish writing his/her thesis, research papers with specific deadline in mind). I am not sure what would have been the best option for all participants; it may have been just "optional" opportunity to form groups and present talks and posters. But overall, I feel the group work/poster presentation was a success.
- Everything was well organized.
- The TA sessions weren't too helpful -- I think problem sessions where we, the students, tried to work out exercises with guidance from TAs would have been more useful. Lectures and notes were organized and overall quite clear
- The material presented was very well selected, and both the lecturers and the TAs did an excellent job at addressing extra questions from the audience, and helping with the group work! They managed to attract the attention of everyone, including people not directly interested in dispersive PDEs!
- Great
- blackboard presentation more beneficial than projector
- TA sessions are a waste of time. Participant talks on research topics are more adequate to fill the gap.
- I found the TA sessions to be confusing and had trouble piecing the exercises with the bigger picture. Perhaps if we got a list of the exercises before the TA session that day, it would be easier to get the flow.
- I particularly liked the fact that lecture notes were provided in advance. The notes helped me prepare for lecture so that I would have a better understanding of the topic when it was presented in the lecture. Thank you to the organizers!
- The topics were well organized and delivered by the speakers.
- The lectures were really, really good! I only wish there would have been more of them! The overall program left a lot of room for individual study/further review, but I think it would have been even better to have more content, given the extraordinary quality of the presentation (we "only" had 90 minutes of lectures per day). The TA sessions were too slow and too basic, I felt.
- The lecture is very nice and beneficial and the food is also very nice. Thank you so much.
- I think we can do it with 2 90-minute lectures instead of 2 45-minute ones.
- The program was fast-paced in a good way. At times I wish the TA sessions would give us more time and opportunities to think through the exercises.
- the summer school is very helpful and I studied a lot from those lectures.
- The first week's food was better than the second's.
- I think having either only a presentation or only a poster would be better. Having both seemed to required more time than I would have liked. I think I could have used the time I spent making

the poster on reviewing lectures. I really liked having the lectures posted online. I found it very helpful.

- Using projector was not a good idea.
- Could have more lectures and less TA sessions.
- Great.

**Summer Graduate School:  
Stochastic Partial Differential  
Equations**

July 7, 2014 to July 18, 2014

MSRI, Berkeley, CA, USA

Organizers:

**Yuri Bakhtin (New York University, Courant Institute)**

**Ivan Corwin (Columbia University)**

**James Nolen (Duke University)**

## Final report

### MSRI summer school on Stochastic Partial Differential Equations

July 2014

Organizers: Yuri Bakhtin (New York University, Courant Institute),

Ivan Corwin (Columbia University), James Nolen (Duke University)

Stochastic Partial Differential Equations (SPDEs) serve as fundamental models of physical systems subject to random inputs, interactions or environments. It is a particular challenge to develop tools to construct solutions, prove robustness of approximation schemes, and study properties like ergodicity and fluctuation statistics for a wide variety of SPDEs. The purpose of this two week workshop was to educate graduate students on the state-of-the-art methods and results in SPDEs. In order to achieve this we had:

1. **Three lecture series (9 hours per lecture series):** Yuri Bakhtin's course was entitled "Ergodic theory of SPDEs"; Ivan Corwin's course was entitled "Exact solvability of SPDEs"; James Nolen's course was entitled "Fluctuation theory of PDEs with random coefficients".
2. **Lecture notes accompanying each course:** Each of the lecturers (as well as the TA's) produced lecture notes which we distributed electronically to the participants before or during the lectures. These notes will be finalized and distributed in a single email to all participants.
3. **Daily afternoon TA sessions (8 hours in total):** In these sessions, the TA's (Jeff Kuan, Harvard; and David Kelley, NYU) covered background material as well as provided some supplemental context for the materials covered in the main lectures.
4. **Daily afternoon problem sessions (8 hours in total):** During the lecture series and TA sessions, problems were assigned (generally two or three per lecture). During these afternoon sessions, participants had the chance to work together on solving these problems. The TA's and lecturers were present as well to help participants.
5. **A "secret questions" envelop:** For those participants who were hesitant to ask questions during or after lectures, we provided a "secret questions" envelop. Participants could anonymously put a question in and the lecturers or TA's would address it. There was on average one question a day in the envelop. There were also many questions during the lectures.
6. **An afternoon accompanying seminar series at Berkeley:** On Thursday of the first week we scheduled a half day. However, for those participants who were interested in hearing about some ongoing research related to Corwin's lecture series, there was a series of three talks held at Berkeley (co-organized by Corwin and Fraydoun Rezakhanlou). This series was attended by about 25 of the summer school participants. The speakers were Mihai Nica (Courant), Hao Shen (Columbia and Warwick) and Li-Cheng Tsai (Stanford).

## **Evaluation of the components of the programs**

The lecturers (who were also the organizers) and TA's went to great lengths to make sure that participants of all levels of ability and background could appreciate the school and gain something from it. Each lecture series started from basic definitions and built up to cutting edge research topics and techniques. It was quite evident from attendance, and participant questions and comments that the participants stayed involved and interested throughout the two week period. The TA sessions focused on providing all participants with the necessary background to appreciate the lecture series. Additionally, the TA's interacted with the participants quite a lot outside of the lectures.

The distribution of lecture notes for all of the courses made it easier for participants to keep up and to review materials after the classes and while working on problems. The problem sessions were very well attended and while some participants worked hard on the in class problems, others used this as a chance to try to figure out extensions to the materials from the course and engage in the first steps of research. The "secret questions" envelop was fairly well utilized and the questions put into it helped the lectures and TAs figure out if there were any points of confusion (primarily about concepts or notation), and quickly remedy these issues.

For those participants who were particularly interested, the lecturers made themselves available to meet one-on-one and discuss further during breaks or in the afternoon. The special Berkeley seminar series organized by Corwin and Fraydoun Rezakhanlou (Professor at Berkeley) also provided participants with a chance to delve deeper into the cutting edge research related to SPDEs. Rezakhanlou also attended much of the summer school and made himself available to meet with a number of the participants during the period.

## **Participants**

The participants in attendance of the summer school had very diverse backgrounds. A few months before the school we surveyed the participants to gauge their backgrounds in various relevant subjects (probability, stochastic calculus, PDES, complex analysis, combinatorics). The responses were extremely helpful in focusing the lecture series and TA sessions. In particular, due to the lack of combinatorial background, Corwin refocused his lectures away from matters involving symmetric functions and their relation to SPDEs, and more towards probabilistic and complex analytic methods related to exact solvability of SPDEs.

Having participants from all across the country and from many different levels of background was, in fact, a strong point of the program. Even though participants ranged from just starting their Ph.D. to having just finished, it was clear that there was a great deal of participant-led learning. During problem sessions, the participants naturally organized themselves into study / problem groups of generally 3 – 5 people. The problem session officially ran from 4pm-5pm, though participants routinely stayed until well after 6pm working together.

## Details on the lecture series

(1) Yuri Bakhtin. Ergodic theory of stochastic PDEs.

The basic problem in the ergodic theory of random dynamical systems is the description of invariant distributions and their properties. This is always an important issue since the long-term statistics of the solutions are determined by invariant distributions.

Stochastic PDEs define random evolutions in functional spaces, and the infinite-dimensional setting presents significant difficulties in comparison with finite-dimensional situations. The ultimate goal of the course was to study modern methods developed over last two decades for hydrodynamical SPDEs: Navier--Stokes equation and Burgers equation with random forcing. These methods are applicable in other settings as well, and the course was built around these two stochastic systems.

A variety of tools from functional analysis, control theory and probability theory were involved. Although a certain level of preparation was expected from the participants, a significant amount of time in this course was devoted to material that served as preparatory. For example, we spent some time explaining the physical reality modeled by the random systems under consideration, to construct solutions, study their properties first, and only then did we address the ergodic issues.

In fact, the course began with a discussion of deterministic and random dynamical systems and Markov processes in general and classical methods of proving existence and uniqueness of invariant distributions: compactness, Krylov--Bogolyubov method, coupling, regularity conditions of minorization type, i.e., Doeblin and Harris conditions, Strong Feller property, Lyapunov functions. One Force One Solution principle was then introduced with several finite dimensional instructive examples considered.

In infinite-dimensional situations one needs more advanced versions of these notions such as Asymptotic Strong Feller property and asymptotic coupling. We introduced these notions and applied them to the study of the ergodic theory of the randomly forced Navier-Stokes system in 2D. The regularity properties of transition probability required an introduction to Malliavin calculus.

Finally, we turned to the ergodic theory of the Burgers equation with random forcing and ended by constructing invariant distributions for compact and noncompact settings.

(2) Ivan Corwin: Exact solvability of SPDEs.

The Kardar-Parisi-Zhang (KPZ) equation and universality class was introduced in 1986. It is believed to describe the long-time/large-scale behavior of a wide class of mathematical and physical systems including driven lattice gases, randomly growing interfaces, directed polymers, and certain noisy stochastic PDEs. At the center of this class was a stochastic PDE called the KPZ equation.

The first half of this course was devoted to making some sense of the KPZ equation. We worked with the stochastic heat equation (whose logarithm is, by definition, the solution to the KPZ equation). In particular, using chaos series we proved convergence of certain directed polymer models to the

stochastic heat equation. We also described how other models (like growth processes or interacting particle systems) have “weak” limits to the stochastic heat equation.

The second half of the course turned to the question of how to compute statistics of distributions related to the KPZ equation. We worked with a certain “integrable discretization” of the KPZ equation, called “q-TASEP”. We proved a duality between q-TASEP and another system called the q-Boson process and used this, as well as the tools of the Bethe ansatz, to compute q-TASEP moment formulas. Ultimately, these moment formulas enabled us to compute distributional information about q-TASEP, and by taking various limits of the process (through directed polymer models) we proved similar formulas for the KPZ equation.

### (3) James Nolen: Fluctuation Theory for PDEs with random coefficients

PDEs with random coefficients have been used to model a variety of natural phenomena where the underlying medium is disordered and may best be characterized as random. In this context, it is interesting to understand how the macroscopic behavior of the system is effected by random variation at a microscopic scale. For example, in materials science one would like to predict bulk material properties from the statistics of microstructural properties; a mathematical description of this scenario may involve an elliptic PDE with coefficients that vary randomly on a small spatial scale.

Homogenization techniques for random PDEs were first developed in the 1970s to describe the behavior of the solution mean in a certain scaling limit. This is like a law of large numbers for the random solution. In recent years, however, there has been significant progress in understanding error estimates and understanding the statistical fluctuation of the solutions, moving beyond homogenization. There has also been progress in extending homogenization ideas to nonlinear problems. These lectures gave an introduction to recent developments in this field.

Most of the course focused on linear elliptic equations with random coefficients. Students were introduced to basic techniques for analysis of the PDE and to the idea of homogenization. We learned about Stein's method for normal approximation and about techniques for estimating moments of the solution. The last two lectures covered some recent developments in fluctuation theory for fronts in random media, governed by reaction diffusion equations.

## Conclusion

The SPDE summer school was a clear success. Though the participants came with varied levels of background, they all shared a strong desire to learn the field. The subject of SPDEs can be approached from a variety of angles, and the participants came from many of these different angles (applied math, PDEs, integrability, dynamical systems etc). The three lecture series attempted to give a survey of a number of these different perspectives so participants could go home with a wider picture of the field. It was quite evident from the participants survey ratings (mostly 4s and 5s) and comments throughout the school that this had been achieved.



Just to quote a few relevant comments:

- ☑ I am extremely happy that I have been to this workshop. It was very helpful in terms of math; I got a good background in some topics that I am not familiar with, which will give me a basis in case I want to learn them further. The instructors were very good; also I have appreciated that.
- All the instructors were great. They were very helpful, approachable and nice.
- ☑ It is fabulous. Everything has been GREAT. The lectures are the best, the most patient, top experts in the are, patient and devoted, and really involved with the audiences. The AI's are also very good, very helpful, very kind, always there to answer questions/join discussions. It is the best summer school I have ever been to.

### Organizers and Lecturers

First Name	Last Name	Institution
Yuri	Bakhtin	New York University, Courant Institute
Ivan	Corwin	Columbia University
James	Nolen	Duke University

### Teaching Assistants

First Name	Last Name	Institution
David	Kelly	University of North Carolina
Jeffrey	Kuan	Harvard University



## Stochastic Partial Differential Equations

July 7-July 18, 2014

### Schedule

Monday July 07, 2014			
9:15 AM - 9:30 AM	Simons Auditorium		Welcome
9:30 AM - 10:30 AM	Simons Auditorium	Ivan Corwin	Corwin - Lecture 1
10:30 AM - 11:00 AM	Atrium		Break
11:00 AM - 12:00 PM	Simons Auditorium	Yuri Bakhtin	Bakhtin - Lecture 1
12:00 PM - 1:30 PM	Atrium		Lunch
1:30 PM - 2:30 PM	Simons Auditorium	James Nolen	Nolan - Lecture 1
2:30 PM - 3:30 PM	Simons Auditorium		TA Tutorial
3:30 PM - 4:00 PM	Atrium		Tea Break
4:00 PM - 5:00 PM	Simons Auditorium		Problem Session

Tuesday July 08, 2014			
10:00 AM - 11:30 AM	Simons Auditorium	Yuri Bakhtin	Bakhtin - Lecture 2
10:30 AM - 11:00 AM	Atrium		Break
11:00 AM - 12:00 AM	Simons Auditorium	James Nolen	Nolen - Lecture 2
12:00 PM - 1:30 PM	Atrium		Lunch
1:30 PM - 2:30 PM	Simons Auditorium	Ivan Corwin	Corwin - Lecture 2
2:30 PM - 3:30 PM	Simons Auditorium		TA tutorial
3:30 PM - 4:30 PM	Atrium		Tea Break
4:00 PM - 5:00 PM	Simons Auditorium		Problem Session

Wednesday July 9, 2014			
9:30 AM - 10:30 AM	Simons Auditorium	James Nolen	Nolen - Lecture 3
10:30 AM - 11:00 AM	Atrium		Break
11:00 AM - 12:00 PM	Simons Auditorium	Ivan Corwin	Corwin - Lecture 3
12:00 PM - 02:30 PM	Tilden Park		BBQ Lunch
02:30 PM - 03:30 PM	Simons Auditorium		TA tutorial
3:30 PM - 4:00 PM	Atrium		Tea Break
4:00 PM - 5:00 PM	Simons Auditorium		Problem Session

Thursday July 10, 2014			
9:30 AM - 10:30 AM	Simons Auditorium	Ivan Corwin	Corwin - Lecture 4
10:30 AM - 11:00 AM	Atrium		Break
11:00 AM - 12:00 PM	Simons Auditorium	Yuri Bakhtin	Bakhtin - Lecture 3
12:00 PM - 1:30 PM	Atrium		Lunch

Friday July 11, 2014			
9:30 AM - 10:30 AM	Simons Auditorium	Ivan Corwin	Corwin - Lecture 5
10:30 AM - 11:00 AM	Atrium		Break
11:00 AM - 12:00 PM	Simons Auditorium	James Nolen	Nolen - Lecture 4
12:00 PM - 1:30 PM	Atrium		Lunch
1:30 PM - 2:30 PM	Simons Auditorium	Yuri Bakhtin	Bakhtin - Lecture 4
2:30 PM - 3:30 PM	Simons Auditorium		TA tutorial
3:30 PM - 4:00 PM	Atrium		Tea Break
4:00 PM - 5:00 PM	Simons Auditorium		Problem Session

Monday July 14, 2014			
9:30 AM - 10:30 AM	Simons Auditorium	James Nolen	Nolen - Lecture 5
10:30 AM - 11:00 AM	Atrium		Break
11:00 AM - 12:00 PM	Simons Auditorium	Yuri Bakhtin	Bakhtin - Lecture 5
12:00 PM - 1:30 PM	Atrium		Lunch
1:30 PM - 2:30 PM	Simons Auditorium	Ivan Corwin	Corwin - Lecture 6
2:30 PM - 3:30 PM	Simons Auditorium		TA tutorial
3:30 PM - 4:00 PM	Atrium		Tea Break
4:00 PM - 5:00 PM	Simons Auditorium		Problem Session

Tuesday July 15, 2014			
9:30 AM - 10:30 AM	Simons Auditorium	Ivan Corwin	Corwin - Lecture 7
10:30 AM - 11:00 AM	Atrium		Break
11:00 AM - 12:00 PM	Simons Auditorium	Yuri Bakhtin	Bakhtin - Lecture 6
12:00 PM - 1:30 PM	Atrium		Lunch
1:30 PM - 2:30 PM	Simons Auditorium	James Nolen	Nolen - Lecture 6
2:30 PM - 3:30 PM	Simons Auditorium		TA tutorial
3:30 PM - 4:00 PM	Atrium		Tea Break
4:00 PM - 5:00 PM	Simons Auditorium		Problem Session

Wednesday July 16, 2014			
9:30 AM - 10:30 AM	Simons Auditorium	Yuri Bakhtin	Bakhtin - Lecture 7
10:30 AM - 11:00 AM	Atrium		Break
11:00 AM - 12:00 PM	Simons Auditorium	James Nolen	Nolen - Lecture 7
12:00 PM - 1:30 PM	Atrium		Lunch break

Thursday July 17, 2014			
9:30 AM - 10:30 AM	Simons Auditorium	James Nolen	Nolen - Lecture 8
10:30 AM - 11:00 AM	Atrium		Break
11:00 AM - 12:00 PM	Simons Auditorium	Ivan Corwin	Corwin - Lecture 8
12:00 PM - 1:30 PM	Atrium		Lunch
1:30 PM - 2:30 PM	Simons Auditorium	Yuri Bakhtin	Bakhtin - Lecture 8
2:30 PM - 3:30 PM	Simons Auditorium		TA tutorial
3:30 PM - 4:00 PM	Atrium		Tea Break
4:00 PM - 5:00 PM	Simons Auditorium		Problem Session

Friday July 18, 2014			
9:30 AM - 10:30 AM	Simons Auditorium	Ivan Corwin	Corwin - Lecture 9
10:30 AM - 11:00 AM	Atrium		Break
11:00 AM - 12:00 PM	Simons Auditorium	Yuri Bakhtin	Bakhtin - Lecture 9
12:00 PM - 1:30 PM	Atrium		Lunch
1:30 PM - 2:30 PM	Simons Auditorium	James Nolen	Nolen - Lecture 9
2:30 PM - 3:30 PM	Simons Auditorium		TA tutorial
3:30 PM - 4:00 PM	Atrium		Tea Break
4:00 PM - 5:00 PM	Simons Auditorium		Problem Session

<b>Attending Students</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Elan	Bechor	University of California, Berkeley
Pavel	Bezdek	University of Utah
Gonzalo	Bley	University of Virginia
Eric	Brattain	University of California, Davis
Lise	Chlebak	Tufts University
David	Collins	University of Victoria
Francesco	Cordoni	Università di Trento
William	Cuello	University of California, Davis
Eric	DeMarco	Arizona State University
Wai	Fan	Chinese University of Hong Kong
Qi	Feng	Purdue University
Alejandra	Fonseca Morales	Centro de Investigacion y de Estudios Avanzados del IPN
Eric	Foxall	University of Victoria
Xiaoqian	Gong	Arizona State University
Jingyu	Huang	University of Kansas
Tobias	Hurth	Georgia Institute of Technology
Chris	Janjigian	University of Wisconsin
Peter	Jantsch	University of Tennessee
Hangjie	Ji	Duke University
An	Jiang	Brigham Young University
Wuchen	Li	Georgia Institute of Technology
Shiu-Tang	Li	University of Utah
Yanghui	Liu	University of Kansas
Asad	Lodhia	Massachusetts Institute of Technology
Sooie-Hoe	Loke	Oregon State University
Phong	Luu	University of Georgia
Kelly	MacArthur	University of Utah
Tetyana	Malysheva	University of Oklahoma
Alexander	Moll	Massachusetts Institute of Technology
Ekaterina	Nathanson	University of Iowa
Armenak	Petrosyan	Vanderbilt University
Ahmad	Ridley	University of Maryland
Julian	Romero	University of Los Andes
Nand	Sharma	Colorado State University
Dania	Sheaib	University of Oklahoma
George	Slavov	University of Georgia
Richard	Slevinsky	University of Alberta
Kathleen	Smith	University of Colorado
Sui	Tang	Vanderbilt University
Nihal	Temamogullari	Duke University
Marina	Terzi	Kent State University
Pun Wai	Tong	University of California
Li-Cheng	Tsai	Stanford University
Thada	Udomprapasup	University of California, San Diego

<b>Attending Students</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Sarah	Vallelian	University of Texas
Chuntian	Wang	Sichuan University
Lidan	Wang	University of Washington
Fan	Wei	Harvard University
Qiong	Wu	Tufts University
Ruofan	Yan	Rutgers University
Wiseley	Zhang	San Francisco State University
Gleb	Zhelezov	University of Arizona
Xiaofei	Zheng	Pennsylvania State University
Lan	Zhong	University of Delaware
Jinping	Zhuge	University of Kentucky

## Student Statistics

<b>Total Students</b>		<b>53</b>
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<b>Gender</b>		<b>53</b>
<b>Male</b>	66.04%	35
<b>Female</b>	33.96%	18
<b>Declined to state</b>	0.00%	0

<b>Ethnicity*</b>		<b>55</b>
<b>White</b>	40.00%	22
<b>Asian</b>	45.45%	25
<b>Hispanic</b>	7.27%	4
<b>Pacific Islander</b>	0.00%	0
<b>Black</b>	1.82%	1
<b>Mixed</b>	1.82%	1
<b>Native American</b>	0.00%	0
<b>Declined to state</b>	3.64%	2

\* ethnicity specifications are not exclusive

# 36 responses

36/55 = 65% response rate

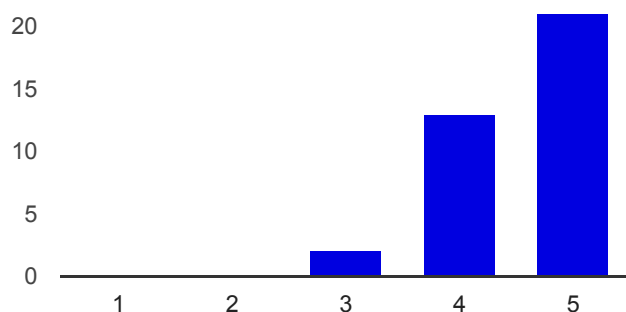
[View all responses](#)   [Publish analytics](#)

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## Summary

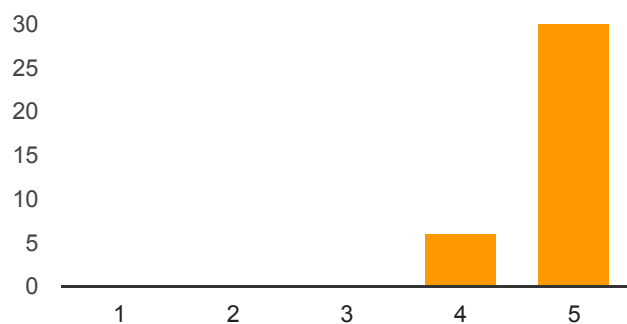
### Topic presentation and organization

The various topics within the summer school integrated into a coherent picture

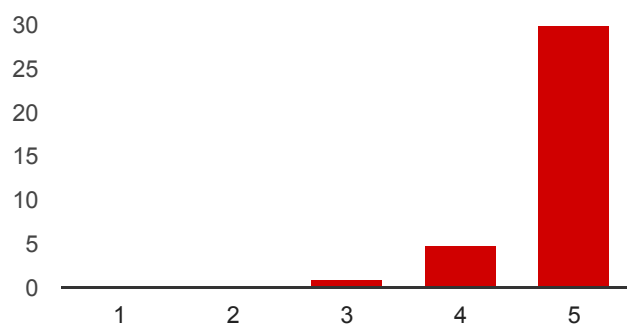


Not at all: 1	0	0%
2	0	0%
3	2	5.6%
4	13	36.1%
Very much: 5	21	58.3%

The faculty speakers were generally clear and well organized in their presentation

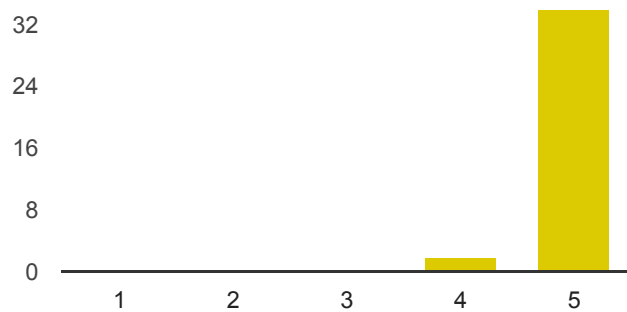


The school was intellectually stimulating



Not at all:	1	0	0%
	2	0	0%
	3	1	2.8%
	4	5	13.9%
Very:	5	30	83.3%

The overall experience of the school was worthwhile

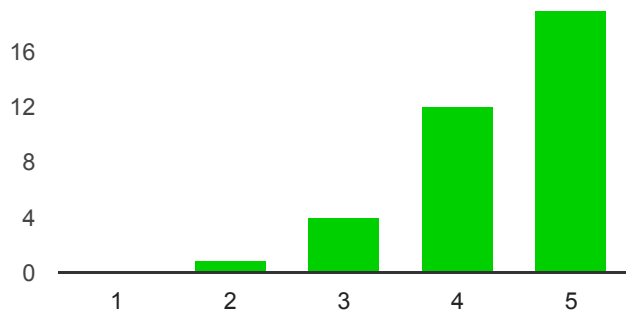


Not at all:	1	0	0%
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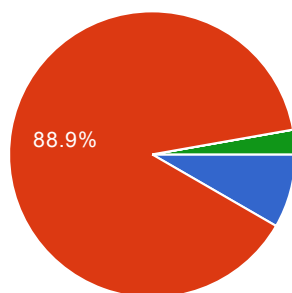
2	0	0%
3	0	0%
4	2	5.6%
Very: 5	34	94.4%

The TA sessions were helpful



Not at all: 1	0	0%
2	1	2.8%
3	4	11.1%
4	12	33.3%
Very much: 5	19	52.8%

The amount of material presented was:



Too much	3	8.3%
Just the right amount	32	88.9%
Not enough	0	0%
No opinion	1	2.8%

Additional comments on the topic presentation and organization

None

N/A

--

It was well organized . Thank you

well prepared

This summer school is very well organized and we really learned a lot. It also provides a good opportunity for us to know each other.

Interesting and novel topics - got a lot out of it.

Lecturers are well prepared. I totally appreciate it.

All the instructors were great. They were very helpful, approachable and nice.

q

The sheer amount of preparatory reading was overwhelming and I read just a fraction of it. Looking back it seems that some of the material was presented as a prerequisite to the course material and other material was more of a general background. It would have been helpful to have that distinction more clear so I could prioritize my readings.

Arrange some sessions for volunteer participants to present their work

The 3 series of lectures were all inspiring and impeccable!

The presenters were very good. The younger TA was not as helpful as the postdoc.

a little too much

The only complaint I have is due to the lack of break between the third lecture of the day and the TA session. In the end, however, we were informally given a break, so it wasn't really a problem.

It is fabulous. Everything has been GREAT. The lectures are the best, the most patient, top experts in the are, patient and devoted, and really involved with the audiences. The AI's are also very good, very helpful, very kind, always there to answer questions/join discussions. It is the best summer school I have ever been to.

Professor Nolen's lectures are really interesting and intellectually stimulating!

I wanted to know more about SPDE's as they are popular nowadays and I found the summer school very helpful in this aspect. Topics were presented in a very motivational way and professors were very cooperative in answering questions.

Having lecture notes provided really benefitted me in preparing for the lectures.

I find the courses very helpful. It seems to me that the speakers needed more time to present the complete materials. I would suggest to extend the length of the MSRI summer school from two weeks to three weeks.

I like all three lecturers teaching style.

good

Excellent workshop. Very inspiring.

Well organized. Especially liked Dr. Corwin's focus on the big picture and summaries

before and after each lecture.

It is just the right amount.

Ivan's lectures were really fast towards the end. Otherwise it was "just the right amount".

I did not have the appropriate background to understand one of the courses at the depth that I wanted. However, the availability of notes and online recordings of the lectures really helped me catch up!

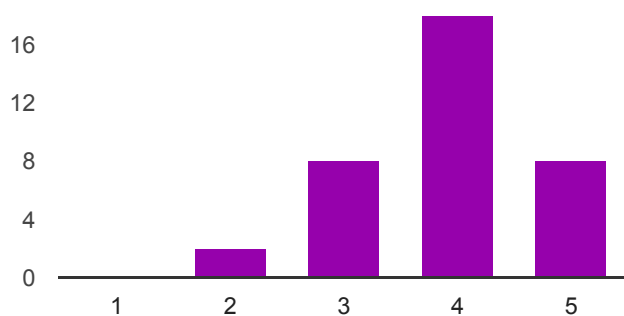
It was awesome, I like it a lot.

The topic presentation was well done, I feel like the problem sessions however could have been a bit more structured.

it is helpful

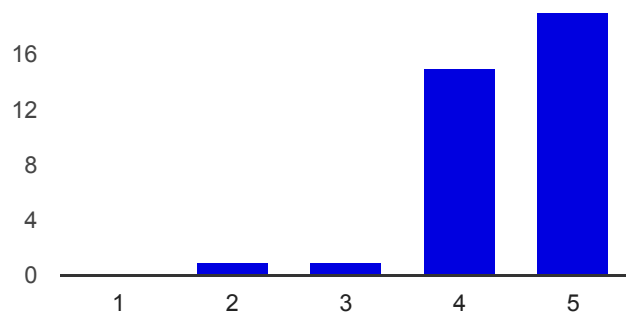
## Personal assessment

I was well prepared to benefit from the school



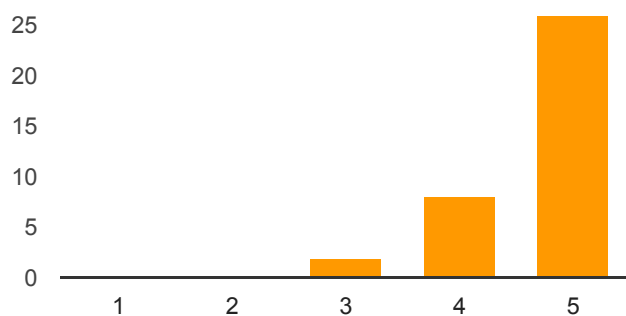
Not at all: 1	0	0%
2	2	5.6%
3	8	22.2%
4	18	50%
Very: 5	8	22.2%

My interest in the subject matter was increased by the school



Very much: 5 19 52.8%

The school helped me meet people with similar scientific interests



Not at all: 1 0 0%

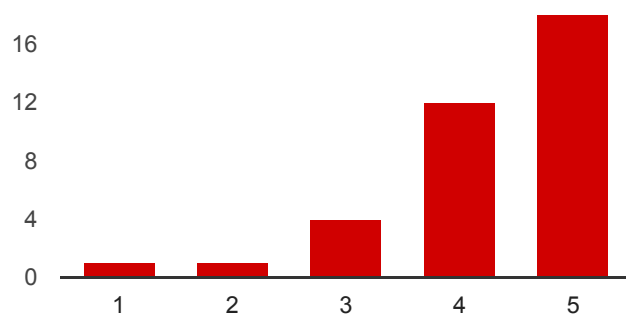
2 0 0%

3 2 5.6%

4 8 22.2%

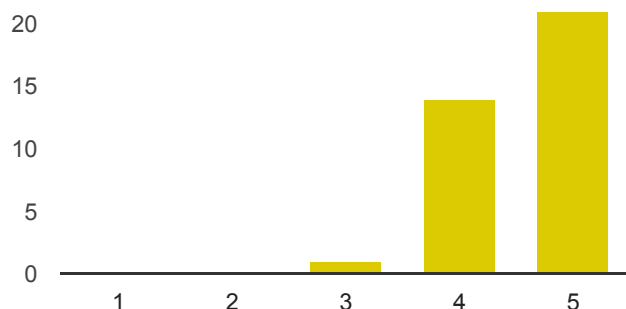
Very much: 5 26 72.2%

It is likely that I will work in the area of the school subject in the future



Not at all:	1	1	2.8%
	2	1	2.8%
	3	4	11.1%
	4	12	33.3%
Very:	5	18	50%

How would you evaluate your interaction with other participants?



not satisfactory:	1	0	0%
	2	0	0%
	3	1	2.8%
	4	14	38.9%
above satisfactory:	5	21	58.3%

### Additional comments on your personal assessment

None

I learn the big picture of this topic, it is helpful

I don't do probability for my research, but I was curious about the topic. I think I wasn't well prepared. But still I got a good sense of what is going on in the area; I got the general picture. Also it was very nice that they talked about open questions in their field.

q

I would like to suggest that dorm room be assigned based on whether the participant is an 'early riser' or a 'night owl'. Perhaps survey sleep schedule preferences and assign accordingly, ... such as a registration question at the same time as the food choice question: Do you prefer to room with someone who is a  Night Owl,  Early Riser,  No Preference I function on \le 6 hours of sleep and often settle into a two-sleep schedule. I often retired after my roommate was asleep and awoke before he did. As much as I tried to move quietly, I'm sure I woke him up at least once every night.

N/A

It has been a wonderful opportunity in terms of both learning and networking. I have made a lot of friends/collaborators, and will certainly benefit from them in the future. It has opened both my eyes and new ground for me.

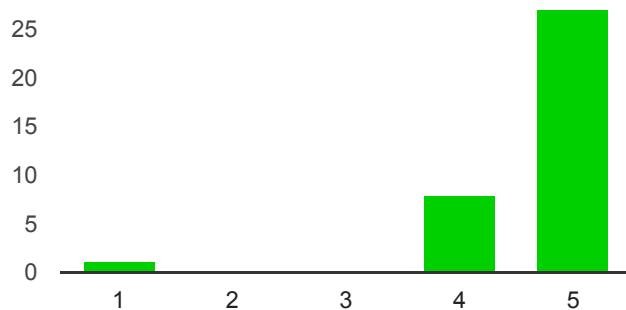
good

Had a wonderful time and met great people.

i made many new friends and it is good

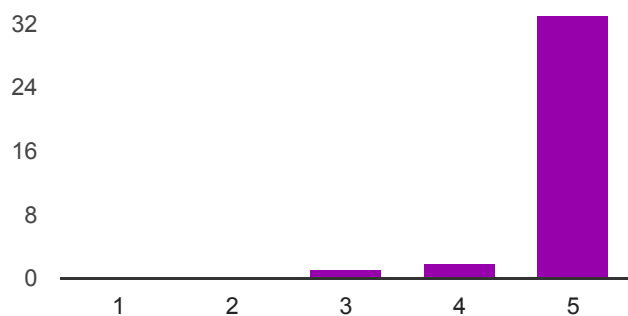
## MSRI Venue

I found the MSRI staff helpful

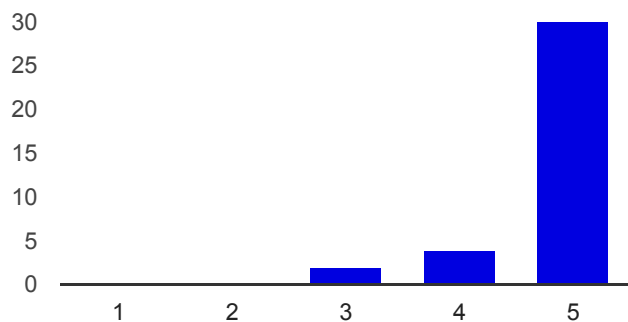


Not at all: 1	1	2.8%
2	0	0%
3	0	0%
4	8	22.2%
Very: 5	27	75%

The MSRI physical facilities were conducive for such a school



How much do you like the MSRI venue? (1 = Not at all, 5 = Very much)



Not at all: 1	0	0%
2	0	0%
3	2	5.6%
4	4	11.1%
Very: 5	30	83.3%

### Additional comments on the MSRI venue

None

I think some of them are not friendly and indifferent to our questions.

The venue is excellent for both personal study and interaction with other participants.

Best view! I really like the MSRI building, the view from it and the nature surrounding it.

Also the venue was great.

q

Can I invite my non-math partner to visit should we happen pass by Berkeley while on vacation?

N/A

It was super cold in the auditorium most of the time. So, I was a bit uncomfortable.

When I asked, the temperature did get better, but then someone else would complain that it was too hot and it would be cold again. Bummer.

The teaching, the organization, the activities, the details, the dining, the lodging, the resources in MSRI...everything is splendid. It has been a life time chance and wonderful experience for me. The staff at MSRI, especially, are all so kind, helpful, organized, and patient.

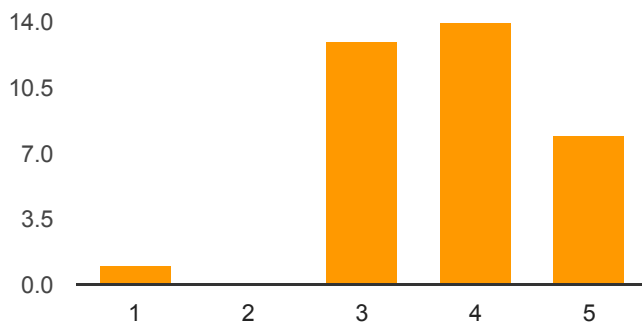
I like the environment in MSRI. People there are very kind and helpful.

I haven't really used computer facilities...

it is fantastic

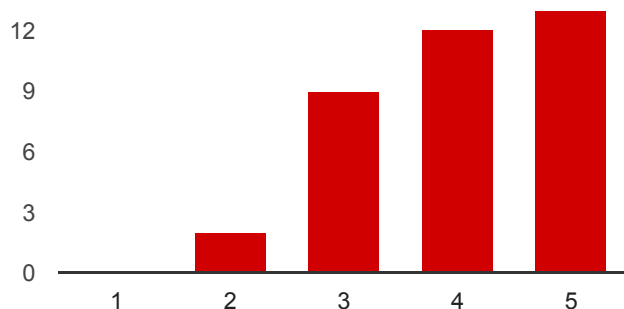
## Accommodation and Food

The summer school accommodation



not satisfactory:	1	1	2.8%
	2	0	0%
	3	13	36.1%
	4	14	38.9%
above satisfactory:	5	8	22.2%

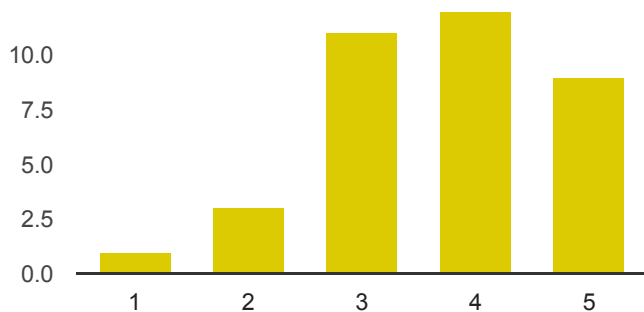
The food at the dormitories





not satisfactory: 1	0	0%
	2	5.6%
	3	25%
	4	33.3%
above satisfactory: 5	13	36.1%

### The food provided at MSRI



not satisfactory: 1	1	2.8%
	3	8.3%
	11	30.6%
	12	33.3%
above satisfactory: 5	9	25%

### Additional comments on accommodation and food

None

Food is good in the dining hall except it is always of the same type. The food provided at MSRI is just okay, there are a few days that the food is terrible.

Accomodations are good and the meal plan is very convenient.

I really appreciate it when the staff was so concerned about people not getting salad.

For me, it's not a big deal. I didn't expect I would be taken care this well. Thank you so much for doing so.

The lunch was great in the first week at MSRI; but in the second week I had some concerns: The second week they did not provide any fresh fruit for the lunch. Monday they gave mac and cheese as the lunch and also the other days we had potatoes as sides instead of healthier veggies etc. The food was not as healthy in the second week as it was in the first week. The second week was based on foods with high glycemic

index, which is not very healthy for me.

q

The woman standing sentinel over the vegetarian option had an exceptionally rough edge. I would like to see vegetarian as the standard and a meat option provided for those who choose it. I say this because even though I'm not vegetarian, I quite often do not eat meat. I do not eat all meats; and when I do eat meat, the proportion of meat to vegetables is routinely very different than what most people eat; and certainly different than what was served. I prefer to eat the vegetarian option together with a small (the volume of two fingers) amount of meat. That was not possible here because if I allowed the caterers to place any meat on my plate, then I wasn't allowed any of the vegetarian option.

N/A

The ladies the first week were more hospitable and seemed to be more efficient and have better food, in my opinion.

The foods are great. More watermelon and less oil may be better. More fruits and veggies maybe. But that is the only little thing in a otherwise perfect picture.

May be more Chinese or asian style food.

Living in dorms with lots of children at camp was a bit odd, but the location was hard to argue with. The food in the cafeteria was excellent. The food provided for lunch was much better the first week.

The dorm had ants and on the last day of the school, water flooded into the suite from the ceiling, through the light fixtures and smoke detectors, setting off the fire alarm, creating a huge puddle in the hallway and rendering the bathroom showers and one of the two toilets unusable. The flooding was addressed shortly after it was reported. Lunch the first week at MSRI was not very good, but in the second week was much better.

The food is OK, but it can be better

## **Thank you for completing this survey**

We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.

Excellent! I'll cherish the memory of attending this summer school. Thanks for having me here :)

I am extremely happy that I have been to this workshop. It was very helpful in terms of math; I got a good background in some topics that I am not familiar with, which will give me a basis in case I want to learn them further. The instructors were very good; also I have appreciated that they gave references and open questions. The people participating and the MSRI staff were also very nice and friendly. Berkeley and San

Francisco is such a nice area; I am also glad to see this area. Thanks for everything!

q

Thanks for a wonderful learning experience in a beautiful setting with knowledgeable and considerate people. The librarian was very helpful. The videos are \*\*\*\*extremely\*\*\*\* helpful.

N/A

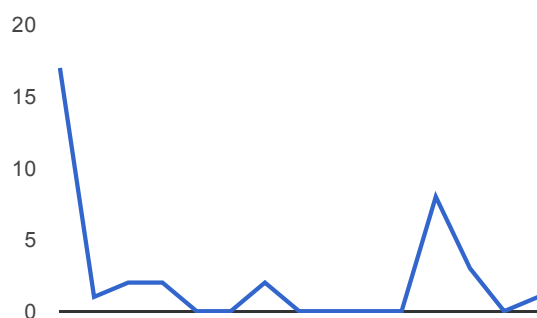
Overall, this was an excellent experience. I would highly recommend any workshop at MSRI to interested parties. Thank you very much.

It is in all a wonderful experience. I will certainly apply for the them ester in the fall and other MSRI activities in the future. MSRI is, indeed, one of the top research facilities in the whole world.

Over all, I like this summer school very much.

i like the experience there, it is really a good experience!!

## Number of daily responses



**Summer Graduate School:  
Seminaire de Mathematiques Superieures 2014:  
Counting Arithmetic Objects  
June 23, 2014 to July 04, 2014  
Montreal, Canada**

Organizers:

**Henri Darmon (McGill University)**

**Andrew Granville (University of Montreal)**

**Benedict Gross (Harvard University)**



Faculté des arts et des sciences  
Département de mathématiques  
et de statistique

## SMS 2014: Director's report.

The 53rd *Séminaire de Mathématiques Supérieures* took place in Montréal in the period June 23- July 4, 2014. It was the largest summer school in recent years, with 112 participants.

Focused on the celebrated work of **Manjul Bhargava**, who was himself one of the featured lecturers, this school was an exceptional event for number theory and beyond, with a great impact on making Bhargava's breakthroughs accessible to a larger audience. Remarkably this year, many of the speakers, Bhargava in particular, were present the full two-week period.

The organizers, **Henri Darmon**, **Andrew Granville** and **Benedict Gross** have done a tremendous job by putting together a fantastic group of speakers and motivated students and in coordinating tightly the lectures in such a way as to insure the highest training impact. Moreover, they have already started to prepare a volume tied to the school activity that promises to play an important role in the field.

I thank all three of them for their hard work as well as **Ms. Sakina Benhima** from the CRM who assisted them and me with the administrative matters required in running this activity.

As in past years, this edition of the *SMS* was only possible with the co-operation of our main partners the **CRM**, **Fields Institute**, **PIMS** and **MSRI** as well as with support from the **ISM**, the **University of Montreal** and with support from the **Canadian Mathematical Society**. I thank all these institutions for their contributions and I also thank the board of directors of the SMS for their work and support.

In the following you will find a detailed scientific, organizational and budgetary report. I thank again the organizers for taking the time to prepare this document.

Sincerely Yours,

A handwritten signature in blue ink that reads 'O. Cornea'.

Octav Cornea  
Director, Séminaire de Mathématiques Supérieures  
[cornea@dms.umontreal.ca](mailto:cornea@dms.umontreal.ca)

September 10, 2014

## École d'été SMS 2014: Comptage d'objets arithmétiques

## SMS 2014 Summer School: Counting Arithmetic Objects

2014-06-23 - 2014-07-04

### 1. Organisateurs / Organisers:

Henri Darmon (McGill University)  
Andrew Granville (Université de Montréal)  
Benedict Gross (Harvard University)

### 2. Conférenciers / Speakers :

Manjul Bhargava (Princeton)  
I/ Introduction and perspective  
II, III/ How to count rings and fields  
IV/ Applications to the Birch and Swinnerton-Dyer conjecture  
V/ Future perspectives

Henri Darmon (McGill)  
I/ Curves, geometric aspects  
II/ Curves, diophantines aspects

Jordan Ellenberg (Wisconsin)  
I, II/ Topological and algebraic geometry method over function fields

Eknath Ghate (TIFR. Mumbai)  
I/ Basic algebraic number theory  
II/ Counting Artin representations and modular forms of eight one

Eyal Goren (McGill)  
I, II/ Algebraic groups, representation theory, and invariant theory

Andrew Granville (U de Montreal)  
I/ Basics of binary quadratic forms and Gauss composition  
II/ Basic analytic number theory

Benedict Gross (Harvard)  
I, II/ Arithmetic invariant theory and hyperelliptic curves

Wei Ho (Columbia)  
Coregular spaces and genus one curves

Melanie Matchett-Wood (Wisconsin)

I/ Cubic rings

II/ Quartic and quintic rings

III/ Rings associated to binary  $n$ -ic forms, composition of  $2 \times n \times n$  boxes and class groups

IV/ Heuristics for number field counts and applications to curves over finite fields.

Jennifer Park (MIT / CRM)

The Chabauty method and symmetric powers of curves

Bjorn Poonen (MIT)

I/ Moduli space of rings

II, III/ Selmer groups and heuristics

IV/ Chabauty methods and hyperelliptic curves

Arul Shankar (Princeton)

Binary quartic forms; bounded average rank of elliptic curves

Michael Stoll (Beyreuth)

Rational points on curves

Takashi Taniguchi (Kobe)

The zeta functions attached to prehomogeneous vector spaces

Frank Thorne (U South Carolina)

Zeta Function methods

Jerry Wang (Princeton)

Counting methods over global fields

9 problem sessions, led by Jordan Ellenberg, Wei Ho, Jennifer Park, Arul Shankar, Frank Thorne and Jerry Wang

### **3. Nombre de participants / Number of participants :112**

### **4. Résumé de l'activité / Activity resume :**

This was the first summer school to focus on the new approach to arithmetic geometry which has been led by Manjul Bhargava, and resulting in several extraordinary results, including that almost  $2/3$  of elliptic curves satisfy the Birch-Swinnerton Dyer

conjectures (up to the 2-part of the Tate-Safarevic group). The vast majority of the work in this area has come from Princeton and Boston, and one goal was to allow a much wider cohort into the subject. The lecturers were specifically asked to help the listeners develop an intuition for the area, and not worry about all of the details. One difficulty in understanding the subject is that the published papers often focus on the more geometric intuition, though much of the (key) ring theory can be developed through simpler algebraic insights and combinatorial constructions. Again the lecturers were asked to bring these to the fore, and did so.

Bhargava himself is a fantastic lecturer and enjoyed, not only gearing his own talks to a wider audience, but working with some of the (fairly junior) lecturers to appropriately focus their talks. The series by Melanie Wood (on all of the rings involved) and by Arul Shankar (on how to count the arithmetic objects involved) were masterful, and gave the listeners the opportunity to delve deep into this important subject with a great sense of the intuition behind these techniques. Bjorn Poonen managed to explain quite a bit of challenging algebraic geometry in a way that brought everyone along, giving insight into conjectures on ranks, as well as the new ways of exploiting Chabauty's method to determine all of the rational points on a given (high genus) curve. Taniguchi and Frank Thorne exposed the deeper analytic techniques, all the while respecting that the majority of the audience were algebraists so needed to be carefully led through the meaning behind each step.

Dick Gross is one of the great arithmetic geometers of our time, and a fantastic expositor, as he once again showed, using the invariant theory (as explained by Jerry Wang) to attack rational points on hyperelliptic curves. There were also excellent "one-off" lectures by Wei Ho, Jennifer Park, Eknath Ghate (though actually two "one-off" lectures) and Michael Stoll, on various exciting parts of the theory. And a rather different perspective explained by the always entertaining and inspiring Jordan Ellenberg.

Each day was rounded off by an extensive problem session, challenging the participants to immerse themselves in the details of the theory of that day. Each day's problem session was led by some of the the more junior lecturers.

## **5. Record of activities :**

The SMS lecture series started on Monday morning and got off to a fantastic start with a masterful lecture by Manjul Bhargava on "Introduction and Perspective", laying out the broad themes for the entire program of lectures. The following lectures that day were devoted to covering essential background topics on algebraic groups, representation theory, and invariant theory (Eyal Goren) and algebraic number theory (Eknath Ghate). The day closed with a historically motivated and insightful discussion of Gauss's theory of composition of binary quadratic forms, delivered by Andrew Granville.

Tuesday was devoted to further nuts and bolts. Henri Darmon lectured on the theory of



algebraic curves, including such basic topics as the Riemann-Roch theorem and its applications, as well as various diophantine aspects, culminating with the correspondence, discovered by Swinnerton-Dyer, between two-torsion elements in the Selmer group of an elliptic curve and equivalence classes of binary quartic forms. Andrew Granville covered basic topics in analytic number theory and in the geometry of numbers.

Wednesday saw further discussion of representation theory by Eyal Goren, and the start of Melanie Matchett Wood's masterful expose of the classification of rings of low degree, followed by a stimulating problem session that was run by Jennifer Park, Arul Shankar and Frank Thorne.

On Thursday, Bhargava and Wood both discussed techniques for parametrising and counting rings and fields of low degree, and Takashi Taniguchi contrasted their approach with more traditional ones based on the notion of the zeta function attached to a prehomogenous vector space. The day closed with a problem session animated by Arul Shankar and Frank Thorne.

On Friday Bhargava continued with his lecture series on counting rings and fields, while Matchett-Wood reviewed various heuristics for number field counts, with special emphasis on the fruitful analogy with the theory of curves over finite fields. Bjorn Poonen closed the week with a lovely discussion of his notion of a "moduli space of rings" which resonated nicely with many of the themes of the summer school.

In response to overwhelming demand from the participants, some extra lectures were scheduled on Saturday. Frank Thorne was thus able to discuss zeta function methods in greater depth, and Eknath Ghate was able to describe the connection between modular forms of weight one and certain Artin representations, of the kind that have been successfully parametrised and counted by Bhargava and his school.

While the first week was devoted to basic background material and to the problem of parametrizing the integral orbits in prehomogenous vector spaces, the second week turned to the more challenging task of counting analogous orbits in settings where the group action has a free ring of invariants. Such actions arise, for instance, in parametrising elements of small order in the Selmer groups of elliptic curves. Arul Shankar thus explained how the relation between 2-selmer elements and equivalence classes of binary quartic forms could be parlayed into striking upper bounds for the average rank of elliptic curves over the rationals. Bjorn Poonen followed with a discussion of the heuristics that such Selmer groups are expected to obey, while Stoll explained the significance of these results for the study of rational points on curves of higher genus. The successful first day of the second week concluded with a well-attended problem session run by Jennifer Park and Arul Shankar.

Tuesday was devoted to a lecture by Wei Ho on the theory of coregular spaces and to Benedict Gross's first lecture, on the theme of arithmetic invariant theory. The problem session, run this time by Wei Ho and Jerry Wang, was as always well attended and much appreciated by the younger participants.

The Wednesday lectures explored in greater depth the results on ranks of elliptic curves, with Manjul Bhargava explaining how they imply (when combined with deep arithmetic results of Gross-Zagier, Kolyvagin, Skinner-Urban, and others) that the Birch and Swinnerton-Dyer conjecture is true for a large, positive proportion of all elliptic curves over the rationals. Poonen described how Bhargava's rank estimates are consistent with various heuristics on the behaviour of Selmer groups which have emerged in recent times, spurred partly by the progress arising from the work of Bhargava, and Gross concluded his two-part series on arithmetic invariant theory.

The Thursday program was devoted to a discussion of hyperelliptic curves, with lectures by Bjorn Poonen, Jordan Ellenberg, and Jerry Wang on the Chabauty method, function field methods, and various counting methods over global fields.

Some of these themes were further amplified in the concluding lectures of Friday, in which Jennifer Park discussed how the Chabauty method can be applied to symmetric powers of curves to yield strong upper bounds on average for the number of rational points of fixed (small) degree on curves of a given genus. Ellenberg concluded his inspiring lecture series on topological and geometric methods in the function field setting. Finally, the SMS ended in grand style, with an ambitious lecture on future perspectives in the subject by Manjul Bhargava, which is sure to have inspired the younger students with the many possibilities still to be explored in this burgeoning new branch of number theory.

## **6. Organisation :**

There were a little over 150 applications received. The 82 participants that were eventually selected were later joined by another 14 well-qualified researchers and local students that registered later in the process. The main selection criterion was the relevance of the SMS theme to the applicant's scientific interests. It was also decided early on to give absolute priority to young researchers without a PhD, and this in itself was enough to narrow down the applicant list to one in which everyone who had a decent scientific justification for wanting to attend could be supported. Among the participants there were 25 women participants of which 3 speakers, 15 postdoctoral researchers and 12 more advanced researchers.

## 7. List of Participants :

<b>SPEAKERS</b>	<b>Institution</b>
Manjul Bhargava	Princeton
Henri Darmon	McGill
Jordan Ellenberg	U Wisconsin
Eknath Ghatge	TIFR
Eyal Goren	McGill
Andrew Granville	U de Montréal
Benedict Gross	Harvard
Wei Ho	Columbia
Melanie Matchett-Wood	U Wisconsin
Jennifer Park	CRM
Bjorn Poonen	MIT
Arul Shankar	Princeton
Michael Stoll	Bayreuth
Takashi Taniguchi	Kobe
Frank Thorne	U South Carolina
Jerry Wang	Princeton

<b>PARTICIPANTS</b>	<b>Institution</b>
Akhtari Shabnam	Univ of Oregon
Alzahrani Manal	Concordia
Amoros Carafi Laia	Université du Luxembourg
Ananth Shankar	Harvard University
Aryan Farzad	University of Lethbridge
Ataei Jaliseh Masoud	Western University
Bardestani Mohammad	University of Ottawa
Bates Matthew	University of Massachusetts
Bettin Sandro	Université de Montréal
Blakestad Clifford	University of Colorado Boulder
Blanco-Chacon Ivan	Aalto University School of Science
Carter Brandon	University of Michigan
Castillo Abel	University of Illinois at Chicago
Chiche-Lapierre Valentine	Concordia
Chow Dylon	University of Illinois at Chicago
Coatney Ryan	University of Arizona
Cowan Alex	Columbia University
David Chantal	Concordia
Davidoff Giuliana	Mount Holyoke College
Davis Rachel	Purdue University
Debaene Korneel	Ghent University
Destagnol Kevin	Université Paris 7
Dixit Anup	University of Toronto
Dupuy Taylor	UCLA
Felix Adam	University of Lethbridge
Fiorilli Daniel	University of Michigan
Freiberg Tristan	University of Missouri
Garcia-Fritz Natalia	Queen's University
Gunton Cody	University of Arizona
Habsieger Laurent	CRM
Hortsch Ruthi	Massachusetts Institute of Technology
Huang Zili	Northwestern University
Ishitsuka Yasuhiro	Kyoto
Jana Subhajit	University of British Columbia
Kamenetsky Daniel	University of South Carolina
Khayutin Ilya	Hebrew University
Klagsbrun Zev	CCR-La Jolla
Krishnamoorthy Raju	Columbia University
Lalin Matilde	Université de Montréal
Lang Jaclyn	University of California - Los Angeles

Le Boudec Pierre	Ecole Polytechnique Fédérale de Lausanne
Lee Seok Hyeong	Princeton University
Lemke Oliver Robert	Stanford University
Leshin Jonah	Brown University
Long Misty	Kansas State University
Maffucci Riccardo Walter	King's College London
Malik Amita	University of Illinois at Urbana-Champaign
Manber Shelly	UC Berkeley
Mangerel Alexander	University of Toronto
McGown Kevin	Ursinus College
McMeekin Christine	Cornell University
Meleleo Giulio	Roma Tre
Milione Piermarco	Universitat de Barcelona
Miller Alison	Princeton University
Miller Daniel	Cornell University
Milovic Djordjo	Leiden University
Mocs Lucia	Princeton University
Morgan Adam	University of Bristol
Najman Filip	University of Zagreb
Nakahara Masahiro	Rice University
Parks James	University of Lethbridge
Pasten Hector	Queen's University
Roe David	University of Calgary
Saha Arnab	Australian National University
Scarfy Justin	The University of British Columbia
Shnidman Ari	University of Michigan
Simard Nicolas	McGill
Singh Vijaykumar	UBC & Simon Fraser University
Somoza Henares Ana	Universitat Politècnica de Catalunya
Su Heng	UC Irvine
Tang Yunqing	Harvard University
Trinh Tien	Rutgers University
Tsang Cindy (Sin Yi)	University of California, Santa Barbara
Tse Ling-Sang	University of Waterloo
Turner Lise	McGill
Vincent Christelle	Stanford University
Wong Peng-Jie	Queen's University
Xia Yuhou	Princeton University
Xio Stanley	University of Waterloo
Yamagishi Shuntaro	University of Waterloo
Youcis Alex	University of California, Berkeley
Zomervucht Wouter	Leiden University

Late registrations	Institution
Amalega Bitongo François	UdM
Beauchamps Houde Gabriel	UdM
Brakocevic Miljan	McGill
Bujold Crystel	UdM
Dias Dimitri	UdM
Elias Yara	McGill
Kisilevski Hershy	Concordia
Koukoulopoulos Dimitris	UdM
Link Sofie	Concordia
Mehdizadeh Marzieh	Concordia
Meisner Patrick	Concordia
Nam Jungbae	Concordia
Sadoughianzadeh Reza	Concordia
Sprung Florian	IHES

## 8. Program :

### SEMAINE I / WEEK I: RINGS AND REPRESENTATIONS WITH ONE INVARIANT

#### Lundi 23 juin/ Monday June 23 – Background

8:00-9:00. Breakfast and registration.

#### 9:00-10:30 : Manjul Bhargava

Introduction and perspective

10 :30. Pause Café/ Coffee break

#### 11:00-12:00 : Eyal Goren

Algebraic groups, representation theory, and invariant theory

12:00-2:00. Dîner/Lunch

#### 2:00-3:00 : Eknath Ghate

Basic algebraic number theory (number fields, class groups, why they are useful/interesting)

3 :00. Pause Café/ Coffee break

#### 3:30-5:00. : Andrew Granville

Basics of binary quadratic forms and Gauss composition.

#### Mardi 24 juin/ Tuesday June 24 – Background, II

8 :30. Petit-déjeuner/ Breakfast

#### 9:00-10:00 : Henri Darmon

Curves, geometric aspects

10 :00. Pause Café/ Coffee break

**10:30-12:00 : Andrew Granville**

Basic analytic number theory

12:00-2:00. Dîner/Lunch

**2 :00-3 :30 : Henri Darmon**

Curves, diophantine aspects

3 :30. Pause Café/ Coffee break

**Mercredi 25 juin/ Wednesday June 25 – Rings and representations with one invariant, I**

8 :30. Petit-déjeuner/ Breakfast

**9:00-10:30 : Eyal Goren**

More algebraic groups, representation theory and invariant theory.

10 :30. Pause Café/ Coffee break

**11:00-12:30 : Melanie Matchett-Wood**

Cubic rings

12:30-2:30. Dîner/Lunch

**2:30-4:00 : Melanie Matchett-Wood**

Quartic and quintic rings

4 :00. Pause Café/ Coffee break

**4:30-5:30. : Jennifer Park, Arul Shankar and Frank Thorne**

Problem session

**Jeudi 26 Juin/ Thursday June 26 – Rings and representations with one invariant, II**

8 :30. Petit-déjeuner/ Breakfast

**9:00-10:30 : Manjul Bhargava**

How to count rings and fields I

10 :30. Pause Café/ Coffee break

**11:00-12:30 : Melanie Matchett-Wood**

Rings associated to binary  $n$ -ic forms, composition of  $2 \times n \times n$  boxes and class groups

12:30-2:30. Dîner/Lunch

**2 :30-4 :00 : Takashi Taniguchi**

The zeta functions attached to prehomogeneous vector spaces

4 :00. Pause Café/ Coffee break

**4 :30-5 :30 : Arul Shankar and Frank Thorne**

Problem session

**Vendredi 27 juin / Friday June 27 – Rings and representations with one invariant, III**

8 :30. Petit-déjeuner/ Breakfast

**9:00-10:30 : Manjul Bhargava**

How to count rings and fields II

10 :30. Pause Café/ Coffee break

**11:00-12:30 : Melanie Matchett-Wood**

Heuristics for number field counts and applications to curves over finite fields.

12:30-2:30. Dîner/Lunch

**2:30-3:30 : Bjorn Poonen**

Moduli space of rings

3 :30. Pause Café/ Coffee break  
**4:00-6:00. : Arul Shankar and Frank Thorne**  
Problem session

**Samedi 28 juin / Saturday June 28**

8 :30. Petit-déjeuner/ Breakfast  
**9 :00-10 :30 : Frank Thorne**  
Zeta Function methods  
10 :30. Pause Café/ Coffee break  
**11 :00-12 :30 : Eknath Ghate**  
Counting Artin representations and modular forms of eight one

**SEMAINE II/ WEEK II: CURVES AND REPRESENTATIONS WITH A FREE RING OF INVARIANTS**

**Lundi 30 juin / Monday, June 30**

8 :30. Petit-déjeuner/ Breakfast  
**9:00-10:30 : Arul Shankar**  
Binary quartic forms; bounded average rank of elliptic curves I  
10 :30. Pause Café/ Coffee break  
**11:00-12:30 : Bjorn Poonen**  
Selmer groups and heuristics I  
12:30-2:30. Dîner/Lunch  
**2:30-3:30. :Michael Stoll**  
Rational points on curves  
3 :30. Pause Café/ Coffee break  
**4:00-5:00 : Jennifer Park and Arul Shankar**  
Problem session

**Mardi 1<sup>er</sup> juillet / Tuesday, July 1**

8 :30. Petit-déjeuner/ Breakfast  
**9:00-10:30 : Arul Shankar**  
Binary quartic forms; bounded average rank of elliptic curves II  
10 :30. Pause Café/ Coffee break  
**11:00-12:30. : Wei Ho**  
Coregular spaces and genus one curves  
12:30-2:30. Dîner/Lunch  
**2:30-4:00 : Benedict Gross**  
Arithmetic invariant theory and hyperelliptic curves I  
4 :00. Pause Café/ Coffee break  
**4:30-5:30 : Wei Ho and Jerry Wang**  
Problem session

**Mercredi 2 juillet / Wednesday, July 2**

8 :30. Petit-déjeuner/ Breakfast



**9:00-10:30 : Manjul Bhargava**

Applications to the Birch and Swinnerton-Dyer conjecture.

10 :30. Pause Café/ Coffee break

**11:00-12:30 : Bjorn Poonen**

Selmer groups and heuristics II

12:30-2:30. Dîner/Lunch

**2:30-3:00 : Jerry Wang**

Pencils of quadrics ; the geometry

**3 :00-4 :00 : Benedict Gross**

Arithmetic invariant theory and hyperelliptic curves II

4 :00. Pause Café/ Coffee break

**4:30-6:00 : Jennifer Park and Jerry Wang**

Problem session

**Jeudi 3 juillet / Thursday, July 3**

8 :30. Petit-déjeuner/ Breakfast

**9:00-10:30 : Bjorn Poonen**

Chabauty methods and hyperelliptic curves

10 :30. Pause Café/ Coffee break

**11:00-12:30 : Jordan Ellenberg**

Topological and algebraic geometry method over function fields I

12:30-2:30. Dîner/Lunch

**2:30-3:30 : Jerry Wang**

Counting methods over global fields

3 :30. Pause Café/ Coffee break

**4:00-6:00 : Jordan Ellenberg, Jennifer Park and Jerry Wang**

Problem session

**6 :00 : RECEPTION**

**Vendredi 4 juillet / Friday, July 4**

8 :30. Petit-déjeuner/ Breakfast

**9:00-10:00 : Jennifer Park**

The Chabauty method and symmetric powers of curves

10 :00. Pause Café/ Coffee break

**10:30-12:00 : Jordan Ellenberg**

Topological and algebraic geometry methods over function fields II

12:30-2:00. Dîner/Lunch

**2 :00-4:00 : Manjul Bhargava**

Future perspectives

<b>MSRI Supported Students</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Matthew	Bates	University of Massachusetts
Clifford	Blakestad	University of Colorado
Brandon	Carter	University of Michigan
Abel	Castillo	University of Illinois
Dylon	Chow	University of Illinois at Chicago
Ryan	Coatney	University of Arizona
Ruthi	Hortsch	Massachusetts Institute of Technology
Zili	Huang	Northwestern University
Jaclyn	Lang	University of California, Los Angeles
Jonah	Leshin	Brown University
Misty	Long	Kansas State University
Amita	Malik	University of Illinois at Urbana-Champaign
Shelly	Manber	UC Berkeley Math Faculty
Christine	McMeekin	Cornell University
Daniel	Miller	Cornell University
Masahiro	Nakahara	Rice University
Ananth	Shankar	Harvard University
Heng	Su	University of California, Irvine
Tien	Trinh	Rutgers University
Cindy	Tsang	University of California, Santa Barbara
Ling-Sang	Tse	University of Waterloo
Yuhou	Xia	Princeton University
Alex	Youcis	University of California, Berkeley

## Student Statistics

<b>Total Students</b>		<b>23</b>
-----------------------	--	-----------

<b>Gender</b>		<b>23</b>
<b>Male</b>	56.52%	13
<b>Female</b>	39.13%	9
<b>Declined to state</b>	4.35%	1

<b>Ethnicity*</b>		<b>23</b>
<b>White</b>	39.13%	9
<b>Asian</b>	43.48%	10
<b>Hispanic</b>	4.35%	1
<b>Pacific Islander</b>	0.00%	0
<b>Black</b>	0.00%	0
<b>Native American</b>	0.00%	0
<b>Declined to state</b>	13.04%	3
<b>Mixed</b>	0.00%	0

\* ethnicity specifications are not exclusive

# 16 responses

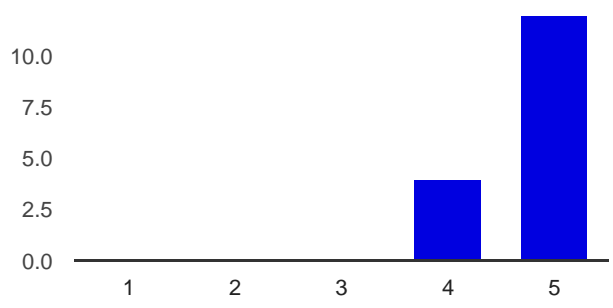
16/23 = 70% response rate

[View all responses](#)   [Publish analytics](#)

## Summary

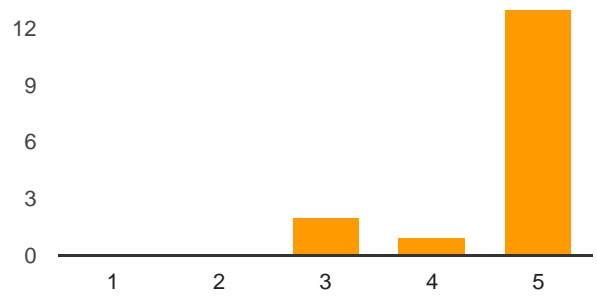
### Topic presentation and organization

The various topics within the summer school integrated into a coherent picture



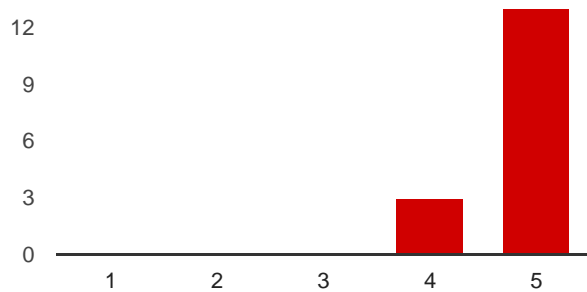
Not at all: 1	0	0%
2	0	0%
3	0	0%
4	4	25%
Very much: 5	12	75%

The faculty speakers were generally clear and well organized in their presentation



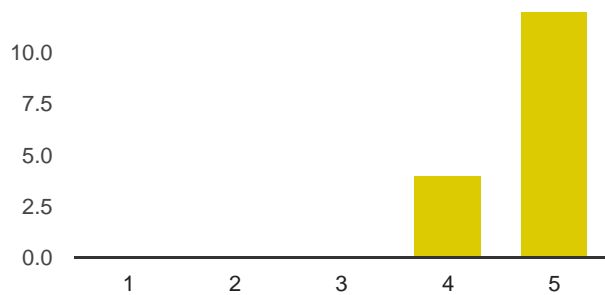
Not at all: 1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>2</b>	12.5%
4	<b>1</b>	6.3%
Very much: 5	<b>13</b>	81.3%

### The school was intellectually stimulating



Not at all: 1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>0</b>	0%
4	<b>3</b>	18.8%
Very: 5	<b>13</b>	81.3%

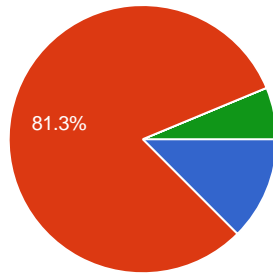
### The overall experience of the school was worthwhile



Not at all: 1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>0</b>	0%
4	<b>4</b>	25%

Very: 5    **12**    75%

**The amount of material presented was:**



Too much	<b>2</b>	12.5%
Just the right amount	<b>13</b>	81.3%
Not enough	<b>0</b>	0%
No opinion	<b>1</b>	6.3%

**Additional comments on the topic presentation and organization**

none

n/a

N.

good

I was extremely impressed with the general clarity of the presentations, as well as the cohesiveness of the entire summer school.

Fantastic school. I had specific goals when I came to attend the school. I ended up learning all that I had set out to learn, and a lot more.

Very well.

It was very well organized, and the speakers that were invited were very good. Bhargava, Wood, Poonen, Granville, Darmon, and etc. all presented very good talks. It was very interesting, and it was presented at just the right level for grad students. Overall, it was a very worthwhile summer school and I am very glad that I had the opportunity to attend.

I think some of the speakers assumed too much background of the audience, and their talks were just not understandable, especially when they go into the very details of the proofs. I think most of the talks were great, but there were a few that I couldn't really get anything out of them.

This was probably the best mathematical conference or summer school I have ever attended, both in terms of the organization as well as the content. All of the speakers gave extremely good lectures, and the atmosphere encouraged much discussion.

I found the second week more stimulating than the first, but I also understand the need to provide background to the talks.

There was a bit of a discrepancy between amount of information assumed, and the topics

discussed. For example, it seems strange to have such a conference, and not assume that people know what a scheme is, or what Riemann-Roch says, and then turn around and give the entirety of a course on LAGs in an hour and a half.

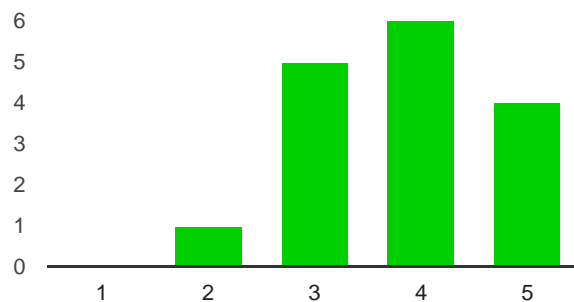
no additional comments

The speakers all did a marvelous job at giving clear and inspiring talks.

Great lectures!!!

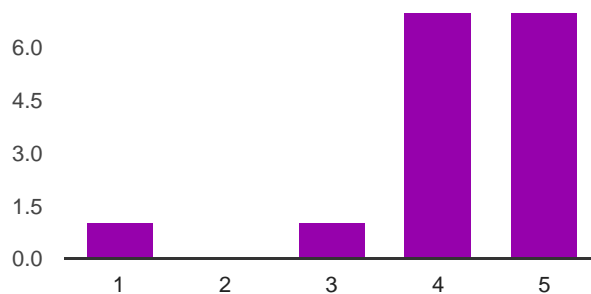
## Personal assessment

### I was well prepared to benefit from the school



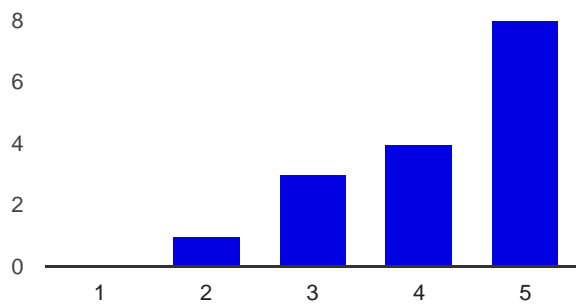
Not at all: 1	<b>0</b>	0%
2	<b>1</b>	6.3%
3	<b>5</b>	31.3%
4	<b>6</b>	37.5%
Very: 5	<b>4</b>	25%

### My interest in the subject matter was increased by the school



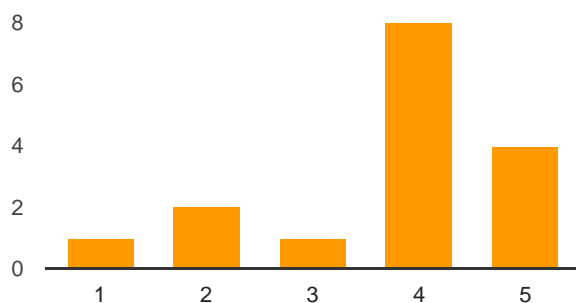
Not at all: 1	<b>1</b>	6.3%
2	<b>0</b>	0%
3	<b>1</b>	6.3%
4	<b>7</b>	43.8%
Very much: 5	<b>7</b>	43.8%

**The school helped me meet people with similar scientific interests**



Not at all: 1	<b>0</b>	0%
2	<b>1</b>	6.3%
3	<b>3</b>	18.8%
4	<b>4</b>	25%
Very much: 5	<b>8</b>	50%

**It is likely that I will work in the area of the school subject in the future**

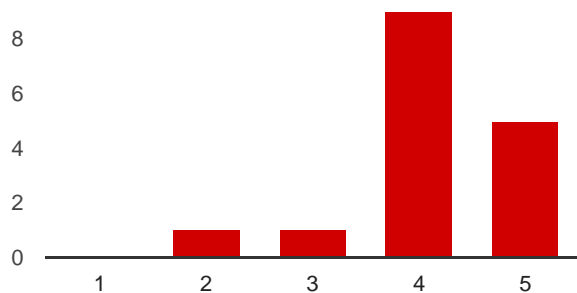


Not at all: 1	<b>1</b>	6.3%
2	<b>2</b>	12.5%
3	<b>1</b>	6.3%
4	<b>8</b>	50%



Very: 5    **4**    25%

### How would you evaluate your interaction with other participants?



not satisfactory: 1	<b>0</b>	0%
2	<b>1</b>	6.3%
3	<b>1</b>	6.3%
4	<b>9</b>	56.3%
above satisfactory: 5	<b>5</b>	31.3%

### Additional comments on your personal assessment

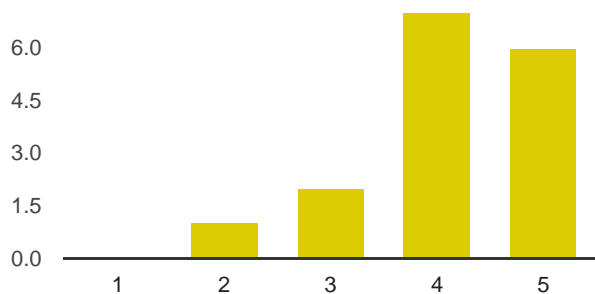
none

It was a very good networking experience.

I was able to meet quite a few other participants and I think it was a great experience.

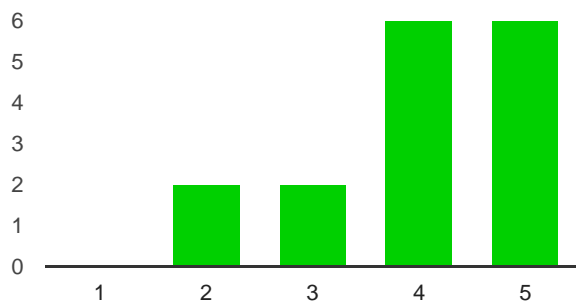
## Venue

### I found the onsite staff helpful



Not at all: 1	<b>0</b>	0%
2	<b>1</b>	6.3%
3	<b>2</b>	12.5%
4	<b>7</b>	43.8%
Very: 5	<b>6</b>	37.5%

### The physical facilities were conducive for such a school



Not at all: 1	<b>0</b>	0%
2	<b>2</b>	12.5%
3	<b>2</b>	12.5%
4	<b>6</b>	37.5%
Very: 5	<b>6</b>	37.5%

### Additional comments on the venue

.

Cookies, bagels, and other snack items frequently ran out before everyone had a chance to take one.

none

The lack of wi-fi in the residences was very cumbersome.

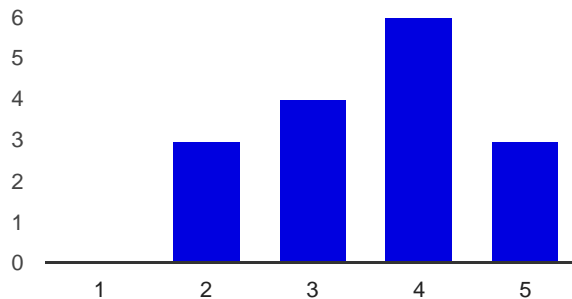
## Accommodation and Food

### The summer school accommodation



not satisfactory: 1	<b>0</b>	0%
2	<b>2</b>	12.5%
3	<b>11</b>	68.8%
4	<b>2</b>	12.5%
above satisfactory: 5	<b>1</b>	6.3%

### The food provided



not satisfactory: 1	<b>0</b>	0%
2	<b>3</b>	18.8%
3	<b>4</b>	25%
4	<b>6</b>	37.5%
above satisfactory: 5	<b>3</b>	18.8%

### Additional comments on accommodation and food

The gym at UdeM does not sell short term memberships. That was very inconvenient

The main problem with our accommodation was that it had no wireless internet.

No internet access in the rooms in the dormitory.

Wifi was at an extra cost and there was no air conditioning. The per diem was a good budget and there were good restaurants nearby the school.

The restaurants are a bit far from the hotel, but I guess it can't be helped.

It would be helpful if wireless internet access was included at the accommodations.

Living in a small room with no air conditioner for two weeks in the middle of summer was quite

unpleasant. Also, that internet in our rooms was not free of charge was quite disappointing.

Essentially having no options except eating out was exhausting after a while.

none

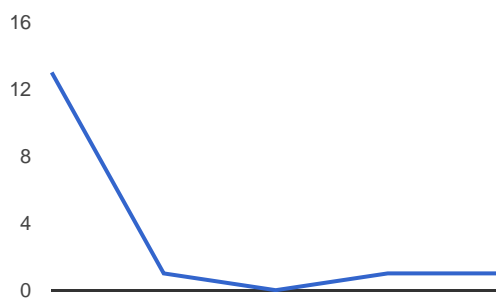
The dorm rooms were too hot (no AC) and no internet, which was very inconvenient.

## Thank you for completing this survey

**We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.**

none

## Number of daily responses



**Summer Graduate School:  
IAS/PCMI 2014: Mathematics and Materials**  
June 29, 2014 to July 19, 2014  
Park City, UT

Organizers:

**Mark Bowick (Syracuse University)**

**David Kinderlehrer (Carnegie Mellon University)**

**Govind Menon (Brown University)**

**Charles Radin (University of Texas)**

## Final report

### MSRI & IAS/PCMI summer school on: Mathematics and Materials

June 29, 2014 - July 19, 2014

Organizers: Mark Bowick (Syracuse University), David Kinderlehrer (Carnegie Mellon University), Govind Menon (Brown University), Charles Radin (University of Texas)

#### DIRECTORS REPORT

Each year, the focus of the IAS/Park City Mathematics Institute is determined by its Research Program and Graduate Summer School. This year, these programs were a vibrant and interdisciplinary mix of mathematical and physical problems motivated by materials science. Both programs attracted students and faculty from departments of chemistry, physics, mathematics and engineering. Topics were chosen to attract mathematicians to many of the fundamental geometric problems in materials science. This led to a focus on a combination of problems at the interface between statistical mechanics, geometry, and the calculus of variations, in order that all participants, especially the students, would obtain a core of knowledge, that they wouldn't be exposed to elsewhere. The mathematical techniques were drawn from analysis, the calculus of variations, discrete geometry, differential geometry, partial differential equations, and probability theory.

One major theme of the program, developed over three weeks, was a treatment of statistical mechanics that ranged from conceptual foundations (ergodicity and entropy in principle and in practice) to rigorous mathematical treatments of phase transitions. Various applications of statistical mechanics were considered, including the study of particulate matter (tilings, packings and crystals), and the development of models for emerging areas of nanoscience, such as synthetic self-assembly. A second theme was the development and analysis of models of soft matter physics, which included studies of the folding and wrinkling of thin films, and the behavior of liquid crystals. These two themes were not distinct since certain problems in phase transitions, such as hysteresis, were studied using tools from the calculus of variations, while statistical mechanics plays a fundamental role in the modeling of liquid crystals.

In a parallel program Undergraduate students followed two three-week courses in which they learned mathematical material fundamental in the study of materials. In one course they learned the calculus of variations, and in the other they learned about aperiodic tilings and quasicrystals. Undergraduates are rarely exposed to applications of mathematics in materials science for a lack of suitable course material.

Participants in the Undergraduate Faculty Program laid the foundation for an undergraduate course on the mathematics of materials. The Undergraduate Faculty Program lecturer, with some other PCMI participants, is planning on writing an undergraduate text on the subject, building on the work done during PCMI.

The mathematics course for the Teacher Program was centered on geometric topics that included tilings of the plane, sphere packing, and related questions about fractions. The teachers also discussed pedagogical issues related to making class room discussions more productive, and prepared materials to support the implementation of the Common Core mathematics standards.

One notable feature of this year's program was the degree to which participants from the various programs interacted. It was not uncommon to see researchers, teachers and students together, constructing origami structures or building a model of a 3-dimensional quasi-crystals. Such interactions are the glue that holds PCMI together and help build bridges between the various components of the mathematical community.

## **GSS & RP REPORT**

The main ideas explored in the graduate school and research program in the 2014 program were an interdisciplinary mix of mathematical and physical problems motivated by materials science. One theme of the program, developed over three weeks, was a treatment of statistical mechanics that ranged from conceptual foundations (ergodicity and entropy in principle and in practice) to rigorous mathematical treatments of phase transitions. Various applications of statistical mechanics were considered, including the study of particulate matter (tilings, packings and crystals), and the development of models for emerging areas of nanoscience, such as synthetic self-assembly. A second theme in the meeting was the development and analysis of models of soft matter physics, including studies of folding and wrinkling of thin films, as well as liquid crystals. These two themes were not completely distinct, since certain problems in phase transitions, such as hysteresis, were studied using tools from the calculus of variations, and statistical mechanics plays a fundamental role in modeling liquid crystals.

The main reason for choosing these topics was as follows: (i) the organizers wanted to construct a summer school in the areas that would not replicate the topics studied in existing summer schools in mathematics and materials; (ii) the organizers wanted to attract mathematicians to many of the fundamental geometric problems in materials science; (iii) the organizers wanted a healthy, and vibrant, interdisciplinary mix. This led them to focus on a combination of problems at the interface between statistical mechanics, geometry, and the calculus of variations, in order that all participants, especially the students, would obtain a core of knowledge, that they wouldn't be exposed to elsewhere. For the same reasons, the organizers expect the PCMI lecture notes to be a unique and valuable resource for the future.

The program included the participation of students and faculty from departments of chemistry, physics, mathematics and engineering. Various communities within mathematics were represented — analysis, calculus of variations, discrete geometry, differential geometry, partial differential equations, and probability theory.

## DESCRIPTIONS

### **Michael P. Brenner, Harvard University; *Self-assembly of sphere packings***

In biological systems, there are striking examples where complicated structures (i.e., the bacterial ribosome) can spontaneously assemble, driven by specific interactions between the components. But how can systems be designed to have this property? Recent technological advances have created the opportunity for making technologically relevant systems that self assemble, using strands of DNA or objects coated with DNA. We will use these systems as inspiration to formulate a series of theoretical models to understand how self assembly works in these systems, through theory, numerical simulation and experiment — and start to speculate as to whether resulting principles might be useful for unravelling the rules of biological self-assembly.

### **Henry Cohn, Microsoft Corp.; *Packing, coding, and ground states: from information theory to physics***

In these lectures, we'll study simple models of materials from three different perspectives: geometry (packing problems), information theory (error-correcting codes), and physics (ground states of interacting particle systems). These perspectives each shed light on some of the same problems and phenomena, while bringing different techniques to bear.

One noteworthy phenomenon is the exceptional symmetry that is found in certain special cases, and we'll examine when and why it occurs.

### **Veit Elser, Cornell University; *Model building in statistical mechanics***

According to Einstein, "Everything should be made as simple as possible, but not simpler." A similar, though not exactly equivalent principle applies to the study of statistical mechanics: to be useful, a model of many-particle behavior should be no more complex than it needs to be. In statistical mechanics the object is not so much to find ever more accurate (and at the same time simple) laws, but to distill simplified models that capture the behavior of interest in minimalist terms. Mathematicians tend to equate statistical mechanics models (and their solution) with the subject itself, and miss out on the equally important process of constructing models. These lectures address this second point, with examples drawn from models well known to mathematicians: tilings, sphere packings, and percolation.

### **Daan Frenkel, University of Cambridge; *Entropy, probability and packing***

The Second Law of Thermodynamics is exceptional because it distinguishes between the past and the future. It also allows us to define a quantity called Entropy that is maximal for a closed system in equilibrium. However, the Second Law does not give a physical interpretation of entropy. Over the past decades our understanding of entropy has increased substantially - partly



due to our ability to perform numerical simulations. In my lectures I will discuss different aspects of entropy in Soft Matter and Granular Media. My conclusion is that Gibbs is always right.

**Richard D. James, University of Minnesota; *Phase transformations, hysteresis and energy conversion: the role of geometry in the discovery of materials***

We identify a particular problem of geometry whose solution profoundly affects the reversibility of phase transformations. This problem has deep links to the study of the calculus of variations and partial differential equations. Solutions of this problem in special cases lend themselves to the discovery of new materials, by systematically changing the composition of known materials to satisfy certain nongeneric restrictions on the lattice parameters of the two phases. This procedure is being put into practice widely. Some materials found by this procedure can be used in interesting ways to convert heat to electricity (without the need of a separate electrical generator), and provide possible ways to recover the vast amounts of energy stored on earth at small temperature difference. For further background, see the video and references at [www.aem.umn.edu/~james/research/home.html](http://www.aem.umn.edu/~james/research/home.html)

**Robert V. Kohn, Courant Institute; *Wrinkling of thin elastic sheets***

Why does the Mobius strip have its familiar shape? Why does a crumpled sheet of paper have sharp folds meeting at points? How is wrinkling different from folding? What determines the shape of a hanging drape? I'll address these and other questions, while explaining why the mechanics of thin sheets has become a research frontier in the Calculus of Variations.

The mathematical heart of the matter is the elastic energy of a thin sheet, which is very nonconvex. It is often fruitful to ask how the minimum energy scales with the film thickness and other physical parameters. Finding the answer requires proving upper bounds and lower bounds that scale the same way. The upper bounds are often easier, since nature gives us a hint. The lower bounds tend to be subtle, since they must be ansatz-independent. In many cases, the arguments used to prove the lower bounds help explain "why" we see particular patterns.

**Roman Kotecký, University of Warwick; *Statistical mechanics of nonlinear elasticity***

The aim of these lectures is to explore statistical physics foundations of nonlinear elasticity. The relevant microscopic models are random gradient vector fields with Gibbs probability distribution. Eventually, the variational characterization of nonlinear elasticity is obtained as a scaling limit in terms of large deviations of random gradient fields. This can be actually viewed as a microscopic justification of the Cauchy-Born rule. We will begin by studying statistical properties of gradient fields in a better understood scalar case. In particular, we will discuss various phase transitions for random interfaces modeled by random gradient scalar fields and related models.

Technical difficulties involved in studying random gradient fields stem from a slow decay of their correlations. This prevents us to treat perturbations by a straightforward cluster expansion

and leads to a necessity of a multi-scale handling with a help of a renormalization group approach. All these technical tools will be carefully explained and implemented.

**Peter Palffy-Muhoray, Kent State University; *The effects of particle shape on soft condensed matter systems***

Soft matter systems can show remarkably complex responses to excitations. Much of this rich diversity originates in interparticle interactions, which can be partitioned into long range attractive and short range repulsive contributions. Particle shape plays an important role in both of these. I will examine these contributions using density functional theory, and discuss relevant results from convex geometry. I will present some new results, and consider their implications on the behavior of soft condensed matter systems.

<b>Organizers and Lecturers</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
David	Kinderlehrer	Carnegie Mellon University
Govind	Menon	Brown University
Charles	Radin	University of Texas
Mark	Bowick	Syracuse University

<b>MSRI Supported Students</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Noemi	Barrera	Politecnico di Milano
Beomjun	Choi	National Institute for Mathematical Sciences
Ngoc	Do	Texas A & M University
Brittan	Farmer	University of Michigan
Alex	Gutierrez	University of Minnesota Twin Cities
Shibi	Kapistharam Vasudevan	University of Missouri
Therese	Landry	San Francisco State University
Lidia	Mrad	Purdue University
Tayyab	Nawaz	University of Illinois at Urbana-Champaign
Drew	Swartz	Purdue University
Abigail	Williams	Northeastern University

## Student Statistics

<b>Total Students</b>		<b>11</b>	
-----------------------	--	-----------	--

<b>Gender</b>		<b>11</b>	
<b>Male</b>	54.55%	6	
<b>Female</b>	45.45%	5	
<b>Declined to state</b>	0.00%	0	

<b>Ethnicity*</b>		<b>11</b>	
<b>White</b>	36.36%	4	
<b>Asian</b>	45.45%	5	
<b>Hispanic</b>	9.09%	1	
<b>Pacific Islander</b>	0.00%	0	
<b>Black</b>	0.00%	0	
<b>Mixed</b>	0.00%	0	
<b>Native American</b>	0.00%	0	
<b>Declined to state</b>	9.09%	1	

\* ethnicity specifications are not exclusive

# 6 responses

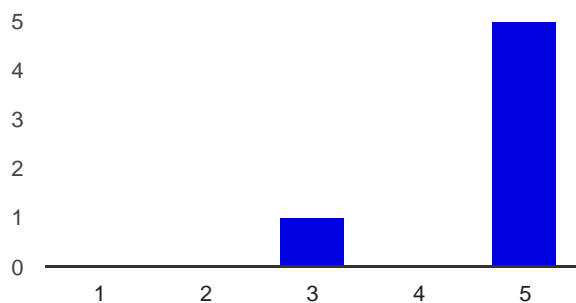
6/11 = 55% response rate

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## Summary

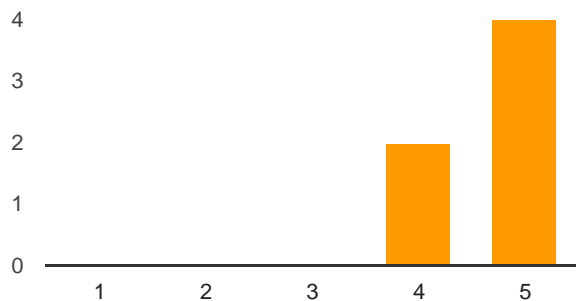
### Topic presentation and organization

The various topics within the summer school integrated into a coherent picture



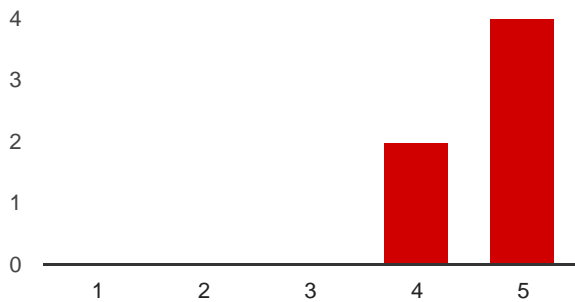
Not at all: 1	0	0%
2	0	0%
3	1	16.7%
4	0	0%
Very much: 5	5	83.3%

The faculty speakers were generally clear and well organized in their presentation



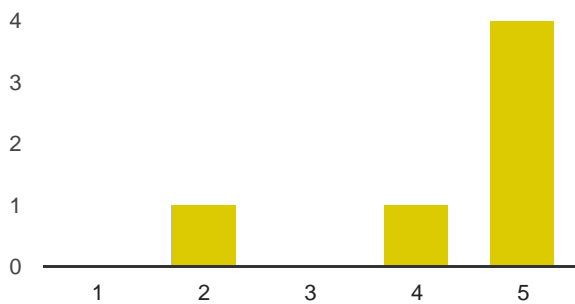
Not at all: 1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>0</b>	0%
4	<b>2</b>	33.3%
Very much: 5	<b>4</b>	66.7%

**The school was intellectually stimulating**



Not at all: 1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>0</b>	0%
4	<b>2</b>	33.3%
Very: 5	<b>4</b>	66.7%

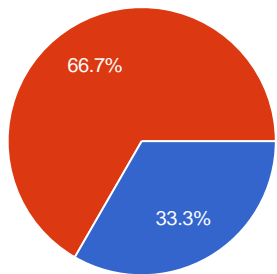
**The overall experience of the school was worthwhile**



Not at all: 1	<b>0</b>	0%
2	<b>1</b>	16.7%
3	<b>0</b>	0%
4	<b>1</b>	16.7%

Very: 5    **4**    66.7%

**The amount of material presented was:**



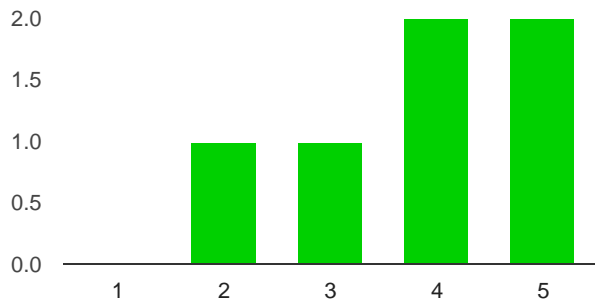
Too much	<b>2</b>	33.3%
Just the right amount	<b>4</b>	66.7%
Not enough	<b>0</b>	0%
No opinion	<b>0</b>	0%

**Additional comments on the topic presentation and organization**

The topics covered in the Graduate Summer School were very good. There was some overlap between the talks, but it was nice to hear different perspectives. With three weeks of talks, I was a bit overloaded with new information by the end.

**Personal assessment**

**I was well prepared to benefit from the school**

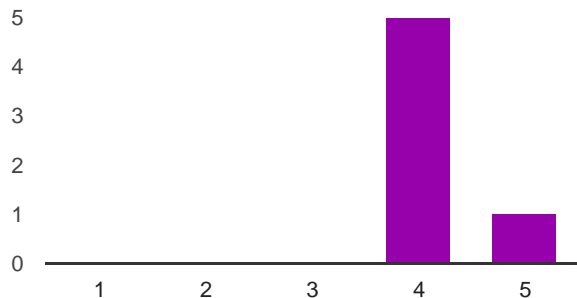


Not at all: 1	<b>0</b>	0%
2	<b>1</b>	16.7%
3	<b>1</b>	16.7%



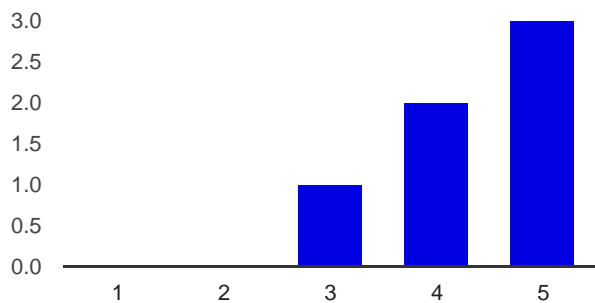
4    2    33.3%  
 Very: 5    2    33.3%

**My interest in the subject matter was increased by the school**



Not at all: 1    0    0%  
                   2    0    0%  
                   3    0    0%  
                   4    5    83.3%  
 Very much: 5    1    16.7%

**The school helped me meet people with similar scientific interests**

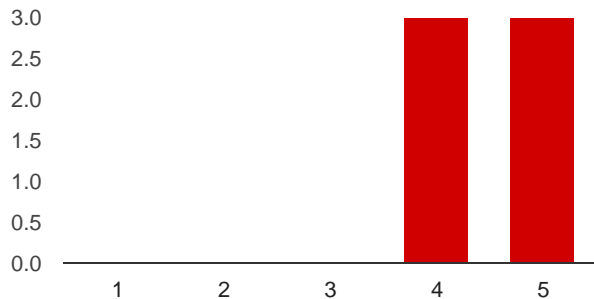


Not at all: 1    0    0%  
                   2    0    0%  
                   3    1    16.7%  
                   4    2    33.3%  
 Very much: 5    3    50%

**It is likely that I will work in the area of the school subject in the future**

Not at all:	1	1	16.7%
	2	0	0%
	3	0	0%
	4	4	66.7%
Very:	5	1	16.7%

**How would you evaluate your interaction with other participants?**



not satisfactory:	1	0	0%
	2	0	0%
	3	0	0%
	4	3	50%
above satisfactory:	5	3	50%

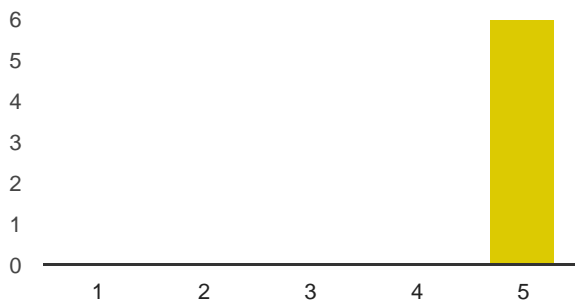
**Additional comments on your personal assessment**

I was able to network with some faculty during the summer school. I also met other graduate students from other schools.

Through contacts made at the summer school, I will be starting a collaboration with researchers in Germany. I think this will be an immense benefit to my future career.

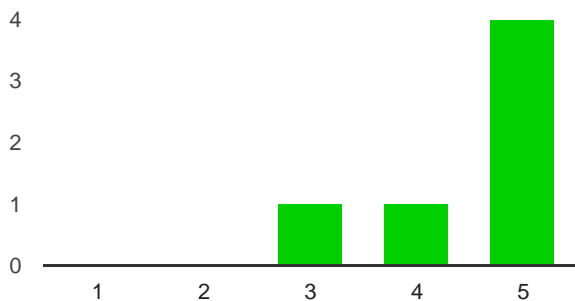
## Venue

### I found the onsite staff helpful



Not at all: 1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>0</b>	0%
4	<b>0</b>	0%
Very: 5	<b>6</b>	100%

### The physical facilities were conducive for such a school



Not at all: 1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>1</b>	16.7%
4	<b>1</b>	16.7%
Very: 5	<b>4</b>	66.7%

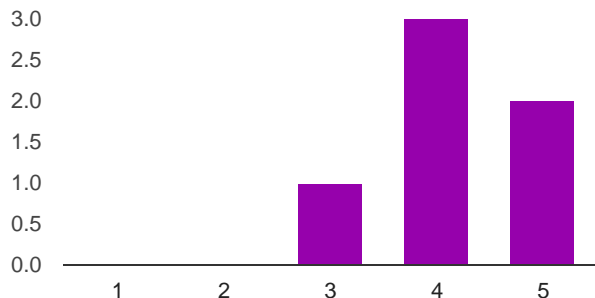
### Additional comments on the venue

Would be nice to have more study space, classrooms, blackboards etc;

The theater at Prospecter Square is great for big talks. It would be nice to have a few more rooms available for private meetings, as most were filled by one of the programs.

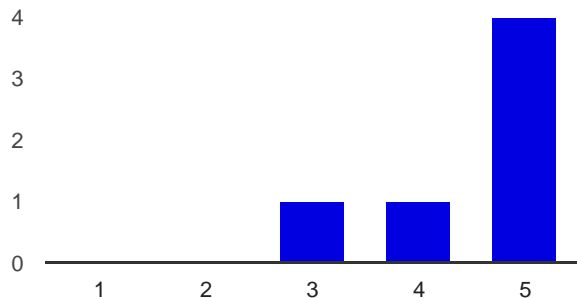
## Accommodation and Food

### The summer school accommodation



not satisfactory: 1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>1</b>	16.7%
4	<b>3</b>	50%
above satisfactory: 5	<b>2</b>	33.3%

### The food provided



not satisfactory: 1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>1</b>	16.7%

4 1 16.7%  
above satisfactory: 5 4 66.7%

### Additional comments on accommodation and food

Variety in food (for example, Indian, Chinese etc) would be nice especially for participants not ethnically American. Regarding accomodation, it would be nice, for single graduate students, to have separate beds of their own, instead of sharing a bed or using a couch sleeper which is not as comfortable.

The food was great. The accommodations were pretty nice, although my room was a bit small. I stayed in Shadow Ridge. The room was great, but it was a 30 minute walk from the conference center. It made everything a little trickier. Also, the fire alarm really liked to go off in the middle of the night.

Would be nice if everyone could be housed closer to the location of the lectures.

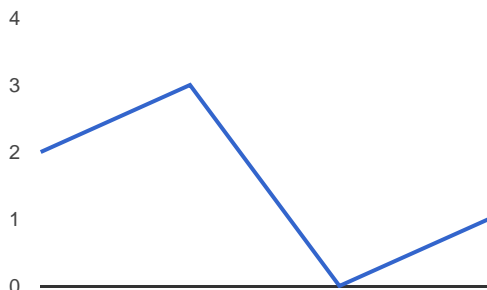
### Thank you for completing this survey

**We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.**

I would have liked it if there had been more information about the speakers and their areas of study before I applied to the school.

The 3D printing workshop was a great idea. In the future, PCMI should have a few more printers on hand.

### Number of daily responses



# **Summer Graduate School: Algebraic Topology**

June 30, 2014 to July 11, 2014

Guanajuato, Mexico

Organizers:

**Jose Cantarero-Lopez (Centro de Investigación en Matemáticas)**

**Michael Hill (University of Virginia)**

# Final Report: MSRI Graduate Summer Workshop 747: Algebraic Topology

Organizers:

Michael Hill (University of Virginia)

José Cantarero (Centro de Investigación en Matemáticas, A.C.)

30 June–11 July, 2014

## Goals and Organization

The goals of this workshop were to introduce graduate students from various backgrounds to the tools of algebraic topology and to help them engage with primary source material for the field. The focus was on more classical material, though the faculty lecturers ensured that they connected the material presented with on-going work in the field. This was accomplished by having faculty and student lectures, problem sessions, and panel discussions:

1. **4 lecture series** of 4 lectures each, introducing students to the **classical foundational aspects of the field**:
  - (a) Michael Hill (University of Virginia) - Introduction to Equivariant Stable Homotopy
  - (b) Samuel Gitler (Centro de Investigación y de Estudios Avanzados del IPN) - Toric Topology
  - (c) José Cantarero (Centro de Investigación en Matemáticas, A.C.) - Homotopical group theory
  - (d) Julie Bergner (University of California) - An introduction to homotopical categories
2. A series of **4 lectures** by Jesús González (Centro de Investigación y de Estudios Avanzados del IPN) on a homotopical view of robotics, part of the exciting new areas in **applied algebraic topology**.
3. **17 student talks** on a sampling of **fundamental papers** of the field, essentially tracing a continuous narrative of understanding manifolds and spaces through the various topological techniques that have evolved.
4. **Problem Sessions** organized by Cantarero and Hill, providing students an opportunity to ask questions about the material from lectures, to work sample problems, and to help prepare their own talks. A key aspect was

a daily list of problems for the students. These focused on fundamental aspects of the lectures, allowing students to explore concrete tasks which explored some of the subtleties.

5. **Career and Jobs Skills Panels** by the faculty and post-docs at the program and by professor Xavier Gómez Mont from CIMAT, helping students navigate the often confusing trajectory of academia by describing their experience and answering questions. Since half of the students were from Mexico, relevant information concerning differences in the academic process in Mexico was provided as well.

## Evaluation of the Workshop

We were very pleased with how the components of the workshop fit together. The lecturers all gave clear, elementary talks, providing the students with broad-strokes overviews. These explained the basic questions and tools in the field, establishing a foundation on which the student lecturers could then build.

In general, we were very happy also with the student participation. Although the quality of the student talks varied, all of the students worked very hard on the preparation and many of the talks were excellent. We were especially impressed with how students from various academic backgrounds were able to engage with these source materials and give clean presentations. All students benefited from the opportunity to practice speaking, and many of the Mexican students doubly benefited by having a chance to practice giving a research level talk in English. Students from Mexican institutions were grateful to have an advanced summer school on algebraic topology in Mexico.

The format of the workshop also fostered close connections between the students. Throughout the day, we witnessed students talking to each other about mathematics, including both advanced students explaining concepts to beginning students as well as students of comparable levels working together on problems and questions. The problem sessions in particular were a big success, as students talked in groups about their ideas, and then worked with the faculty present to flesh them out. Conversations about problems, talks, and mathematics in general often carried over into the coffee breaks and then well into the evening at dinner and coffee shops in town.

In summary, we felt that our goals for the workshop were realized; the students immersed themselves in the methods and questions of modern algebraic topology. Some initial feedback from students includes:

I am really enjoying the minicourses about things that I didn't know, it is making me want to dig deeper into my thesis and use those things.

I learnt a lot while preparing for my talk. [This was a student who went beyond the content of the assigned paper, looked up some of the references and an application!]



## Students and Student Lectures

We modeled the “student lecture” component on MIT’s “Kan Seminar”, building on the success of the Algebraic Topology summer school at MSRI. In this, students read foundational papers and then prepare a 45 minute lecture on the work. The faculty and TAs present help students resolve any confusion and help them craft their talks, and then some feedback is given to the students. Thus the talks have two pedagogical goals:

1. familiarize students with the most influential texts in the field while encouraging them to really delve deeply into a text and
2. provide a safe forum for students to practice giving talks about mathematical works, allowing them to explore speaking styles and helping them better lecture.

We feel that both goals were met with these talks.

We chose a list of about 30 of the most important papers in algebraic topology from the last 50 years (taking care to only include those that are sufficiently self-contained to be approachable by an early career graduate student). Participating students were asked to rank several papers if they wanted to speak, and we then assigned talks based on their rankings. The selections allowed us to have a single narrative running through the entire workshop: the interplay between the study of manifolds and more abstract algebraic topology methods.

Overall, the talks were quite good and very clearly well prepared. Several students gave fantastic talks, ranking well with serious research talks given at conferences. Others struggled to find a coherent story in their paper, making their talks more difficult to follow. One factor influencing this was the tremendous background of the students, even those involved in giving talks. A second was language proficiency, as some Latin American students felt self-conscious about lecturing in English.

While we choose largely self-contained papers, students who had only seen a semester or two of algebraic topology found themselves at a distinct disadvantage. In many cases, it was not so much that the material was too advanced but rather that they had no real experience analyzing primary source mathematics. In the future, to combat this, we would assign talks earlier still, asking the students to send us notes for their talk a month or so in advance of the workshop. This would give us time to provide more detailed feedback. Additionally, we will provide some emailed comments about ways to prepare (beyond the ones given this time), helping make the experience less scary and more of a learning endeavor.

## Faculty Lectures

### **Michael Hill: Introduction to Equivariant Stable Homotopy**

Hill’s lectures explored the basics of equivariant stable homotopy theory, exploring the differences brought about by the inclusion of the action of a finite

group. The first few lectures described the basic categorical constructions in the equivariant context, describing the adjoints to the forgetful functors induced by the inclusion of subgroups. Later lectures described the equivariant analogue of the Suspension theorem, and the ramifications of the various choices of representations used in the stabilizations.

Equivariant stable homotopy has been an integral feature of algebraic topology from the beginning. Hill-Hopkins-Ravenel's recently solution to the Kervaire Invariant One Problem sparked a reinterest in the area, with special focus on computations. The lectures emphasized the intuition underlying the constructions, helping students better understand why things are true and what shows up.

### **Samuel Gitler: Toric Topology**

Gitler's lectures focused on some recently work of his and coauthors on the exciting area of toric topology. This subject sits at the intersection of algebraic geometry, topology, and equivariant homotopy theory. Gitler spent some time focusing on a vast generalization of a result familiar to all first year topology students: the suspension of a Cartesian product splits into factors built out of smash products. In the relative context, there is a natural filtration on the Cartesian powers which Gitler and his collaborators explored, and from this, various endofunctors on the category of pairs of CW-complexes were produced.

Toric manifolds and toric geometry has been an active area of research for many years. The surprising, combinatorial nature of the data of a toric manifold leads to striking theorems. Gitler provided a self-contained introduction to this beautiful field.

### **José Cantarero: Homotopical Group Theory**

Cantarero's lectures focused on the  $p$ -local study of classifying spaces of finite and compact Lie groups. The first two lectures introduced the necessary categorical language and motivation for fusion systems and  $p$ -local finite groups, starting from homological decompositions of classifying spaces of finite groups. The last two lectures motivated the study of  $p$ -compact groups as a generalization of compact Lie groups from the point of view of homotopy theory and introduced the modern theory of  $p$ -local compact groups.

Homotopical group theory has seen a lot of progress in the last three decades, leading to the solution of the maximal torus conjecture, the Martino-Priddy conjecture and Steenrod's problem of spaces with polynomial cohomology. These lectures emphasized the motivation for the construction of all these abstract objects, to help students understand the technical constructions encountered in this area.

## **Jesús González: A Homotopical View of Robotics**

González first explained in his lectures how motion planning problems can be rephrased in terms of topological complexity of the space where the motion occurs. This is a homotopy invariant of type Lusternik-Schnirelman, usually computed using lower and upper bounds which were introduced in the first lecture. The second lecture focused on the relationship between the topological complexity of real projective spaces and the immersion problem for these manifolds. Obstruction theory and Hopf invariants as advanced methods for computations were the focus of the last two lectures.

Topological complexity has been a very active field of research since its introduction by Michael Farber in 2003. Many open questions and computations were mentioned in these lectures, which also introduced classical and modern tools which every algebraic topology student must be acquainted with.

## **Julie Bergner: An Introduction to Homotopical Categories**

Bergner presented a self-contained treatment of homotopical categories. Starting with simplicial sets and their model structures, Bergner moved on to the basics of what we should expect from homotopical categories. She then gave several different models for higher categories, a very exciting and active area of algebraic topology, again grounding the abstract results in very concrete and approachable terms.

Homotopical categories are the heart of modern algebraic topology, and a great deal of recent work has gone into the foundations of the subject. The subject, while very beautiful, has few readily accessible sources (the best currently available is perhaps the technical book of Lurie). Bergner provided students with the intuition behind many of the results in this area, explaining not only why the results are true but also why we would expect such results.

## **Conclusion**

We felt that the workshop achieved our goals of providing a mathematically challenging but socially safe space for students from a wide variety of backgrounds to immerse themselves in mathematics. CIMAT was a wonderful setting for the workshop, with excellent facilities for lectures and a lot of nooks and crannies that allowed students to engage in vigorous mathematical discussion. Guanajuato was also a fantastic location, and students bonded while exploring the various winding streets and cafes.

The student talks were on the whole very successful, we were pleased with how the invited lecture series turned out, and we felt that the various vocational sessions (i.e., the panel discussions) went well. Although there are small things we might do differently should we run such a workshop again, all in all the workshop appeared to us to be a success.

## Organizers\* and Lecturers

First Name	Last Name	Institution
Julie	Bergner	UC Riverside
Jose	Cantarero	Centro de Investigacion en Matemáticas, A.C.
Samuel	Gitler	Centro de Investigacion y de Estudios Avanzados del IPN
Xavier	Gomez Mont	CIMAT
Jesús	González	Centro de Investigacion y de Estudios Avanzados del IPN
Mike	Hill	University of Virginia

<b>Attending Students</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Gabriel	Angelini-Knoll	Wayne State University
George	Carder	Portland State University
Paul	David	Claremont Graduate University
Anne	Dranovski	University of Toronto
Philip	Egger	Northwestern University
Jennifer	Garbett	University of Notre Dame
Bogdan	Krstic	Oregon State University
Zachery	Lindsey	Indiana University
Leanne	Merrill	University of Oregon
Tasos	Moulinos	University of Illinois at Chicago
Ziva	Myer	Bryn Mawr College
Joshua	Rhodes	San Francisco State University
Peder	Thompson	University of Nebraska

## Student Statistics

<b>Total Students</b>		<b>13</b>
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<b>Gender</b>		<b>13</b>
<b>Male</b>	69.23%	9
<b>Female</b>	30.77%	4
<b>Declined to state</b>	0.00%	0

<b>Ethnicity*</b>		<b>13</b>
<b>White</b>	84.62%	11
<b>Asian</b>	0.00%	0
<b>Hispanic</b>	0.00%	0
<b>Pacific Islander</b>	0.00%	0
<b>Black</b>	0.00%	0
<b>Mixed</b>	7.69%	1
<b>Native American</b>	0.00%	0
<b>Declined to state</b>	7.69%	1

\* ethnicity specifications are not exclusive

This form will soon be upgraded to the new version of Google Forms. [Learn more.](#)

# 10 [responses](#)

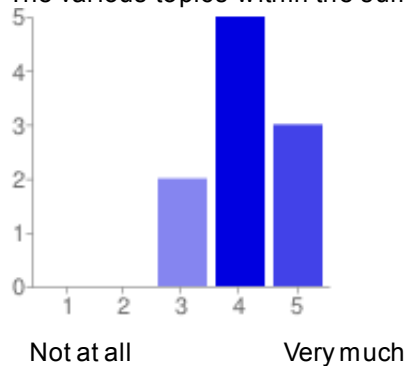
10 responses out of 13 attendees = 77% response rate

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## Summary [See complete responses](#)

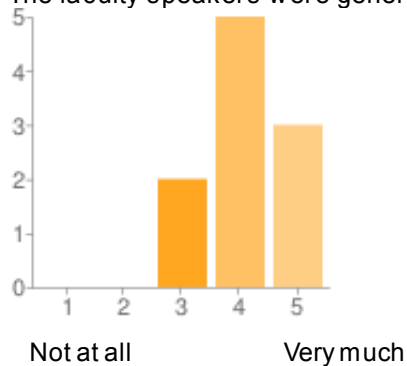
### Topic presentation and organization

The various topics within the summer school integrated into a coherent picture



1 - Not at all	0	0%
2	0	0%
3	2	20%
4	5	50%
5 - Very much	3	30%

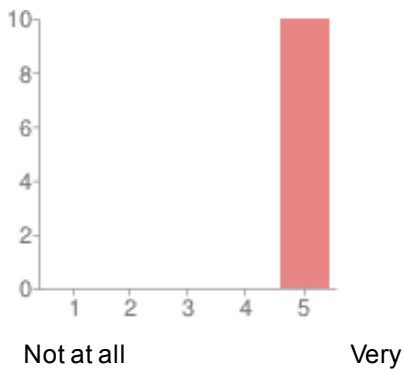
The faculty speakers were generally clear and well organized in their presentation



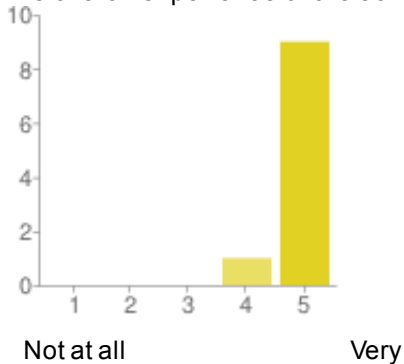
1 - Not at all	0	0%
2	0	0%
3	2	20%
4	5	50%
5 - Very much	3	30%

The school was intellectually stimulating

1 - Not at all	0	0%
2	0	0%
3	0	0%
4	0	0%
5 - Very	10	100%

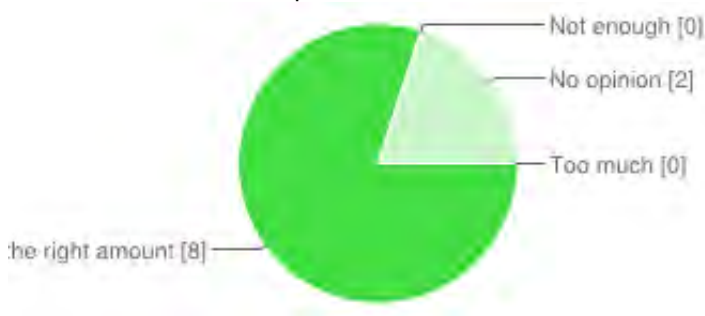


The overall experience of the school was worthwhile



1 - Not at all	0	0%
2	0	0%
3	0	0%
4	1	10%
5 - Very	9	90%

The amount of material presented was:



Too much	0	0%
Just the right amount	8	80%
Not enough	0	0%
No opinion	2	20%

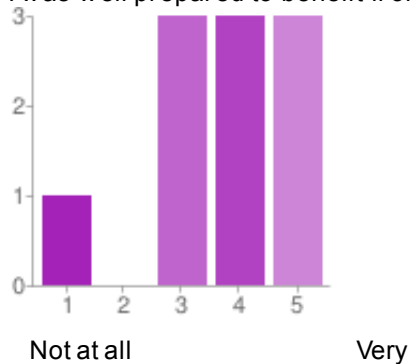
**Additional comments on the topic presentation and organization**

The organizers did a great job of putting together talks which covered fundamentals in algebraic topology as well as new areas of research. Norma and Jose did a great job of welcoming us to a new environment and giving opportunities to see parts of Mexico we wouldn't have been able to otherwise. It was a great opportunity for me personally to give a talk as well. Thank you! Very good I so appreciated the opportunity to attend the summer school in Guanajuato! n/a No comment Very well done I can't comment on this. Please see my "Personal Assessment" section. The faculty speaker score is based on th ...



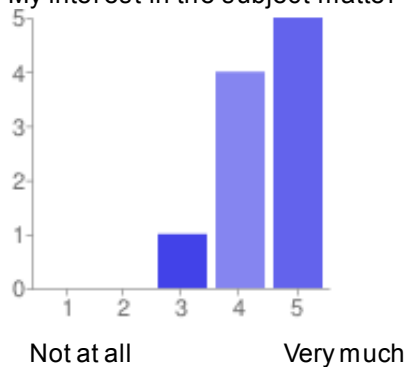
## Personal assessment

I was well prepared to benefit from the school



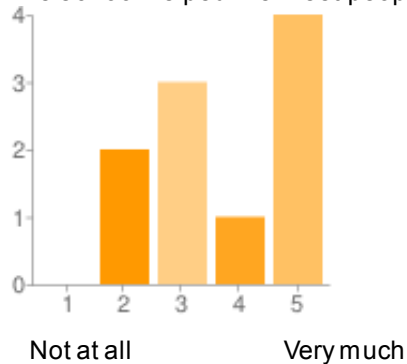
1 - Not at all	1	10%
2	0	0%
3	3	30%
4	3	30%
5 - Very	3	30%

My interest in the subject matter was increased by the school



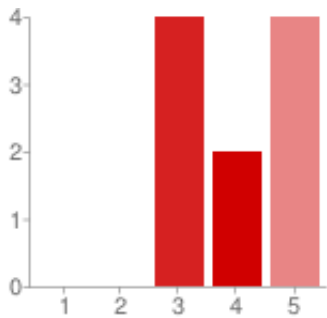
1 - Not at all	0	0%
2	0	0%
3	1	10%
4	4	40%
5 - Very much	5	50%

The school helped me meet people with similar scientific interests



1 - Not at all	0	0%
2	2	20%
3	3	30%
4	1	10%
5 - Very much	4	40%

It is likely that I will work in the area of the school subject in the future

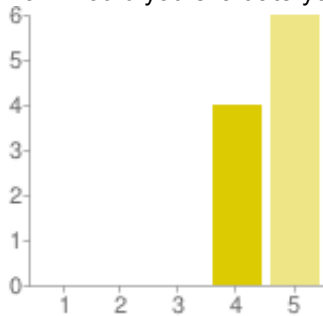


Not at all

Very

1 - Not at all	0	0%
2	0	0%
3	4	40%
4	2	20%
5 - Very	4	40%

How would you evaluate your interaction with other participants ?



not satisfactory above satisfactory

1 -not satisfactory	0	0%
2	0	0%
3	0	0%
4	4	40%
5 -above satisfactory	6	60%

### Additional comments on your personal assessment

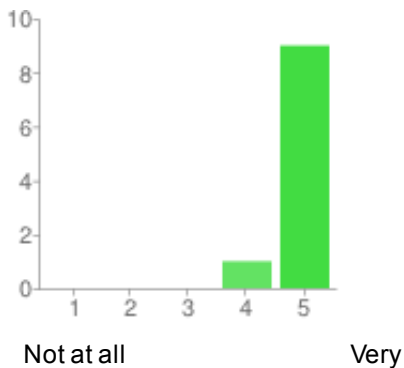
n/a I was under a false presumption that this summer school would help me learn the foundational ideas in algebraic topology, but instead it was assumed that I was coming in with a strong background in the field. Had I known in advanced the amount of information I needed in order to benefit from the workshop, I probably wouldn't have applied. Thankfully it seems that I was one of the exceptions in this regard; most other people seemed to have far more experience than me in algebraic topology. To be specific, my interest is in differential geometry. I know there is a degree of algebraic to ...

### Venue

Please rate the different categories

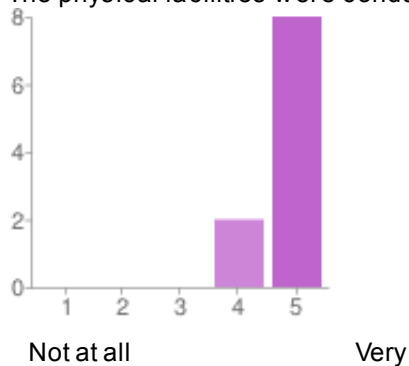
I found the onsite staff helpful

1 - Not at all	0	0%
2	0	0%
3	0	0%
4	1	10%



5 - Very 9 90%

The physical facilities were conducive for such a school



1 - Not at all	0	0%
2	0	0%
3	0	0%
4	2	20%
5 - Very	8	80%

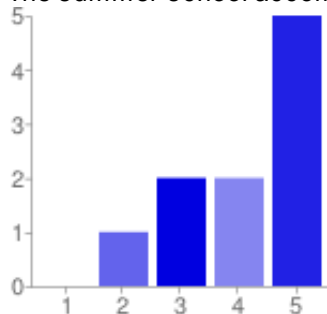
### Additional comments on the venue

n/a Everything was great at CIMAT and they were great hosts. The only thing is that sometimes a few flies got into the lecture hall, and it was very distracting. CIMAT is wonderful!

## Accommodation and Food

Please rate the different categories

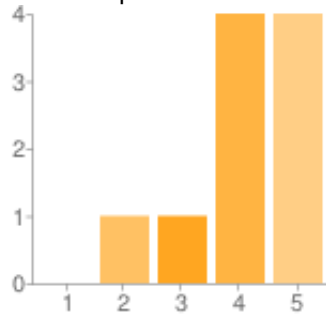
The summer school accommodation



1 -not satisfactory	0	0%
2	1	10%
3	2	20%
4	2	20%
5 -above satisfactory	5	50%

not satisfactory above satisfactory

The food provided



1 -not satisfactory	0	0%
2	1	10%
3	1	10%
4	4	40%
5 -above satisfactory	4	40%

not satisfactory above satisfactory

#### Additional comments on accommodation and food

n/a Cimatel had electricity problems. The food wasn't great even though the portions were huge I am a vegetarian. Although I came to the workshop knowing that none of the staff would know about my dietary restriction, they seemed to never remember that I was vegetarian. This kept occurring. Even on the last day of the program I had to remind the staff of this (and it was the same exact staff for the entirety of my stay).

#### Thank you for completing this survey

We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.

Thanks!!! n/a The atmosphere in the summer school was really good. People were really helpful to each other while explaining and asking questions about different subjects. I also really enjoyed the fact that there were Mexican and US students, I think that enriched the experience of learning and social interaction. The school was great!

Number of daily responses



**Seminaire de Mathematiques Superieures  
2015: Geometric and Computational Spectral  
Theory**

June 15, 2015 - June 26, 2015

MONTREAL, CANADA

Organizers:

**Alexandre Girouard (Laval University)**

**Dmitry Jakobson (McGill University)**

**Michael Levitin (University of Reading)**

**Nilima Nigam (Simon Fraser University)**

**Iosif Polterovich (Université de Montréal)**

**Frederic Rochon (Université du Québec à Montréal)**



Faculté des arts et des sciences  
Département de mathématiques  
et de statistique

## SMS 2015: Director's report.

The 54th *Séminaire de Mathématiques Supérieures* took place in Montréal in the period June 15-July 26, 2015. Touching on a diverse spectrum of themes related to spectral theory, the school was distinguished not only by the excellence of the speakers and students but also by an innovative structure with 19 speakers out of which 7 were junior. This allowed for a particularly interactive activity that consisted not only of mini-courses but also computer labs as well as short presentations by the junior researchers. It all led to a stimulating and intense school.

The organizers, **Alexandre Girouard**, **Dmitry Jakobson**, **Michael Levitin**, **Nilima Nigam**, **Iosif Polterovich**, and **Frédéric Rochon** have done a terrific job in putting together this diverse and exciting program. I thank all of them for their hard work as well as **Ms. Sakina Benhima** from the CRM who assisted them and me with the administrative matters required in running this activity.

As in past years, this edition of the *SMS* was only possible with the co-operation of our main partners the **CRM**, **Fields Institute**, **PIMS** and **MSRI** as well as with support from the **ISM**, the **University of Montreal**, the **Analysis Laboratory** of the CRM and with support from the **Canadian Mathematical Society**. I thank all these institutions for their contributions and I also thank the board of directors of the SMS for their work and support.

In the following you will find a detailed scientific, organizational and budgetary report. I thank again the organizers for taking the time to prepare this document.

Sincerely Yours,

A handwritten signature in blue ink that reads 'O. Cornea'.

Octav Cornea  
Director, Séminaire de Mathématiques Supérieures  
[cornea@dms.umontreal.ca](mailto:cornea@dms.umontreal.ca)

September 14, 2014

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2015 Séminaire de mathématiques supérieures:  
Geometric and Computational Spectral Theory  
June 15 - June 26, 2015

1. Organizers

Alexandre Girouard (Université Laval), Dmitry Jakobson (McGill University), Michael Levitin (University of Reading), Nilima Nigam (Simon Fraser University), Iosif Polterovich (Université de Montréal), Frédéric Rochon (UQ ÀM).

2. Invited Speakers

I. Minicourse lecturers:

Gregory Berkolaiko (Texas A&M): Interlacing eigenvalue inequalities and counting zeros of graph eigenfunctions.

Dorin Bucur (Chambéry): Optimization and spectral inequalities.

Bruno Colbois (Neuchâtel): The spectrum of the Laplacian: a geometric approach.

Chen Greif (UBC): Numerical Solution of Linear Eigenvalue Problems.

Daniel Grieser (Oldenburg): Asymptotics of eigenvalues on thin things.

Colin Guillarmou (ENS): A scattering theory approach for X-ray tomography.

Bernard Helffer (Paris-Sud): On nodal partitions and minimal spectral partitions (an introduction).

Guido Kanschat (Heidelberg): Finite element approximation of eigenvalue problems.

Richard Melrose (MIT): Laplacians degenerating at a point and gluing.

Richard Schoen (Stanford): The spectral geometry of the Dirichlet-Neumann operator.

Mikhail Sodin (Tel Aviv): Random Nodal Portraits.

Alexander Strohmaier (Loughborough): Computation of Eigenvalues, Spectral Zeta Functions and Zeta-Determinants on Hyperbolic Surfaces.

II. Invited junior speakers:

Eldar Akhmetgaliyev (Caltech): Integral equation methods for spectral problems.

Yaiza Canzani (Harvard): Zero sets of monochromatic random waves.

Semyon Dyatlov (MIT): Spectral gaps via additive combinatorics.

Asma Hassannezhad (Max Planck Institute): Counting function and multiplicity of the Laplacian eigenvalues

Corentin Léna (Universita degli studi di Torino): On the number of nodal domains for flat tori.



Romain Petrides ((Universit de Lyon 1): Existence and regularity of maximal metrics for the Laplace eigenvalues on surfaces.

David Sher (University of Michigan): The Steklov spectrum of surfaces.

### 3. Summary

Perhaps the largest school in spectral geometry since the late nineties, this event brought together students and internationally renowned experts in the geometric and computational aspects of spectral theory. The area of spectral theory has fascinated mathematicians and physicists for centuries, and recent years have seen remarkable progress in several branches of the field. The school consisted of twelve minicourses focussing on four main themes: geometry of eigenvalues, geometry of eigenfunctions, computational spectral theory and spectral theory on singular spaces. Inside each theme, three minicourses were given, typically one 4-hour minicourse at the introductory level and two more advanced 3-hour minicourses. A particular emphasis was made on the interplay between the four main topics of the school, notably between the computational and the geometric part — which was one of the most novel aspects of the school. The minicourses were complemented by exercise sessions, computer labs and short (25 minutes) presentations by selected junior participants who have already made important contributions to the subject.

### 4. Record of activities

To orient students with the basics, Week 1 of the summer school began with an introduction by Bruno Colbois to important ideas in the geometry of the Laplace spectrum on compact Riemannian manifolds. Initially, he emphasized the major results, discussing in depth their implications before getting into technical details. This proved helpful to provide an overview for the students, many of which discussed the lectures during the breaks. Over the course of 4 lectures on Monday and Tuesday, Colbois showed the audience key results and techniques in the area, revealing deep geometric insights and sharing open problems. He also organized an open problem session on Monday evening.

In the afternoons on Monday and Tuesday, Guido Kanschat provided an introduction to the finite element approximation theory for eigenproblems. Starting from the basic variational setting, Kanschat showed the importance of designing discretization schemes appropriate for the operator under consideration. For many students, this was the first exposure to numerical analysis in this setting. To aid them, Kanschat designed and conducted computer lab exercises using the deal-ii open source software. Students in the labs were excited to be able to 'see' eigenfunctions for the Laplacian on unusual geometries, and to manipulate boundary conditions. A positive outcome was the 'cross-fertilization' - some students with a priori computing

backgrounds ended up working with students whose training was in geometric spectral theory. Such interactions bode well for the future of the field.

On Tuesday evening, Eldar Akhmetgaliyev presented recent progress in the use of boundary integral techniques for very high-accuracy calculations of spectra, including for the mixed and Steklov problems. These rely on detailed knowledge of the asymptotic behaviour of solutions near singularities, which in turn relies on understanding the geometry of such eigenfunctions. David Sher presented recent work on spectral asymptotics for the Steklov eigenvalues; the results are intriguingly sharp. The pair of lectures highlighted the strengths as well as complementary natures of the approaches.

Starting on Wednesday, Dorin Bucur lectured on isoperimetric inequalities from a shape optimization point of view, allowing for elegant proofs of classical results. Richard Schoen presented more advanced lectures on the spectral geometry of the Dirichlet-Neumann operator and its deep relationship with the problem of finding free boundary minimal surfaces in the ball, bringing the students the state-of-the-art. On Wednesday and Thursday Chen Greif provided an introduction to the field of discrete eigenvalue computation. Since the eigenvalues of a general matrix larger than  $5 \times 5$  cannot be found explicitly, approximation is key. Once again, it is important to design the correct algorithm for a given operator. Greif showed examples where even well-known eigenvalue methods will fail on problems which do not meet the assumptions for the algorithms' convergence. On Friday, Gregory Berkolaiko presented some fascinating lectures on the relation between graph eigenvalues and interlacing eigenvalue inequalities. These were very accessible, and Berkolaiko ensured the audience understood the key ideas by using interesting computer animations and simple exercises. Berkolaiko concluded his lecture series the following Monday with two very interesting lectures on zeros of graph eigenfunctions, as well as on related problems in Mathematical Physics (including the study of graphene).

The second week of the SMS started with a series of talks by Dan Grieser on eigenvalue asymptotic on "thin things," where he explained how to obtain complete asymptotic expansions of eigenvalues of the Laplacian on domains which are close to one-dimensional, for example fat graphs and thin triangles. Dan's lectures also included an introduction to spectral theory on manifolds with corners; he concluded his lectures on Tuesday.

On Monday and Tuesday, Colin Guillarmou gave a series of lectures on a scattering theory approach for X-ray tomography. He discussed how ideas from scattering theory can be applied to study the problem of injectivity of the X-ray transform and application to boundary rigidity problems. A surprising feature originally due to Pestov-Uhlmann is that in dimension 2, there are strong connections between the Dirichlet-to-Neumann operator for the Laplacian and X-ray transform.

On Wednesday, Mikhail Sodin started his lectures titled "Random Nodal Portraits." He described the progress and challenges of understanding the zero sets of smooth Gaussian random functions of several real variables.

Examples included various ensembles of Gaussian real-valued polynomials (algebraic or trigonometric) of large degree, and smooth Gaussian functions on the Euclidean space with translation-invariant distribution. The lectures, which continued on Thursday and on Friday, were based on joint works with Fedor Nazarov.

Next, Richard Melrose started his lecture series on "Laplacians degenerating at a point and gluing." He talked about the behaviour of the Laplace operator for metrics degenerating at a point, especially as related to "gluing constructions" in Riemannian geometry. Examples of degenerations included those obtained by approaching the boundary on the moduli spaces of Riemann surfaces. Some background material for those lectures was previously introduced in the lectures of Dan Grieser. The lectures continued on Thursday and Friday.

In the afternoon, Alex Strohmaier started his lecture series titled "Computation of Eigenvalues, Spectral Zeta Functions and Zeta Determinants on Hyperbolic Surfaces." In the first lecture, he discussed how the method of particular solutions can be used to compute eigenvalues of the Laplace operator on Riemannian manifolds, including hyperbolic surfaces. The second lecture was devoted to the computation of spectral invariants such as the spectral Zeta function and the Zeta regularized determinant of the Laplace operator. The third lecture (given on Thursday) concerned Dirichlet-to-Neumann map and applications to the study of resonances for non-compact manifolds.

In the afternoon, Corentin Lena gave a talk about the number of nodal domains for flat tori. He concentrated on studying Courant-sharp eigenfunctions, as well as on a question raised by T. Hoffmann-Ostenhof in 2012: are there eigenfunctions having an odd number of nodal domains. The day ended by Dmitry Jakobson's survey lecture on Dynamics, Geometry and Spectral Theory; the lecture included videos of Chladni plates.

On Thursday, Bernard Helffer started his lectures on nodal partitions and minimal spectral partitions. The first lecture concentrated on examples and methods of the study of eigenfunctions with the Courant sharp property. Bernard first reviewed basic spectral theorems: Courant, Pleijel, Weyl, Faber-Krahn and application to the analysis of the Courant sharp situation. In the second lecture (given on Friday), he gave an introduction to minimal partitions, main theorems and examples. The third lecture concerned the magnetic characterization of minimal partitions and applications.

Thursday concluded with two lectures by young researchers. Asma Hassannezhad lectures on counting function and multiplicity of the Laplacian eigenvalues. She discussed the study of geometric upper bounds for the multiplicity and counting function of the Laplacian eigenvalues, including some of classical upper bounds due to Cheng, Gromov and Buser, and extensions to domains with Dirichlet and Neumann boundary conditions. Semyon Dyatlov discussed a novel application of methods from additive combinatorics

to the study of spectral gaps on convex co-compact hyperbolic surfaces. Using a fractal uncertainty principle, the size of this gap was expressed via an improved bound on the additive energy of the limit set, making it possible to calculate the size of the gap for a given surface.

On Friday, Sodin, Melrose and Helffer concluded their lectures. In the afternoon, there were two talks by young researchers. In the first talk, Romain Petrides discussed existence and regularity of maximal metrics for the Laplace eigenvalues on surfaces, an old question studied since 1980s by Hersch, Yau, Li, Yang and many others. He also give the link between this problem and minimal immersions into spheres. Yaiza Canzani gave the last talk of the conference. She discussed the structure of zero sets of monochromatic random waves, discussing recent extensions of results of Nazarov and Sodin by Sarnak, Wigman and herself.

## 5. Organization

The school featured about 90 participants (including the speakers and the local participants) from 13 countries spanning five continents. The speakers featured some of the world leading researchers, including two ICM plenary speakers. The non-local junior participants were selected mainly on the basis of the relevance of their research background to the topic of the school. A vast majority of non-local junior participants received financial support that allowed to cover accommodation for the duration of the school. There were 12 women among the participants, including one organizer and two invited junior speakers.

## 6. PARTICIPANTS

<b>ORGANIZERS</b>	
Alexandre Girouard	Université Laval
Dmitry Jakobson	McGill University
Michael Levitin	University of Reading
Nilima Nigam	Simon Fraser University
Iosif Polterovich	Université de Montréal
Frédéric Rochon	UQAM
<b>SPEAKERS</b>	
	<b>Affiliation</b>
Gregory Berkolaiko	Texas A&M University
Dorin Bucur	Université de Savoie
Bruno Colbois	Université de Neuchâtel
Chen Greif	UBC
Daniel Grieser	Univeristy of Oldenburg
Collin Guillarmou	ENS Paris
Bernard Helffer	Université Paris-Sud
Guido Kanschat	Universität Heidelberg
Richard Melrose	MIT
Richard Schoen	Stanford University
Mikhail Sodin	Tel Aviv University
Alexander Strohmaier	Loughborough University
<b>YOUNG SPEAKERS</b>	
Asma Hassannezhad	Max Planck Institute
Eldar Akhmetgaliyev	Caltech
Yaiza Canzani	McGill
Semyon Dyatlov	MIT
Romain Petrides	Université de Lyon 1
David Sher	University of Michigan

<b>PARTICIPANTS</b>	<b>Affiliation</b>
Aiello Gordon	University of Iowa
Ariturk Sinan	Rice University
Armstrong Gavin	University of Oregon
Bei Francesco	Humboldt Universitat zu Berlin
Berger Amandine (F)	Université de Neuchâtel
Booton Laura (Berkolaiko)	Texas A&M University
Cameron Thomas	Washington State University
Causley Broderick	Higher School of Economics
Cecchini Simone	Northeastern University
Cheng Da Rong	Stanford University
Chung Jooyeon F	University of Illinois, Urbana-Champaign
Coleman Neal	Indiana University
Fang Yang-Long	University College London
Fedosova Ksenia (F)	Bonn University
Flynn Steven	UC Santa Cruz
Fritsch Karsten	University College London
Ghorbanpour Asghar	Western University
Gittins Katie (F)	University of Bristol
Gomes Sean (Andrew Hassel)	Australian National University
Greverath Désirée (F)	Stanford University
Honghao Gao	Northwestern University
Joyner Chris	Queen Mary University of London
Karakoc Selcuk	Tulane University
Karpukhin Mikhail	McGill University
Kinzebulatov Damir	University of Toronto
Lee Gihyun	Seoul National University
Lee Ho Jun	Seoul National University
Lee Minjae	UC Berkeley
Lena Corentin	Universita degli studi di Torino
Li Chao	Stanford University
Liu Wen (Berkolaiko)	Texas A&M University
Lungenstrass Tomàs	Pontificia Universidad Católica de Chile
Lvovski Yuri	The Hebrew University of Jerusalem
Morgan Katrina	University of North Carolina
Muckerman Dylan	University of North Carolina at Chapel Hill
Nasserden Dillon	Simon Fraser University
Orduz Juan	Humboldt Universität zu Berlin
Otero Ignacio	CINVESTAV-IPN
Ozturk Hasen	University of Reading
Petiard Luc	Université de Neuchâtel
Ponge Raphaël	Seoul National University
Rayko Arseniy	Lomonosov Moscow State University
Savale Nikhil	University of Notre-Dame

Schenck Emmanuel	Paris 13
Shestakov Ivan	University of Oldenburg
Shi Pengshuai	Northeastern University
Sukhtaiev Selim	University of Missouri - Columbia
Tian Bo	University of Maryland
Tran Nhan	Kansas State University
Valero Carlos	Universidad de Guanajuato
Voss Saskia(F)	Universität Bonn
Wolf Robert	University of Kentucky
Yi Yan	University of Kansas

<b>Late registrations</b>	<b>Affiliation</b>
Craig Gordon	Université Laval
Fiset Marc-Antoine	McGill University
Galkowski Jeffrey	CRM
Labrie Marc-Antoine	Université de Montréal
Lagacé Jean	Université de Montréal
Lu Siyuan	McGill University
Mahdi Ammar	UQAM
Medeiros-Charbonneau Michael	McGill University
Moisan-Roy Patrice	Université Laval
Poliquin Guillaume	Université de Montréal
Roy Simon-Pierre	Université Laval
Roy-Fortin Guillaume	Université de Montréal
Selmani Sam	McGill University

## 7. PROGRAM

### Semaine/Week I

#### Lundi 15 juin

- 08:00-09:30 Inscription et café croissants /Registration and Coffee & Croissants (Room 1221)  
09:30-10:30 **Bruno Colbois** (Univ de Neuchâtel)  
“The spectrum of the Laplacian: a geometric approach I”  
10:30-10:45 Pause-café / Coffee break (Salle / Room 1221)  
10:45-11:45 **Bruno Colbois** (Univ de Neuchâtel)  
“The spectrum of the Laplacian: a geometric approach II”  
11:45-13:30 Pause-déjeuner / Lunch break  
13:30-14:30 **Guido Kanschat** (Universität Heidelberg)  
“Finite element approximation of eigenvalue problems I”  
14:30-14:45 Pause-café / Coffee break (Salle / Room 1221)  
14:45-15:45 **Guido Kanschat** (Universität Heidelberg)  
“Finite element approximation of eigenvalue problems II”  
15:45-16:15 Pause-café / Coffee break (Salle / Room 1221)  
16 :15- Exercices / Discussions

#### Mardi 16 juin

- 09:00-09:30 Café croissants / Coffee & Croissants (Room 1221)  
09:30-10:30 **Bruno Colbois** (Univ de Neuchâtel)  
“The spectrum of the Laplacian: a geometric approach III”  
10:30-10:45 Pause-café / Coffee break (Salle / Room 1221)  
10:45-11:45 **Bruno Colbois** (Univ de Neuchâtel)  
“The spectrum of the Laplacian: a geometric approach IV”  
11:45-13:30 Pause-déjeuner / Lunch break  
13:30-14:30 **Guido Kanschat** (Universität Heidelberg)  
“Finite element approximation of eigenvalue problems III”  
14:30-14:45 Pause-café / Coffee break (Salle / Room 1221)  
14:45-15:45 **Guido Kanschat** (Universität Heidelberg)  
“Finite element approximation of eigenvalue problems IV”  
15:45-16:15 Pause-café / Coffee break (Salle / Room 1221)  
16:15-16:40 **Eldar Akhmetgaliyev** (California Institute of Technology)  
“Integral equation methods for spectral problems”  
16:45-17:10 **David Sher** (University of Michigan)  
17:30- Cocktail de bienvenue/Welcoming Reception



### **Mercredi 17 juin**

- 09:00-09:30 Café croissants / Coffee & Croissants (Room 1221)  
09:30-10:30 **Dorin Bucur** (Université de Savoie)  
“Shape optimization and spectral inequalities I”  
10:30-10:45 Pause-café / Coffee break (Salle / Room 1221)  
10:45-11:45 **Richard Schoen** (Stanford University)  
“The spectral geometry of the Dirichlet-Neumann operator I”  
11:45-13:30 Pause-déjeuner / Lunch break  
13:30-14:30 **Chen Greif** (University of British Columbia)  
“Numerical Solution of Linear Eigenvalue Problems I”  
14:30-14:45 Pause-café / Coffee break (Salle / Room 1221)  
14:45-15:45 **Chen Greif** (University of British Columbia)  
“Numerical Solution of Linear Eigenvalue Problems II”  
15:45-16:15 Pause-café / Coffee break (Salle / Room 1221)  
16:15- Exercices / Discussions

### **Jeudi 18 juin**

- 09:00-09:30 Café croissants / Coffee & Croissants (Room 1221)  
09:30-10:30 **Dorin Bucur** (Université de Savoie)  
“Shape optimization and spectral inequalities II”  
10:30-10:45 Pause-café / Coffee break (Salle / Room 1221)  
10:45-11:45 **Richard Schoen** (Stanford University)  
“The spectral geometry of the Dirichlet-Neumann operator II”  
11:45-13:30 Pause-déjeuner / Lunch break  
13:30-14:30 **Chen Greif** (University of British Columbia)  
“Numerical Solution of Linear Eigenvalue Problems III”  
14:30-14:45 Pause-café / Coffee break (Salle / Room 1221)  
14:45-15:45 **Chen Greif** (University of British Columbia)  
“Numerical Solution of Linear Eigenvalue Problems IV”  
15:45-16:15 Pause-café / Coffee break (Salle / Room 1221)  
16:15- Exercices / Discussions

## Vendredi 19 juin

- 09:00-09:30 Café croissants / Coffee & Croissants (Room 1221)  
09:30-10:30 **Dorin Bucur** (Université de Savoie)  
“Shape optimization and spectral inequalities II”  
10:30-10:45 Pause-café / Coffee break (Salle / Room 1221)  
10:45-11:45 **Richard Schoen** (Stanford University)  
“The spectral geometry of the Dirichlet-Neumann operator II”  
11:45-13:30 Pause-déjeuner / Lunch break  
13:30-14:30 **Gregory Berkolaiko** (Texas A&M University)  
“Interlacing eigenvalue inequalities and counting zeros of graph eigenfunctions I”  
14:30-14:45 Pause-café / Coffee break (Salle / Room 1221)  
14:45-15:45 **Gregory Berkolaiko** (Texas A&M University)  
“Interlacing eigenvalue inequalities and counting zeros of graph eigenfunctions II”  
15:45-16:15 Pause-café / Coffee break (Salle / Room 1221)  
16:15- Exercices / Discussions

## Semaine/Week II

### Lundi 22 juin

- 09:00-09:30 Café croissants / Coffee & Croissants (Room 1221)  
09:30-10:30 **Daniel Grieser** (Carl von Ossietzky Universität Oldenburg)  
“Asymptotics of eigenvalues on thin things I”  
10:30-10:45 Pause-café / Coffee break (Salle / Room 1221)  
10:45-11:45 **Daniel Grieser** (Carl von Ossietzky Universität Oldenburg)  
“Asymptotics of eigenvalues on thin things II”  
11:45-13:30 Pause-déjeuner / Lunch break  
13:30-14:30 **Gregory Berkolaiko** (Texas A&M University)  
“Interlacing eigenvalue inequalities and counting zeros of graph eigenfunctions III”  
14:30-14:45 Pause-café / Coffee break (Salle / Room 1221)  
14:45-15:45 **Gregory Berkolaiko** (Texas A&M University)  
“Interlacing eigenvalue inequalities and counting zeros of graph eigenfunctions IV”  
15:45-16:15 Pause-café / Coffee break (Salle / Room 1221)  
16:15-17:15 **Colin Guillarmou** (École Normale supérieure)  
“A scattering theory approach for X-ray tomography I”

## Mardi 23 juin

- 09:00-09:30 Café croissants / Coffee & Croissants (Room 1221)  
09:30-10:30 **Daniel Grieser** (Carl von Ossietzky Universität Oldenburg)  
“Asymptotics of eigenvalues on thin things II”  
10:30-10:45 Pause-café / Coffee break (Salle / Room 1221)  
10:45-11:45 **Daniel Grieser** (Carl von Ossietzky Universität Oldenburg)  
“Asymptotics of eigenvalues on thin things IV”  
11:45-13:30 Pause-déjeuner / Lunch break  
13:30-14:30 **Colin Guillarmou** (École Normale supérieure)  
“A scattering theory approach for X-ray tomography II”  
14:30-14:45 Pause-café / Coffee break (Salle / Room 1221)  
14:45-15:45 **Colin Guillarmou** (École Normale supérieure)  
“A scattering theory approach for X-ray tomography I”  
15:45-16:15 Pause-café / Coffee break (Salle / Room 1221)  
16:15- Exercices / Discussions

## Mercredi 24 juin

- 09:00-09:30 Café croissants / Coffee & Croissants (Room 1221)  
09:30-10:30 **Mikhail Sodin** (Tel-Aviv University)  
“Random Nodal Portraits I”  
10:30-10:45 Pause-café / Coffee break (Salle / Room 1221)  
10:45-11:45 **Richard Melrose** (MIT)  
“Laplacians degenerating at a point and gluing I”  
11:45-13:30 Pause-déjeuner / Lunch break  
13:30-14:30 **Alexander Strohmaier** (Loughborough University)  
“Computation of Eigenvalues, Spectral Zeta Functions and Zeta-Determinants on Hyperbolic Surfaces I”  
14:30-14:45 Pause-café / Coffee break (Salle / Room 1221)  
14:45-15:45 **Alexander Strohmaier** (Loughborough University)  
“Computation of Eigenvalues, Spectral Zeta Functions and Zeta-Determinants on Hyperbolic Surfaces II”  
15:45-16:15 Pause-café / Coffee break (Salle / Room 1221)  
16:15-16:40 **Corentin Lena** (Universita degli studi di Torino)  
“On the number of nodal domains for flat tori”  
16:45- Exercices / Discussions

## Jeudi 25 juin

- 09:00-09:30 Café croissants / Coffee & Croissants (Room 1221)  
09:30-10:30 **Mikhail Sodin** (Tel-Aviv University)  
“Random Nodal Portraits II”  
10:30-10:45 Pause-café / Coffee break (Salle / Room 1221)  
10:45-11:45 **Richard Melrose** (MIT)  
“Laplacians degenerating at a point and gluing II”  
11:45-13:30 Pause-déjeuner / Lunch break  
13:30-14:30 **Alexander Strohmaier** (Loughborough University)  
“Computation of Eigenvalues, Spectral Zeta Functions and Zeta-Determinants on Hyperbolic Surfaces III”  
14:30-14:45 Pause-café / Coffee break (Salle / Room 1221)  
14:45-15:45 **Bernard Helffer** (Université Paris-Sud)  
“On nodal partitions and minimal spectral partitions (an introduction) I”  
15:45-16:15 Pause-café / Coffee break (Salle / Room 1221)  
16:15-16:40 **Asma Hassannezhad** (Max-Planck Institute for Mathematics)  
“Counting function and multiplicity of the Laplacian eigenvalues”  
16:45-17:10 **Semyon Dyatlov** (UC Berkeley) “Spectral gaps via additive combinatorics”

## Vendredi 26 juin

- 09:00-09:30 Café croissants / Coffee & Croissants (Room 1221)  
09:30-10:30 **Mikhail Sodin** (Tel-Aviv University)  
“Random Nodal Portraits III”  
10:30-10:45 Pause-café / Coffee break (Salle / Room 1221)  
10:45-11:45 **Richard Melrose** (MIT)  
“Laplacians degenerating at a point and gluing III”  
11:45-13:30 Pause-déjeuner / Lunch break  
13:30-14:30 **Bernard Helffer** (Université Paris-Sud)  
“On nodal partitions and minimal spectral partitions (an introduction) II”  
14:30-14:45 Pause-café / Coffee break (Salle / Room 1221)  
14:45-15:45 **Bernard Helffer** (Université Paris-Sud)  
“On nodal partitions and minimal spectral partitions (an introduction) III”  
15:45-16:15 Pause-café / Coffee break (Salle / Room 1221)  
16:15-16:40 **Romain Petrides** (Institut Camille Jordan)  
“Existence and regularity of maximal metrics for the Laplace eigenvalues on surfaces”  
16:45-17:10 **Yaiza Canzani** (McGill University)  
“Zero sets of monochromatic random waves”

<b>MSRI Supported Students</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Gordon	Aiello	University of Iowa
Gavin	Armstrong	University of Oregon
Thomas	Cameron	Washington State University
Simone	Cecchini	Northeastern University
Jooyeon	Chung	University of Illinois at Urbana-Champaign
Neal	Coleman	Indiana University
Steven	Flynn	University of California, Santa Cruz
Honghao	Gao	Northwestern University
Selcuk	KARAKOC	Tulane University
Minjae	Lee	University of California, Berkeley
Chao	Li	Stanford University
Ignacio	Otero	CINVESTAV
Pengshuai	Shi	Northeastern University
Selim	Sukhtaiev	University of Missouri
Bo	Tian	University of Maryland
Nhan	Tran	Kansas State University
Robert	Wolf	University of Kentucky
Yi	Yan	University of Kansas

## Officially Registered Participant Information

<b>Participants</b>		<b>18</b>
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<b>Gender</b>		<b>18</b>
<b>Male</b>	94.44%	17
<b>Female</b>	5.56%	1
<b>Declined to state</b>	0.00%	0

<b>Ethnicity*</b>		<b>18</b>
<b>White</b>	50.00%	9
<b>Asian</b>	44.44%	8
<b>Hispanic</b>	5.56%	1
<b>Pacific Islander</b>	0.00%	0
<b>Black</b>	0.00%	0
<b>Native American</b>	0.00%	0
<b>Mixed</b>	0.00%	0
<b>Declined to state</b>	0.00%	0

\* ethnicity specifications are not exclusive

# 12 responses

12 responses out of 18 students = 66% response rate

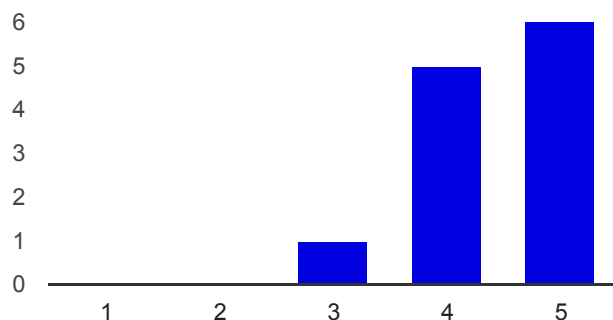
[View all responses](#)   [Publish analytics](#)

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## Summary

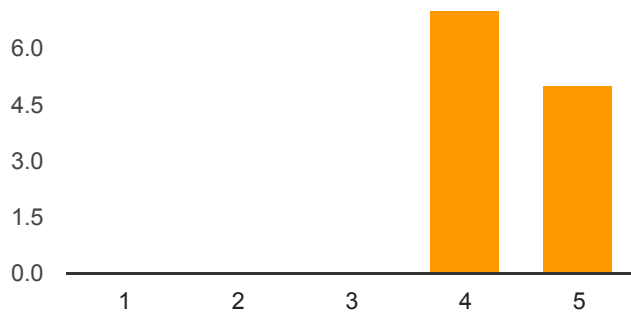
### Topic presentation and organization

The various topics within the summer school integrated into a coherent picture

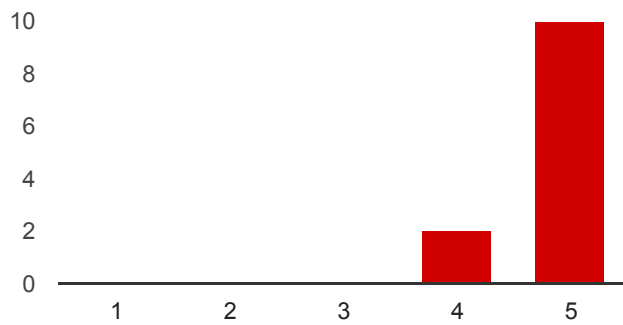


Not at all:	1	0	0%
	2	0	0%
	3	1	8.3%
	4	5	41.7%
Very much:	5	6	50%

The faculty speakers were generally clear and well organized in their presentation

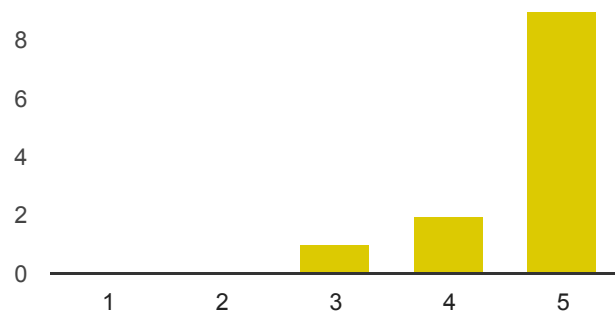


The school was intellectually stimulating



Not at all:	1	0	0%
	2	0	0%
	3	0	0%
	4	2	16.7%
Very:	5	10	83.3%

The overall experience of the school was worthwhile

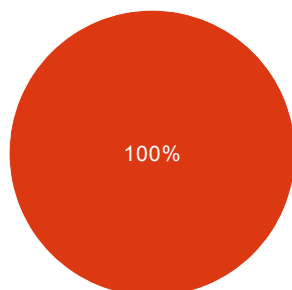


Not at all:	1	0	0%
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2	0	0%
3	1	8.3%
4	2	16.7%
Very: 5	9	75%

The amount of material presented was:



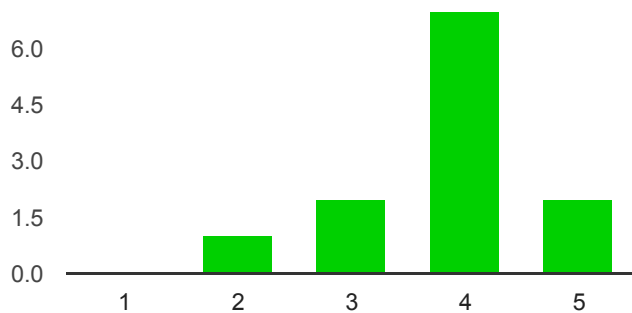
Too much	0	0%
Just the right amount	12	100%
Not enough	0	0%
No opinion	0	0%

### Additional comments on the topic presentation and organization

The topics were quite structured and clear, and connected to give an overview of the area.

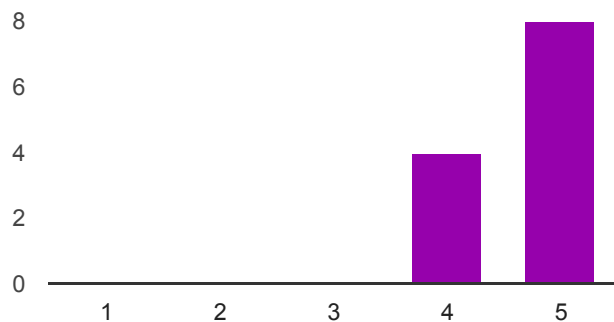
## Personal assessment

I was well prepared to benefit from the school



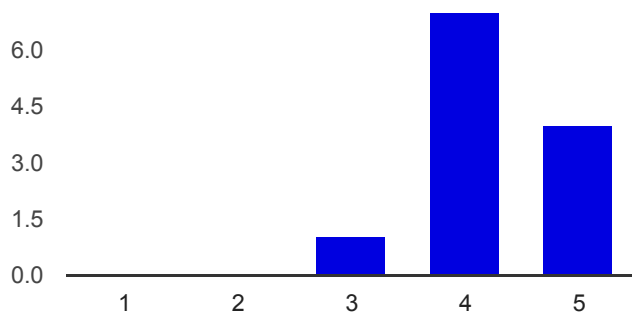
Not at all:	1	0	0%
	2	1	8.3%
	3	2	16.7%
	4	7	58.3%
Very:	5	2	16.7%

My interest in the subject matter was increased by the school



Not at all:	1	0	0%
	2	0	0%
	3	0	0%
	4	4	33.3%
Very much:	5	8	66.7%

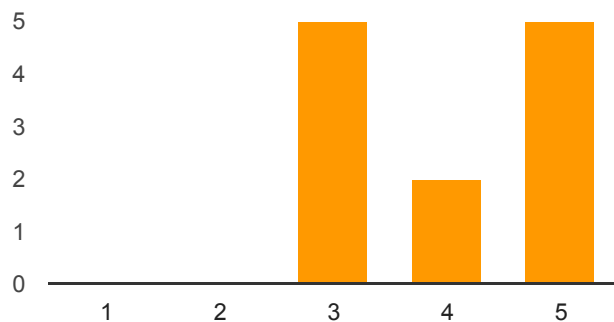
The school helped me meet people with similar scientific interests



Not at all:	1	0	0%
	2	0	0%
	3	1	8.3%
	4	7	58.3%

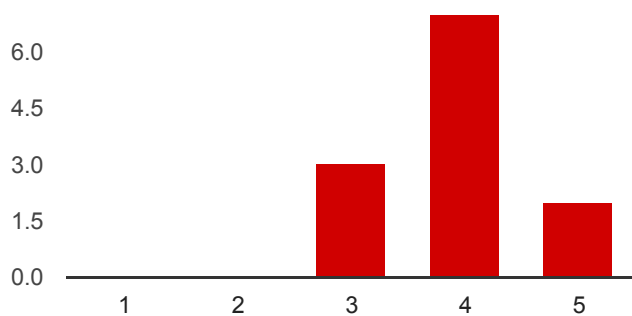
Very much: 5 4 33.3%

It is likely that I will work in the area of the school subject in the future



Not at all: 1 0 0%  
 2 0 0%  
 3 5 41.7%  
 4 2 16.7%  
 Very: 5 5 41.7%

How would you evaluate your interaction with other participants?



not satisfactory: 1 0 0%  
 2 0 0%  
 3 3 25%  
 4 7 58.3%  
 above satisfactory: 5 2 16.7%

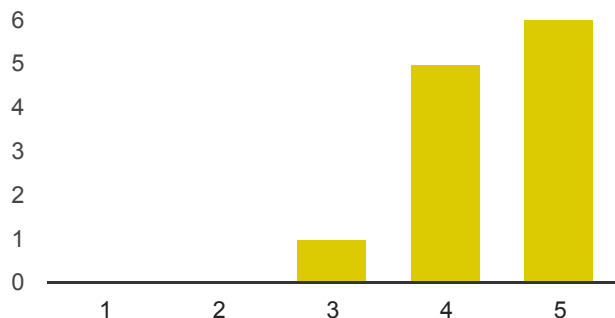
Additional comments on your personal assessment

My interests lie in the numerical side of the eigenvalue problem, moreover I generally consider a large range of operators, not just the Laplacian. However, I very much enjoyed hearing how others view the eigenvalue problem from a purely geometric and topological standpoint. Though I may not take any of these ideas directly to my research, I found a few nuggets of information and much inspiration.

The school has been quite helpful to know tools that I can apply to my area of study. It is quite surprising the connections that I found with my work.

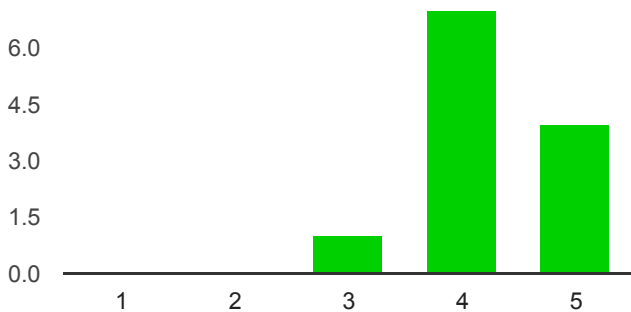
## Venue

I found the onsite staff helpful



Not at all:	1	0	0%
	2	0	0%
	3	1	8.3%
	4	5	41.7%
Very:	5	6	50%

The physical facilities were conducive for such a school



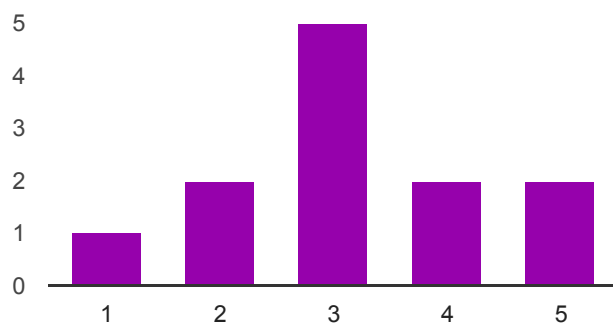
Not at all:	1	0	0%
	2	0	0%
	3	1	8.3%
	4	7	58.3%
Very:	5	4	33.3%

### Additional comments on the venue

The University of Montreal is a wonderful place to study.

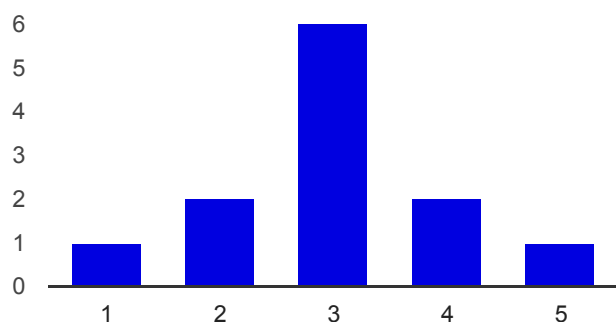
## Accommodation and Food

### The summer school accommodation



not satisfactory:	1	1	8.3%
	2	2	16.7%
	3	5	41.7%
	4	2	16.7%
above satisfactory:	5	2	16.7%

### The food provided



above satisfactory. 0 = not satisfactory

### Additional comments on accommodation and food

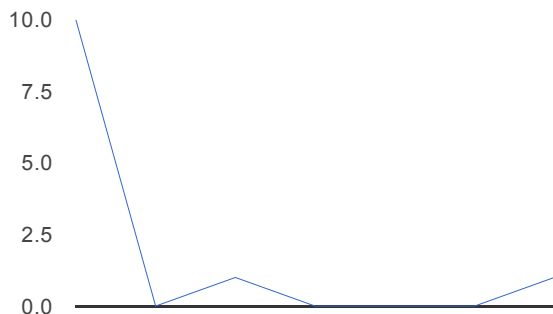
Accommodation is overall good except for that no in-room internet was provided. This is quite unbelievable nowadays. Breakfast provided was really good. No lunch or dinner was provided.

### Thank you for completing this survey

We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.

Thank you for allowing me to participate in one of their programs. Thank you very much for all their support. The school has been of great value in my academic preparation.

### Number of daily responses



**Summer Graduate School**  
**Geometric Group Theory**  
June 15, 2015 - June 26, 2015  
MSRI, Berkeley, CA, USA

Organizers:

**John Mackay (University of Bristol)**

**Anne Thomas (University of Sydney)**

**Kevin Wortman (University of Utah)**

**FINAL REPORT**  
**MSRI SUMMER GRADUATE WORKSHOP ON**  
**‘GEOMETRIC GROUP THEORY’**  
**SUMMER 2015**

JOHN MACKAY, ANNE THOMAS, KEVIN WORTMAN

The goal of this Summer Graduate Workshop was to introduce graduate students to some core topics in Geometric Group Theory (GGT) which will be under study at the upcoming MSRI program on GGT in 2016. Our aim was for students to learn the necessary theoretical background on the given areas, but also to gain the confidence and skills required to apply these ideas to particular questions.

The workshop was massively oversubscribed, with more than twice as many applicants as places; because of this demand, 56 students were accepted in total out of over 90 applications.

The workshop was designed to balance two main components:

- (1) **Lecture series:** We had four minicourses each consisting of five lectures of 75–90 minutes each. Two minicourses were given in each week, with lectures either all in the morning or all in the afternoon.

Geometric Group Theory encompasses a wide range of topics; the four topics were chosen because they are central themes in GGT and in the upcoming MSRI program, accessible to students with a range of backgrounds, and yet lead through to important questions in current research.

- (2) **Problem sessions:** Following each lecture (and a break), we had a problem session also of 75–90 minutes on the topic of the previous lecture. In these problem sessions the lecturer gave out five or six problems for the students to consider. Following this, we grouped the students into threes and fours to work together on these problems or questions they had from the lecture. While this went on, three of the lecturers and organizers went around the groups to keep things on track, offer suggestions and learn what had been discovered.

We now offer some comments and evaluation on how the workshop went.

- (1) The four lecturers were chosen because they are gifted expositors, as well as experts on their given topics. They each gave excellent courses that were accessible, interesting and topical, connecting to current research breakthroughs and challenges. Our view is confirmed by the overwhelmingly positive student feedback we received in person and via survey.

Each of the lecturers had an interactive lecture style with frequent questions, though many students seemed to save their questions for the problem sessions. The lecture length seemed to work well, giving an opportunity to cover a lot of ground at a reasonably relaxed pace; for the days when the lectures were 90 minutes long, a short break mid-lecture refreshed everyone. Detailed descriptions of the courses follow at the end of this report.



- (2) We chose to make the dominant feature of the workshop the problem sessions, with each problem session 75–90 minutes long. We did this because of the diversity of students: some had just finished their first year of grad school, while others were finishing their Ph.D. in a GGT subject. The lecturers prepared around six problems for each session, from routine to advanced, and their careful preparation was crucial to the success of these problem classes.

We loosely enforced group work for the problem sessions: dividing into groups of three or four who were sitting near each other. This has some disadvantages, as the back-of-the-room types tended to be together. However, as we went around the room, talking to them group by group, nearly everyone worked actively and enthusiastically together, helping each other. Our monitoring seemed to keep everyone engaged and making progress, and they enjoyed explaining their ideas to each other and to us. These discussions usually spilled into the breaks and often the next day!

We had one or two students who did not engage in group work well, but the attendance was at least in the high 40s through to the end of the second week, when tiredness started to take its toll.

Our lecturers said they were grateful for these opportunities to discuss with the students as it gave them immediate informal feedback which they used to adjust their lecture approach for the rest of the week. It gave all the students chances to personally interact and ask questions of the lecturers and organizers. They also thought that it was great preparation for the students, helping them to get comfortable working with each other and making contacts at other universities.

- (3) Serendipitously, our time at MSRI overlapped with that of Prof. Francis Su of Harvey Mudd College, President of the MAA, who was organizing a six-week MSRI-UP undergraduate research program. There was a fair amount of interaction between the participants at the two programs, particularly at the lunch times. It was great to see conversations where GGT students answered questions and gave tips on grad school life and application processes for the undergrads.

Towards the end of the workshop, we were delighted to take up Prof. Su's offer to lead a lunchtime discussion on "The transition to life as a faculty member". This went very well, with many questions asked and much insight given. We encourage future summer schools to keep a little flexibility in their schedules to allow for such unexpected opportunities.

- (4) The barbecue in the first week was a great idea to help build rapport and get everyone interacting. Throughout the workshop, at breaks, lunches, and walks there was a collegial atmosphere which gave many opportunities for mathematical discussions. With such a large group, it was tricky to arrange other official activities, but we enjoyed a few informal meetings at a local pub.
- (5) As already remarked, the students had a wide range of backgrounds, but regardless of this their enthusiasm and talent were essential to the success of this workshop. We found the pre-workshop survey results helpful in pitching the courses at the right levels: we had asked for their background on relevant topics. We would suggest also asking for years of grad study as this would have been helpful.

We are very grateful to MSRI staff for their exceptional helpfulness and professionalism. Outside the control of MSRI, there was a problem with overcrowding on the buses up the hill to the MSRI building due to a change in the Berkeley campus bus service which meant it was inadequate to deal with our numbers at rush times. After the first day, MSRI staff used a sign-up sheet to spread our numbers over more buses which reduced the issues greatly.

All the local organization was excellently handled by MSRI, such as accommodation, lunches and reimbursement.

As organizers, we are very grateful for the contributions of MSRI, the lecturers, and the students, who together worked to make the workshop a success. As one of the students put it, we “enjoyed every minute of it”!

We conclude by summarizing each of the four minicourses.

*Pallavi Dani: Dehn functions*

The course on Dehn functions began with group presentations, the definition of a Dehn function, and the connections of Dehn functions with the word problem and with Riemannian filling functions. Further topics included the linearity of Dehn functions of hyperbolic groups, Dehn functions of various nilpotent and solvable groups, examples of groups with quadratic isoperimetric inequalities and of groups with large Dehn functions, and a discussion of the question of which functions arise as Dehn functions. Problems were chosen with a view to familiarizing the audience with standard tools such as van Kampen diagrams and corridor arguments. The course ended with higher dimensional Dehn functions and homological Dehn functions, which are topics of current interest.

*Alex Furman: Amenability, Property (T) and affine isometric actions*

In the first two lectures of this course we looked at the concept of amenability for discrete countable groups. We began by considering the various equivalent definitions of amenability, including those in terms of invariant means, fixed points of group actions, Følner sequences, and paradoxical (‘Banach–Tarski’) decompositions. We explored basic properties and examples in the problem classes. Finally, we characterized amenability in terms of unitary representations of the group.

This last topic naturally led us on to the topic of the remaining three lectures: Kazhdan’s Property (T), originally defined in terms of unitary representations. We thought about the basic properties of such groups and important motivating examples and applications. One of the best known of these is Margulis’ construction of expander graphs, which have applications throughout mathematics and computer science. We then explored the connections between a group  $G$  having Property (T), every affine isometric action of  $G$  on a Hilbert space having a fixed point (‘Property FH’), and every action of  $G$  on a tree having a fixed point (Serre’s ‘Property FA’). Finally, we mentioned a brand new (2013) characterization of Property (T) by Ozawa.

*Jason Manning: CAT(0) geometry and cube complexes*

In the first lecture we looked at non-positive curvature for geodesic metric spaces and the CAT(0) condition. We introduced cube complexes and Gromov’s link condition which characterizes when they are CAT(0). In the second lecture we studied non-positively curved cube complexes (NPCCCs) using disk diagrams, connecting to techniques learned in Dani’s course. In the exercises we used ideas from Furman’s Property (T) course to study group actions on such spaces. In the third lecture we saw how

NPCCCs arise in nature, connecting them to immersed hypersurfaces in manifolds and codimension-one subgroups.

In the final two lectures we saw how NPCCCs gave us a powerful tool for studying the separability of subgroups, using free groups as a key example, and saw how the arguments here motivate Haglund–Wise’s definition of special cube complexes.

*Matt Day: Mapping class groups and  $Out(F_n)$*

For mapping class groups, we largely followed Farb–Margalit’s “Primer on Mapping Class Groups”. We began with the classification of surfaces, curves on surfaces and intersection numbers. We then defined the mapping class group of a surface, and gave examples using Dehn twists. The second lecture worked towards the Dehn–Lickorish theorem showing the finite generation of mapping class groups, using tools such as the Birman exact sequence and the curve complex.

For the next lecture or so, we thought about the Nielsen–Thurston classification theorem, pseudo-Anosov homeomorphisms, the definition of Teichmüller space and the Fenchel–Nielsen theorem on finite-order mapping classes. The Dehn–Nielsen–Baer theorem links mapping class groups to the outer automorphism group of a surface group. This naturally led on to our final topic, the (outer) automorphism group of the free group. We looked at Nielsen reduction in  $Aut(F_n)$  and Stallings folding, and Torelli subgroups and Johnson homomorphisms for  $Aut(F_n)$  and mapping class groups. We closed by introducing Culler–Vogtmann Outer space: an analogue of Teichmüller space for  $Out(F_n)$ .

### Organizers

First Name	Last Name	Institution
John	Mackay	University of Bristol
Anne	Thomas	University of Sydney
Kevin	Wortman	University of Utah

### Speakers

First Name	Last Name	Institution
Pallavi	Dani	Louisiana State University
Matthew	Day	University of Arkansas
Alex	Furman	University of Illinois at Chicago
Jason	Manning	Cornell University



## Geometric Group Theory

June 15 -26, 2015

### Schedule

Monday Jun 15, 2015			
9:00 AM - 9:15 AM	Simons Auditorium		Introduction to MSRI
9:15 AM - 10:30 AM	Simons Auditorium	Pallavi Dani	Lecture
10:30 AM - 11:00 AM	Atrium		Break
11:00 AM - 12:15PM	Simons Auditorium		Problem Class
12:15PM - 1:45 PM	Atrium		Lunch
1:45 PM- 3:15PM	Simons Auditorium	Alex Furman	Lecture
3:15 PM - 3:45 PM	Atrium		Tea
3:45 PM - 5:00 PM	Simons Auditorium		Problem Class

Tuesday June 16, 2015			
9:00 AM - 10:15 AM	Simons Auditorium	Pallavi Dani	Lecture
10:15 AM - 10:45 AM	Atrium		Break
10:45 AM - 12:15 PM	Simons Auditorium		Problem Class
12:15 PM - 1:45PM	Atrium		Lunch
1:45PM - 3:00 PM	Simons Auditorium	Alex Furman	Lecture
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM -5:00 PM	Simons Auditorium		Problem Class

Wednesday June 17, 2015			
9:00 AM - 10:15 AM	Simons Auditorium	Pallavi Dani	Lecture
10:15 AM -10:45 PM	Atrium		Break
10:45 PM - 11:30 PM	Simons Auditorium		Problem Class
11:30 PM - 2:00 PM	Tilden Park		BBQ Lunch
2:00 PM - 03:15PM	Simons Auditorium	Alex Furman	Lecture
3:15 PM - 3:45 PM	Atrium		Tea
3:45PM-4:45 PM	Simons Auditorium		Problem Class

Thursday June 18, 2015			
9:00 AM - 10:30 AM	Simons Auditorium	Pallavi Dani	Lecture
10:30 AM - 11:00 AM	Atrium		Break
11:00 AM - 12:15 PM	Simons Auditorium		Problem Class
12:15 PM- 1:45 PM	Atrium		Lunch
1:45 PM - 3:15 PM	Simons Auditorium	Alex Furman	Lecture
3:15 PM - 3:45 PM	Atrium		Tea
3:45 PM - 5:00PM	Simons Auditorium		Problem Class

Friday June 19, 2015			
9:00 AM - 10:15 AM	Simons Auditorium	Pallavi Dani	Lecture
10:15 AM - 10:45 AM	Atrium		Break
10:45 AM - 12:15 PM	Simons Auditorium		Problem Class
12:15 PM - 1:45PM	Atrium		Lunch
1:45 PM - 3:00 PM	Simons Auditorium	Alex Furman	Lecture
3:00 PM -3:30 PM	Atrium		Tea
3:30 PM - 5:00 PM	Simons Auditorium		Problem Class

Monday June 22, 2015			
9:00 AM - 10:30AM	Simons Auditorium	Jason Manning	Lecture
10:30 AM - 11:00 AM	Atrium		Break
11:00 AM - 12:15 PM	Simons Auditorium		Problem Class
12:15PM - 1:45 PM	Atrium		Lunch
1:45 PM- 3:15 PM	Simons Auditorium	Matthew Day	Lecture
3:15 PM - 3:45 PM	Atrium		Tea
3:45 PM - 5:00 PM	Simons Auditorium		Problem Class

Tuesday June 23, 2015			
9:00 AM - 10:15 AM	Simons Auditorium	Jason Manning	Lecture
10:15 AM - 10:45AM	Atrium		Break
10:45 AM - 12:15 PM	Simons Auditorium		Problem Class
12:15 PM - 1:45 PM	Atrium		Lunch
1:45 PM -3:00 PM	Simons Auditorium	Matthew Day	Lecture
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 5:00 PM	Simons Auditorium		Problem Class

Wednesday June 24, 2015			
9:30 AM - 10:45 AM	Simons Auditorium	Jason Manning	Lecture
10:45 AM - 11:15 AM	Atrium		Break
11:15 AM - 12:15 PM	Simons Auditorium		Problem Class
12:15 PM - 1:45 PM	Atrium		Lunch
1:45PM - 3:00 PM	Simons Auditorium	Matthew Day	Lecture
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM -4:30 PM	Simons Auditorium		Problem Class

Thursday June 25, 2015			
9:00 AM - 10:30 AM	Simons Auditorium	Jason Manning	Lecture
10:30 AM - 11:00 AM	Atrium		Break
11:00 AM - 12:15PM	Simons Auditorium		Problem Class
12:15 PM - 1:45 PM	Atrium		Lunch Break
1:45 PM - 3:15 PM	Simons Auditorium	Matthew Day	Lecture
3:00 PM -3:30 PM	Atrium		Tea
3:30 PM - 5:00 PM	Simons Auditorium		Problem Class

Friday June 26, 2015			
9:00 AM - 10:15 AM	Simons Auditorium	Jason Manning	Lecture
10:15 AM - 10:45 AM	Atrium		Break
10:45 AM - 12:15 PM	Simons Auditorium		Problem Class
12:15PM - 1:45 PM	Atrium		Lunch
1:45 PM - 3:00 PM	Simons Auditorium	Matthew Day	Lecture
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 5:00 PM	Simons Auditorium		Problem Class

<b>MSRI Supported Students</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Andreas	Aaserud	University of California
Carolyn	Abbott	University of Wisconsin-Madison
Victoria	Akin	University of Chicago
Faraad	Armwood	North Dakota State University
Hanna	Astephan	University of Utah
Maxime	Bergeron	University of British Columbia
Danielle	Brager	Arizona State University
Corey	Bregman	Rice University
Nicholas	Cahill	University of Utah
Ana Catalina	Camacho Navarro	Colorado State University
Yu-Chan	Chang	Louisiana State University
Tommaso	Cremaschi	Boston College
Yen	Duong	University of Illinois, Chicago
Eduard	Einstein	Cornell University
Barry	Fadness	Portland State University
Maranda	Franke	University of Nebraska
Zachary	Gates	University of Virginia
Dmitri	Gekhtman	California Institute of Technology
Tyrone	Ghaswala	University of Waterloo
Jeremiah	Goertz	Iowa State University
Sahana	Hassan Balasubramanya	Vanderbilt University
Cristhian	Hidber Cruz	Centro de Investigacion y de Estudios Avanzados del IPN
Hongtaek	Jung	Korea Advanced Institute of Science and Technology (KAIST)
Robert	Kelvey	Bowling Green State University
Chris	Kennedy	Ohio State University
Matthew	Kim	San Francisco State University
Michael	Klug	University of California, San Diego
Sudipta	Kolay	Georgia Institute of Technology
Matthew	Lee	University of California, Riverside
Donsung	Lee	Seoul National University
David	Meyer	University of Iowa
Sam	Nariman	Stanford University
Thomas	Ng	Temple University
Mark	Nieland	University at Buffalo (SUNY)
Henning	Niesdroy	Universität Bielefeld
Anisah	Nu'Man	University of Nebraska
Christopher	O'Donnell	Tufts University
Forrest	Parker	Oregon State University
Mark	Pengitore	Purdue University
Jacob	Russell	City University of New York (CUNY)
Chandrika	Sadanand	State University of New York, Stony Brook
Luis	Sanchez	UNAM - Universidad Nacional Autonoma de Mexico
Tian	Sang	University of Melbourne
Daniel	Scofield	North Carolina State University

<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Ignat	Soroko	University of Oklahoma
Kursat	Sozer	Indiana University
Ashleigh	Thomas	Duke University
Bena	Tshishiku	Stanford University
Caglar	Uyanik	University of Illinois at Urbana-Champaign
Pei	Wang	Rutgers University
Laura	Wells	University of Notre Dame
FEIFEI	XIE	University of Massachusetts, Amherst
Jiawei	Zhou	University of California, Irvine
Feng	Zhu	University of Michigan
Zhifei	Zhu	University of Toronto

## Officially Registered Student Information

<b>Participants</b>		<b>59</b>
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<b>Gender</b>		<b>59</b>
<b>Male</b>	72.88%	43
<b>Female</b>	27.12%	16
<b>Declined to state</b>	0.00%	0

<b>Ethnicity*</b>		<b>65</b>
<b>White</b>	44.62%	29
<b>Asian</b>	26.15%	17
<b>Hispanic</b>	6.15%	4
<b>Pacific Islander</b>	1.54%	1
<b>Black</b>	6.15%	4
<b>Native American</b>	0.00%	0
<b>Mixed</b>	4.62%	3
<b>Declined to state</b>	10.77%	7

\* ethnicity specifications are not exclusive



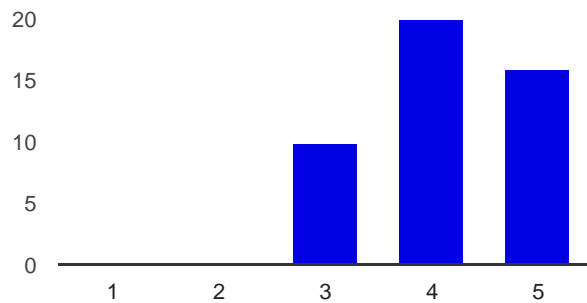
# 46 responses

46/59 = 77% Response Rate  
[View all responses](#) [Publish analytics](#)

## Summary

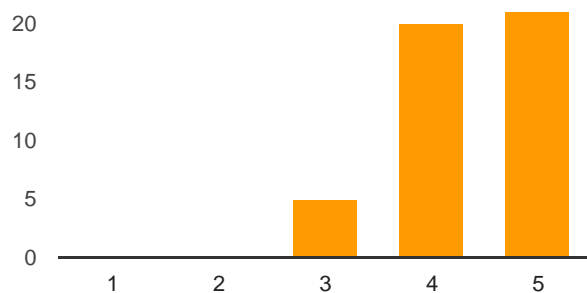
### Topic presentation and organization

The various topics within the summer school integrated into a coherent picture



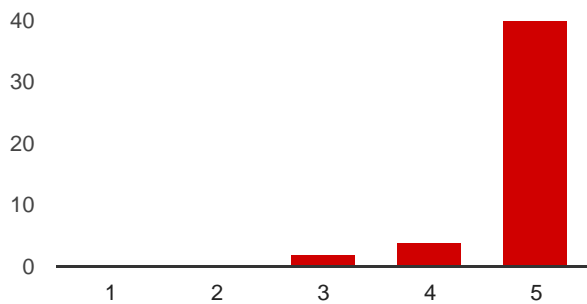
Not at all: 1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>10</b>	21.7%
4	<b>20</b>	43.5%
Very much: 5	<b>16</b>	34.8%

The faculty speakers were generally clear and well organized in their presentation



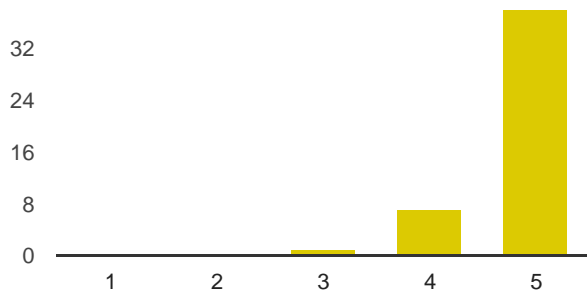
Not at all: 1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>5</b>	10.9%
4	<b>20</b>	43.5%
Very much: 5	<b>21</b>	45.7%

### The school was intellectually stimulating



Not at all: 1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>2</b>	4.3%
4	<b>4</b>	8.7%
Very: 5	<b>40</b>	87%

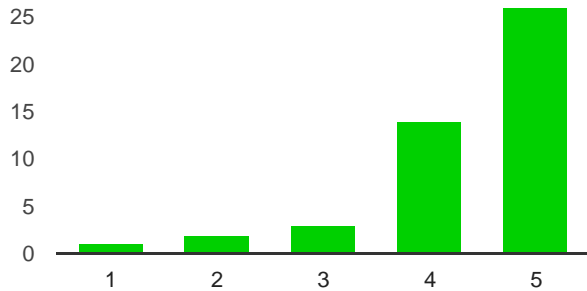
### The overall experience of the school was worthwhile



Not at all: 1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>1</b>	2.2%
4	<b>7</b>	15.2%

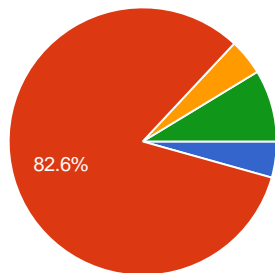
Very: 5 **38** 82.6%

### The TA sessions were helpful



Not at all: 1	<b>1</b>	2.2%
2	<b>2</b>	4.3%
3	<b>3</b>	6.5%
4	<b>14</b>	30.4%
Very much: 5	<b>26</b>	56.5%

### The amount of material presented was:



Too much	<b>2</b>	4.3%
Just the right amount	<b>38</b>	82.6%
Not enough	<b>2</b>	4.3%
No opinion	<b>4</b>	8.7%

### Additional comments on the topic presentation and organization

very good

As a student who just finished my first year of grad school, with no specific background in GGT, I appreciated the clear introduction to the material given by the speakers. It was a great immersion experience! The problem sessions were extremely helpful.

The problem sections were good. But some lectures were too fast and too abstract, it was very difficult to understand the lectures at the first time. In this case, problem sections were not very helpful since some of us might just review the lectures and would not be able to think about the problems.

Would be nice to get problems for problem sessions immediately after the preceding lecture, before the break, to have time to look problems over before collaboration.

The lecturers were all great but it would have been great if we would have been given a list of notes to follow while we were in lectures. I spoke to a lot of people and they said that it was sometimes hard to follow what was being said and take notes at the same time. In that way we could have focused entirely on what was being said and catch the gems of intuition that were being thrown out here and there.

Organisation was great. The only thing I would comment on were the opportunities to interact with the faculty and organisers in a social environment. Even though they weren't staying with us, it would be nice to have had a couple of dinners with them. Cheers Bye Ty

Both the choice and presentation of topics were good, but I would have liked there to be a little more emphasis on details and proofs and a little less on stating big theorem, as some concepts and ideas were not as clearly explained as they could have been.

I thought the presentation and organization was solid. I would have appreciated a few more details from the talks in the second week, but I think it was a good balance overall between presenting important results and historical background while also giving some proofs to help us understand how things are proven in these areas.

The description for the course said that the topics would be accessible for students backgrounds, but it took for granted knowledge on algebraic topology, therefore I believe it would be useful to give a more detailed description of the prerequisites for the summer school.

the lectures were on the whole very good and the problem sessions were generally helpful in improving understanding

I enjoyed all of the minicourses very much. One thing that I think could have helped me get more out of the courses is if the speakers had presented at the beginning (1) some motivation for the topic and (2) some outline of what to expect in the minicourses (i.e. where is this headed?). The latter would be particularly helpful since each minicourse had only a title and no abstract.

I would have liked more specific pre-course reading. The Bridson paper was reasonable to look at, but no one is going to read an entire book, and lecture slides are not a terribly useful standalone resource.

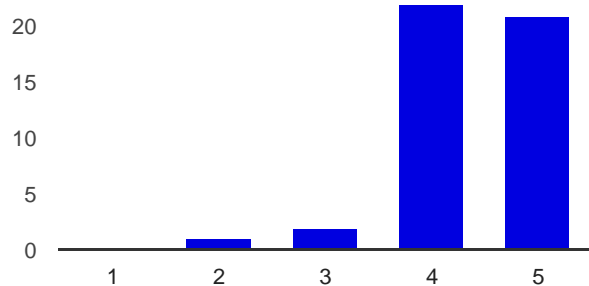
## **Personal assessment**

### **I was well prepared to benefit from the school**



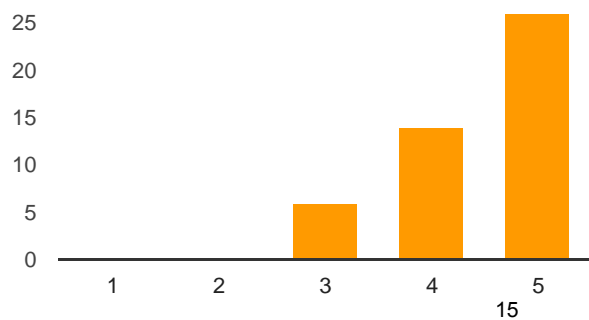
Not at all: 1	<b>0</b>	0%
2	<b>3</b>	6.5%
3	<b>13</b>	28.3%
4	<b>17</b>	37%
Very: 5	<b>13</b>	28.3%

**My interest in the subject matter was increased by the school**



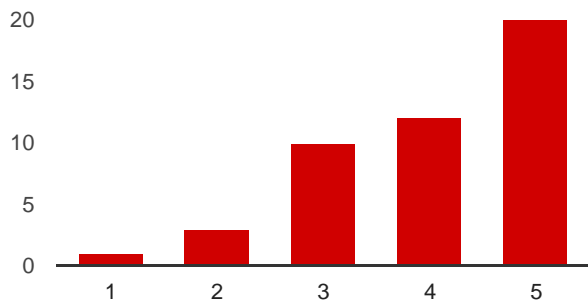
Not at all: 1	<b>0</b>	0%
2	<b>1</b>	2.2%
3	<b>2</b>	4.3%
4	<b>22</b>	47.8%
Very much: 5	<b>21</b>	45.7%

**The school helped me meet people with similar scientific interests**



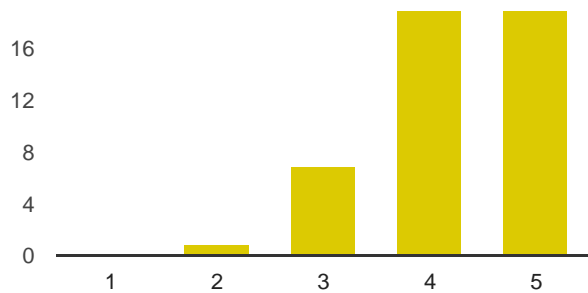
Not at all: 1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>6</b>	13%
4	<b>14</b>	30.4%
Very much: 5	<b>26</b>	56.5%

**It is likely that I will work in the area of the school subject in the future**



Not at all: 1	<b>1</b>	2.2%
2	<b>3</b>	6.5%
3	<b>10</b>	21.7%
4	<b>12</b>	26.1%
Very: 5	<b>20</b>	43.5%

**How would you evaluate your interaction with other participants?**



not satisfactory: 1	<b>0</b>	0%
2	<b>1</b>	2.2%

	3	7	15.2%
	4	19	41.3%
above satisfactory:	5	19	41.3%

### **Additional comments on your personal assessment**

I am definitely interested in group theory. None of this material was immediately pertinent to my own research, but I found a lot of it very interesting and could definitely see myself looking into a couple of these areas more intently down the road.

I personally had an amazing time. I met amazing people, saw amazing mathematics, and enjoyed every minute of it!

The difficulty of problems varied markedly between sessions. Some sessions were very straightforward and we able to finish the problems quickly. In other ones we would struggle for the entire time to get one problem finished. It did not help that sometimes a problem would be incorrect as stated and we would spin our wheels trying to demonstrate something false. It was frustrating that there were not enough problem sheets for everyone. It felt like it would be no problem just print out 60 copies of the problem sheet so that everyone would have access to one. Some lecturers would not have problem sheets whatever so ever and then would just throw problems onto the board. As far the problems were concerned. It would have been great if there was a short review session at the end of the problem session explaining a rough heuristic on how to approach each problem given. It would give us something to ruminate over later if one were to choose to review material later and give us insight from the masters in these subjects and how they think about solving problems. Finally how the groups formed for the problem sessions was really awkward to be honest. It was fortunate that everyone was pretty social and pleasantries were quickly dealt with. On the other hand since these groups were randomly formed you would occasionally have a group of people where every single person was just finishing their first year or everyone had the exact same background. As a result of this some groups would grind to halt and not get any problems done. I don't know how one would deal with this but maybe somehow have it that groups would have balanced backgrounds and experience level.

The other students were intellectually curious and always happy to clarify points from talks or expand upon them.

it would have been nice to have suggested reading material or topics assumed to be background for all the courses (I haven't had functional analysis, so the amenability course was hard to follow)

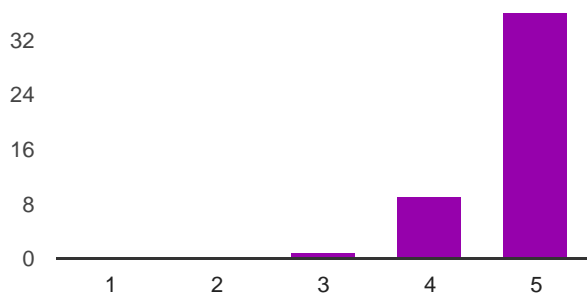
Loved it, totally worthwhile academically and socially.

## **MSRI Venue**

### **I found the MSRI staff helpful**

Not at all: 1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>1</b>	2.2%
4	<b>10</b>	21.7%
Very: 5	<b>35</b>	76.1%

**The MSRI physical facilities were conducive for such a school**



Not at all: 1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>1</b>	2.2%
4	<b>9</b>	19.6%
Very: 5	<b>36</b>	78.3%

**The MSRI computer facilities were adequate for such a school**





Not at all: 1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>4</b>	8.7%
4	<b>10</b>	21.7%
Very: 5	<b>32</b>	69.6%

### **Additional comments on the MSRI venue**

The library orientation was not necessary, and it took too much time. Most of the information are quite well-known (at least for me). It'll be better if just an email to everyone that contains all the information.

so great!

It was often hard to read the chalkboard, and the seats close to the chalkboard were few, and would fill very quickly. I also think some of the presenters had poor handwriting (or not nearly big enough).

Transport between the accommodations provided and MSRI could be improved (there seemed to be an issue with the busses being overcrowded)

Fantastic and picturesque.

The computer session in the library was completely pointless. We were being shown how to send pdf documents via emails and how to use math sci net. We were also shown the book of assistantships and graduate fellowships which described how one would get into grad school. All of us are already in grad school and honestly anyone who has been in grad school for more than a year knows how to use math sci net. If a student has not had any experience with math sci net, it would be a 5 min discussion with someone who has already used it. To be honest, I would cut that portion out completely and just give everyone a handout.

One small comment: Sound travels a fair mount in the lecture hall, so when people talk amongst themselves during a lecture it can be rather distracting. It may be worth telling participants this.

Auditorium is not ideal for group work.

I wish it had longer hours of operation.

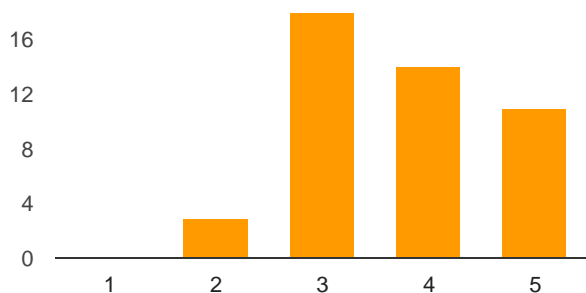
The view from the top of the hill was amazing and the lecture hall was nice except there weren't enough seats for everyone to be in the three rows with table space. The bus situation needs improvement (which, it sounds like is already being discussed). There were more than enough participants to fill a bus, so having one specifically for the program would be nice. The hill line bus driver would sometimes not allow MSRI participants to get on the bus (but would then allow other riders to do so).

The MSRI people were very helpful and communicative with helping getting the reimbursement

forms, a better designed route down the hill back to Berkeley, and providing such a nice auditorium.

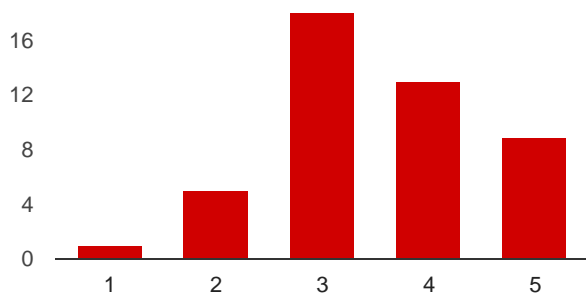
## Accommodation and Food

### The summer school accommodation



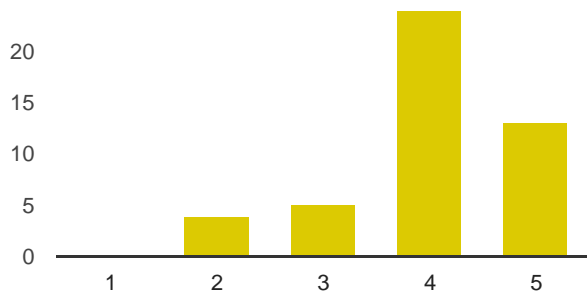
not satisfactory: 1	<b>0</b>	0%
2	<b>3</b>	6.5%
3	<b>18</b>	39.1%
4	<b>14</b>	30.4%
above satisfactory: 5	<b>11</b>	23.9%

### The food at the dormitories



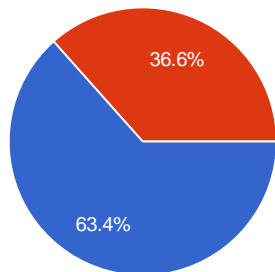
not satisfactory: 1	<b>1</b>	2.2%
2	<b>5</b>	10.9%
3	<b>18</b>	39.1%
4	<b>13</b>	28.3%
above satisfactory: 5	<b>9</b>	19.6%

### The food provided at MSRI



not satisfactory: 1	<b>0</b>	0%
2	<b>4</b>	8.7%
3	<b>5</b>	10.9%
4	<b>24</b>	52.2%
above satisfactory: 5	<b>13</b>	28.3%

### Did you prefer the lunch provided at MSRI in week one or week two



Week 1	<b>26</b>	63.4%
Week 2	<b>15</b>	36.6%

### Additional comments on accommodation and food

Dorm food is REALLY bad.

It was strange that we all separated into different buildings around Foothill residence hall. It was a block to social interaction and unfortunately segregated people into various groups based on who were in the same building with. Moreover sharing residence with the undergraduates was a mistake. They were loud and obnoxious late into the night stealing sleep from the program participants. The food at MSRI took a noticeable downturn in quality in the second week and eating cafeteria food for two meals a day is no way good for anyone's health. The food was not great by any measure of quality.

The bus transportation from campus to MSRI was crowded. Perhaps it would be possible to get an extra bus to run at the times MSRI would need?

The dorm was a dorm. It sufficed. I thought the food was actually pretty decent for a small cafeteria, but there was not a lot of selection to be had. I did think the food provided at MSRI

was not the best, especially the gluten-free options.

Dorm food always will be dorm food, this dorm was actually pretty good! Another barbecue on the second Wednesday also wouldn't have gone astray.

The pillows in the dormitories were worse than any pillow I've used except for the ones on planes; it made it very difficult to sleep through the night. Some warning so that we may want to bring our own pillows would have been appreciated. The beds were also uncomfortable, but that would be harder to improve. Some of the towels provided in the dorms were very small and just barely covered me (and I'm a size 2), but there were larger towels some days; having the towel service provide one towel of each size every time rather than often just two small ones should be an easy fix. The food at MSRI was good both weeks, but having juice as an alternative beverage for those of us who don't drink soda would be nice.

## Thank you for completing this survey

**We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.**

Thanks for two great weeks!!

The program was a great experience and a lot of fun to attend - I would highly recommend participation in future summer schools.

The only problem with had during the summer school was with the shuttle, because the shuttles are too small for so many people, even when we distribute in 3 different groups, there is people who need to get to their jobs and they get frustrated with the students taking the space. The driver can also be very rude and I found it very uncomfortable having to use the service.

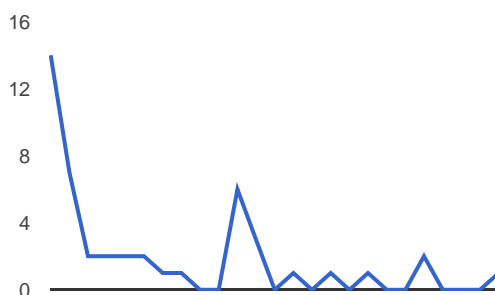
Some sort of goodbye event on the final Friday evening would have been great! But otherwise I'm very grateful that the organisers and speakers took time to organise such an event.

water bottle filler machine hand dryer in bathroom

Everything was great. It would be much convenient if there were a bigger bus or more buses.

Shuttle was overly crowded.

## Number of daily responses



**Summer Graduate School**  
**Mathematical Topics in Systems Biology**  
June 29, 2015 - July 10, 2015  
MSRI, Berkeley, CA, USA

Organizers:

**Steven Alschuler (University of California, San Francisco)**

**Lani Wu (University of California, San Francisco)**

## Final Report

MSRI Graduate Summer Workshop

Mathematical Topics in Systems Biology

June 29-July 10, 2015

Organizers:

Steven Altschuler (UC San Francisco)

Lani Wu (UC San Francisco)

The goal of this workshop was to introduce mathematics graduate students to the rapidly emerging area of systems biology. In particular, we focused on the design and emergent behaviors of molecular networks used by cells to interpret their environments and create robust temporal-spatial behaviors. This workshop was designed to be very hands-on so that students could work alone and in teams to program and present key ideas. To accomplish this, we had:

1. **Four scientific modules, two per week.** The first week focused on stochastic models while the second week focused on data analysis and prediction problems in biology. Module 1 covered the classic Luria Delbruck model of drug resistance, led by Steven Altschuler. Module 2 covered both classic, deterministic Turing pattern models as well as recent, stochastic neutral drift models of pattern formation, led by Steven Altschuler. Module 3 covered topics in computer vision applied to biological image data, led by Lani Wu. Module 4 covered topics in prediction of causality, led by Steven Altschuler and Lani Wu.
2. **Team.** The 20 students were divided into four new teams for each module. Teams were responsible for accomplishing assigned tasks, as well as identifying new challenges. All members were instructed to participate equally in defining problems, performing mathematical analysis, computational modeling and presentations. Modules spanned multiple days, and teams worked together at MSRI or at the dormitories after hours if they so choose.
3. **Definition hunts.** Each module began with a list of terms, typically biological, that were designed to “break the ice” and allow the mathematically trained students to become more familiar with standard biological concepts. These terms were assigned to the different teams, and they typically had a coffee break or lunch time to look up terms, and then return to the lecture hall to present the ideas.
4. **Case studies.** Each module started with a case study lecture to provide background, motivation and problem definition. These lectures were primarily given by Steven Altschuler and Lani Wu, however the three teaching assistants, Drs. Satwik Rajaram, Kevin Thurley and Mr. Charles Hsu also each gave a case study lecture. Team projects were assigned for each case study.
5. **Team discussion.** Each case study was followed by 1-2hrs of team discussion that allowed each team to clarify the goals of the module and to come up with a plan to perform the analysis and computational modeling required for the biological question.

6. **Team programming time.** Each module had 3-4hrs of programming time at MSRI as well as one evening for problems to be broken down, distributed to the team, implemented, tested and summarized for presentation.
7. **Lectures.** Each module had at least one lecture on active problems in the research area. These lectures were given by all instructors and teaching assistants. These included lectures on: neural circuit wiring in the fly visual system (Steven Altschuler), cancer evolution and drug resistance (Satwik Rajaram), symmetry breaking in yeast cell division (Lani Wu), cancer cell heterogeneity (Lani Wu), immunology and gradient sensing (Kevin Thurley), identifying optimal biomarkers for drug discovery (Charles Hsu), PhenoRipper (Satwik Rajaram) and identifying network crosstalk (Lani Wu).
8. **Guest lectures.** We were fortunate enough to identify three local world-class researchers in biology who agreed to complement our selected modules. These were given on: modeling HIV spatial spreading (Leor Weinberger, Gladstone Institute and UCSF), inverse kinematics in protein structure prediction and drug discovery (Matt Jacobson, UCSF) and cell migration (Orion Weiner, UCSF and the Cardiovascular Research Institute).
9. **Professional development.** Two sessions of professional development were given. The first one was given by Francis Edward Su, a visitor at MSRI, who focused on a mathematician's perspective of job advice. The second was given by a panel of the instructors and teaching assistants, which focused on advice specifically for how to identify biological questions, collaborators, and pursue a career on the cutting edge of mathematics and biology.

#### **Evaluation of the success and accomplishments.**

1. **Topics.** The students were very enthusiastic about the diversity and coherence of the topics. We were initially concerned about having the right balance of theory vs. modeling vs. data analysis. However, all students reported that most, if not all, topics were new and exciting to them. The topics themselves were ones that covered the range from "classical" areas that mathematicians in biology would be expected to encounter at least one to "cutting edge" areas that are at the forefront of biological research that requires some form of mathematical reasoning. The mathematics presented was all approachable by the teams, and they did very well at both accomplishing the theoretical tasks as well as connecting them to computational models and biology.
2. **Team efforts.** All students reported enthusiasm for team-style, hands-on problem solving. Teams were reassembled every few days to make sure those students with more or less background in math and biology could learn from each other and build personal networks. Some attendees commented that the change in team members was just right, one or two suggested it was too frequent. On the whole, this was a very successful component of the school.
3. **Student feedback.** Below, we include excerpts of emails that were sent to us afterwards.

---

Many thanks again for a great summer school. I learnt a lot from the collaborative and friendly atmosphere that you created. I write a blog for non-mathematicians interested in math called "Picture

this Maths" with a friend from Cambridge, and I just wrote a post on the RD model of pattern formation in which you are mentioned, so I thought I'd give you the link in case you are interested!

I wanted to thank you (+ Charles, Kevin, and Satwik) for putting the Systems Biology workshop together. Your enthusiasm for the subject is infectious and it had quite an impact on me. It was enough to get me seriously considering a transition into Biology, which is no small feat considering my love for Mathematics. I'd be interested in keeping up with the neat stuff going on in your lab and the field in general, let me know of any good reads!

---

It was such a great pleasure learning from you and Lani, discussing science with you, conversing, hiking up and down to MSRI with you and getting to spend these past 2 weeks together with you!

Thank you for offering us this amazing summer school experience and I hope to run into you (and Lani) in the very near future.

---

I just wanted to send a quick thank you for all the work you did during the summer school and the time leading up to it. It was clear to me how much effort and thought went into everything from your side, and it made me want to match that as much as possible from my side.

I really appreciated how you were able to create a welcoming and dynamic environment that promoted as much learning as possible, but also allowed for us to build relationships that I expect will last well into the future.

---

We owe you all of the thanks! I also wanted to thank you both for the past two weeks. This summer course was exactly what I needed to re-spark my motivation to research in (math) biology. Both your energy and passion for your work was infectious!

The entire course was influential in many ways I can't explain. I have been struggling the past year trying to find the correct way to transition into biology (especially without the support from my current department) but now the next steps seem clearer to me. I am incredibly excited to start the next phase in my transition and I owe that excitement to both of you.

I hope to be back in San Francisco in the future, and would love to come by and see your lab and learn about your new projects. I will be in touch!

Thanks again for encouraging me to see that my dreams aren't so far out of reach.



### Organizers

First Name	Last Name	Institution
Steven	Altschuler	University of California, San Francisco
Lani	Wu	University of California, San Francisco

### Teaching Assistants

First Name	Last Name	Institution
Chien-Hsiang	Hsu	University of California, San Francisco
Satwik	Rajaram	University of California, San Francisco
Kevin	Thurley	University of California, San Francisco

<b>MSRI Supported Students</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Dana	Botesteanu	University of Maryland
Jorly	Chatouphonexay	Arizona State University
Patrick	Davis	Central Michigan University
Rebeca	Falcao	University of British Columbia
Hugh	Ford	University of Melbourne
Derek	Handwerk	Colorado State University
Hyerim	Hong	Seoul National University
Sarafa	Iyaniwura	University of British Columbia
Midhun	Kathanaruparambil Sukumaran	University of Waterloo
Nicholas	Kaufman	University of Delaware
Andrew	Leach	University of Arizona
Abhishek	Mallela	University of Missouri
Catherine	Patterson	University of Iowa
Eric	Puttock	University of California, Irvine
Farrah	Sadre-Marandi	Colorado State University
Anna	Seigal	University of California, Berkeley
Nihal	Temamogullari	Duke University
Benjamin	Thompson	Boston University
Guanyu	Wang	New York University, Courant Institute
Jie	Zhao	Washington State University

## Officially Registered Student Information

<b>Participants</b>		<b>20</b>
---------------------	--	-----------

<b>Gender</b>		<b>20</b>
<b>Male</b>	50.00%	10
<b>Female</b>	50.00%	10
<b>Declined to state</b>	0.00%	0

<b>Ethnicity*</b>		<b>20</b>
<b>White</b>	60.00%	12
<b>Asian</b>	30.00%	6
<b>Hispanic</b>	0.00%	0
<b>Pacific Islander</b>	0.00%	0
<b>Black</b>	5.00%	1
<b>Native American</b>	0.00%	0
<b>Mixed</b>	5.00%	1
<b>Declined to state</b>	0.00%	0

\* ethnicity specifications are not exclusive

# 18 responses

18 responses / 20 Participants = 90%

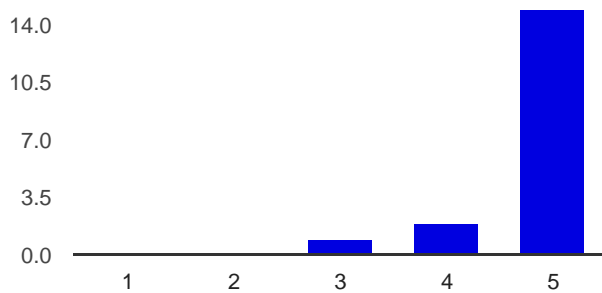
[View all responses](#)   [Publish analytics](#)

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## Summary

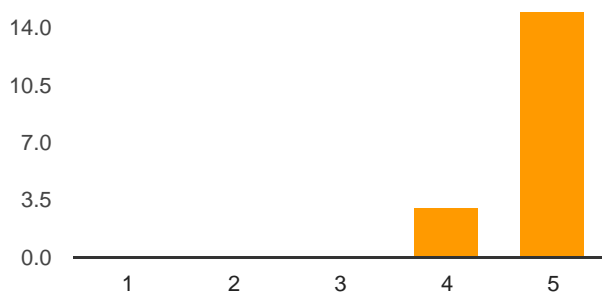
### Topic presentation and organization

The various topics within the summer school integrated into a coherent picture



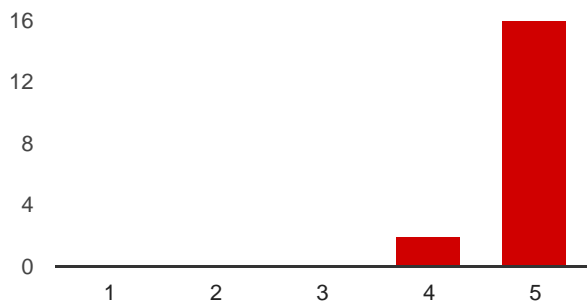
Not at all: 1	0	0%
2	0	0%
3	1	5.6%
4	2	11.1%
Very much: 5	15	83.3%

The faculty speakers were generally clear and well organized in their presentation



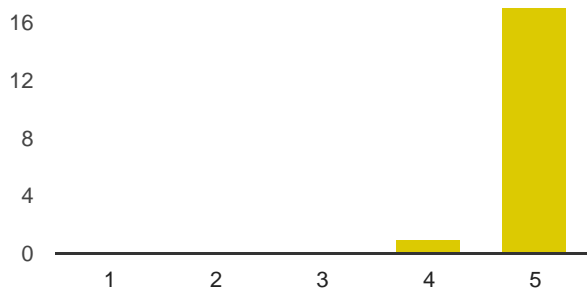
Not at all: 1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>0</b>	0%
4	<b>3</b>	16.7%
Very much: 5	<b>15</b>	83.3%

### The school was intellectually stimulating



Not at all: 1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>0</b>	0%
4	<b>2</b>	11.1%
Very: 5	<b>16</b>	88.9%

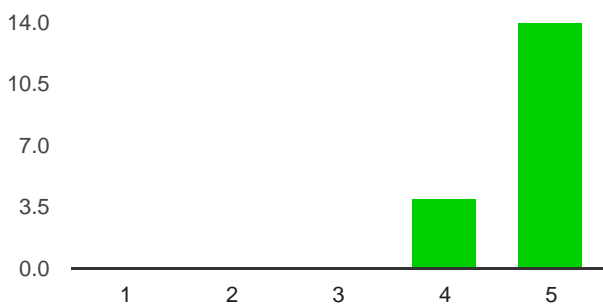
### The overall experience of the school was worthwhile



Not at all: 1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>0</b>	0%
4	<b>1</b>	5.6%

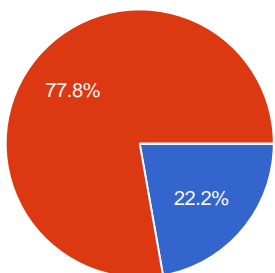
Very: 5    **17**    94.4%

**The TA sessions were helpful**



Not at all: 1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>0</b>	0%
4	<b>4</b>	22.2%
Very much: 5	<b>14</b>	77.8%

**The amount of material presented was:**



Too much	<b>4</b>	22.2%
Just the right amount	<b>14</b>	77.8%
Not enough	<b>0</b>	0%
No opinion	<b>0</b>	0%

**Additional comments on the topic presentation and organization**

Incredible amount of work, but stimulating! I've learnt more in these past 2 weeks than in one year of coursework and/or research. Math-bio related summer schools, workshops or any other kind of learning opportunities are very difficult to find, and there is few material out there that will teach you how to be a good Math biologist, so this summer school was all the more important

and useful! If you could bring back another summer school of this sort / topic, that would do such a great service to all of us budding young researchers in Math Biology.

Each presentation could be supplemented with a summary (handout or pdf) of the underlying biology that is important for the students.

My main qualm with the pacing was the end of the first week where both the stochastic cell polarity and Turing patterns we covered simultaneously. I felt that those assignments could have been done separately, and the extra time on Friday made the subject drag on.

Steve and Lani, et al were amazing instructors and educators. The course was stimulating, challenging, and informative. Overall, it was an amazing experience and will be the bar to which I measure all future workshops/summer courses.

Absolutely loved it. It was completely different than I expected, but exactly what I needed.

Each of the lectures were gold! I was blown away by Steve and Lani and their attention to making the class engaging, useful, and as good an experience for us as possible.

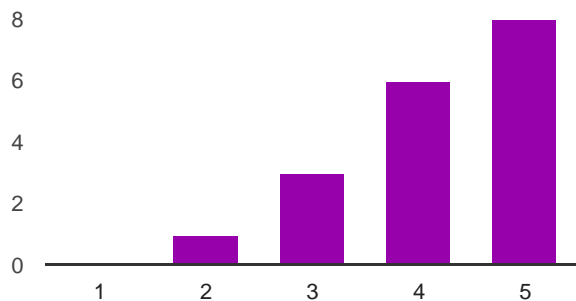
Great job! The only thing I would maybe change is the part we did on image segmentation. I think we could have spent less time coding the various methods for thresholding an image and instead use that time for other projects.

Even though I said too much material presented in above. But i really like it. i hope the summer school could be longer than two weeks.

I was impressed by the amount of work that the organizers and TAs put into the workshop! It must have taken quite a bit of planning and "weeding out" of topics.

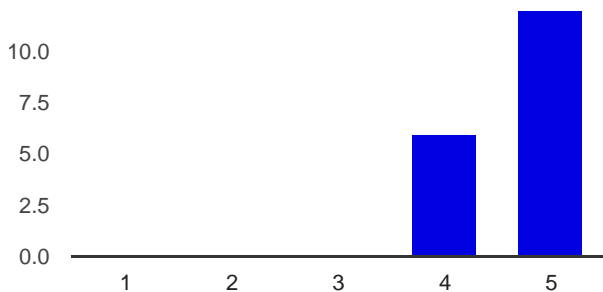
## Personal assessment

### I was well prepared to benefit from the school



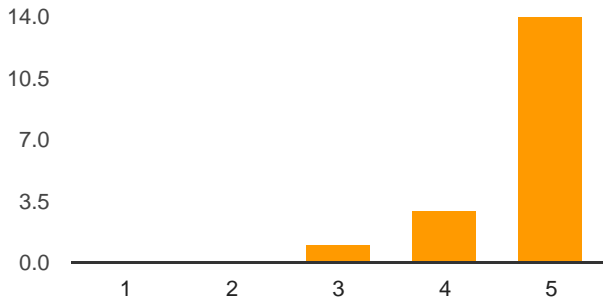
Not at all: 1	<b>0</b>	0%
2	<b>1</b>	5.6%
3	<b>3</b>	16.7%
4	<b>6</b>	33.3%
Very: 5	<b>8</b>	44.4%

### My interest in the subject matter was increased by the school



Not at all: 1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>0</b>	0%
4	<b>6</b>	33.3%
Very much: 5	<b>12</b>	66.7%

### The school helped me meet people with similar scientific interests



Not at all: 1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>1</b>	5.6%
4	<b>3</b>	16.7%
Very much: 5	<b>14</b>	77.8%

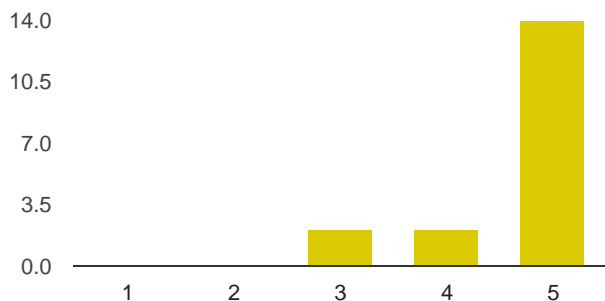
### It is likely that I will work in the area of the school subject in the future





Not at all: 1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>3</b>	16.7%
4	<b>6</b>	33.3%
Very: 5	<b>9</b>	50%

**How would you evaluate your interaction with other participants?**



not satisfactory: 1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>2</b>	11.1%
4	<b>2</b>	11.1%
above satisfactory: 5	<b>14</b>	77.8%

**Additional comments on your personal assessment**

The group of fellow grad students made it a pleasure to learn and work in groups with them, and Steven and Lani were incredible to work with. It felt like we were one big team working towards the common goal of sharing our scientific knowledge and learn from each other.

I was extremely challenged by the material, and had to learn on-the-fly/play catch-up for pretty much everything. My background in MATLAB, biology, stats, and even math were lacking in some respect, but to varying degrees. On a personal note, I am very hard on myself to improve. But I give myself credit in the sense that I was one of the youngest participants and am totally new to the biological topics covered. This workshop was a big eye-opener for what gaps in my

knowledge I have to fill in, and I believe this will be possible with my persistence, work ethic, and mental acuity.

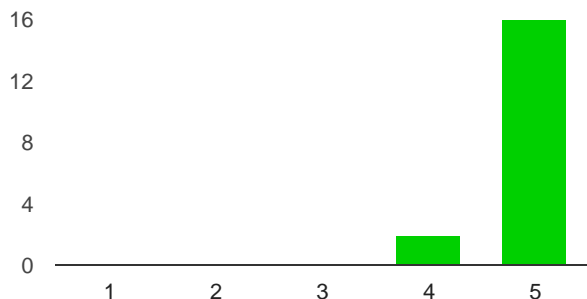
This was very amazing. It's hard to interact with other graduate students working in the field of mathematical biology. Meeting many students who will be building the foundations of systems biology is beneficial for everyone participating in the program.

I really enjoyed this experience. My research has been very focused on one aspect of biology, so it was great to get to see some new areas. I was surprised by how easy it was to jump into these new areas. I think the "Easter egg hunts" helped with this a lot.

I was frustrated with a few of the groups I was in, as there were often participants who didn't make an effort to contribute. Even when some of them wanted to, they had difficulty if they didn't have a strong Matlab background. I suppose this is the nature of group work though, and I should have made a more concerted effort to be inclusive.

## MSRI Venue

### I found the MSRI staff helpful



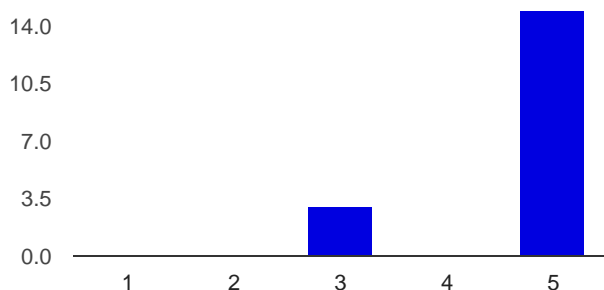
Not at all: 1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>0</b>	0%
4	<b>2</b>	11.1%
Very: 5	<b>16</b>	88.9%

### The MSRI physical facilities were conducive for such a school



Not at all: 1	0	0%
2	0	0%
3	0	0%
4	1	5.6%
Very: 5	17	94.4%

### The MSRI computer facilities were adequate for such a school



Not at all: 1	0	0%
2	0	0%
3	3	16.7%
4	0	0%
Very: 5	15	83.3%

### Additional comments on the MSRI venue

Everyone was kind and accessible. Very good environment for a focused summer study workshop.

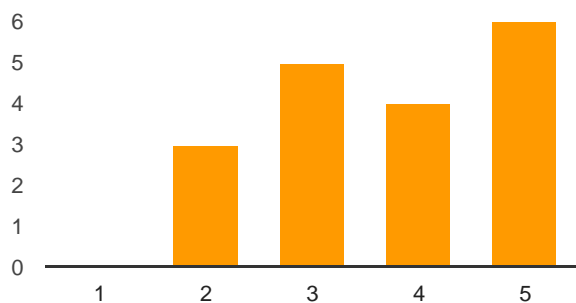
My computer was having issues throughout the workshop, and I am quite grateful to IT support for loaning me a computer for the whole stay! I also received sound technical advice on buying a new laptop. The MSRI venue is beautifully situated on top of the hill, and I couldn't have asked for a better location.

The venue was great, I really appreciated the view :)

Great location, and great support from all the staff! Everyone was so friendly, helpful and so quick to respond to our needs!

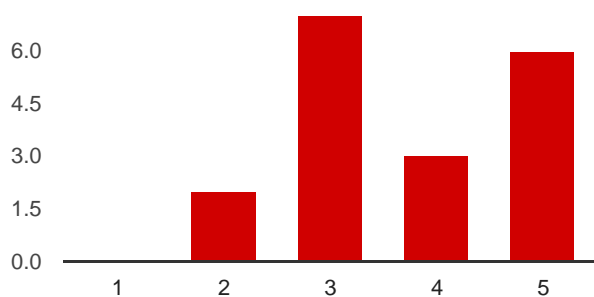
## Accommodation and Food

### The summer school accommodation



not satisfactory: 1	<b>0</b>	0%
2	<b>3</b>	16.7%
3	<b>5</b>	27.8%
4	<b>4</b>	22.2%
above satisfactory: 5	<b>6</b>	33.3%

### The food at the dormitories

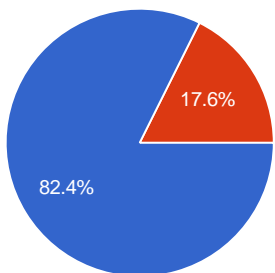


not satisfactory: 1	<b>0</b>	0%
2	<b>2</b>	11.1%
3	<b>7</b>	38.9%
4	<b>3</b>	16.7%
above satisfactory: 5	<b>6</b>	33.3%

### The food provided at MSRI

not satisfactory:	1	0	0%
	2	0	0%
	3	5	27.8%
	4	9	50%
above satisfactory:	5	4	22.2%

**Did you prefer the lunch provided at MSRI in week one or week two**



Week 1	14	82.4%
Week 2	3	17.6%

**Additional comments on accommodation and food**

The dorms were okay. I'm not sure if there is a better option for the cost, so I guess what we were provided is to be expected. Though since there were many younger camps (middle school or below) going on at the same time, it made working in the evening very difficult, do to noise. It would have been nice to be separated from these types of camps since this was a research related visit. Food at the dorms was as expected for dorm food. There were multiple nights I went out to eat instead because it was not very appetizing... Food at MSRI the first week was 10 times better than the food the second week. I miss their salads!

The dorms were overcrowded with a lot of very young athletes and a group that blasted music and partied every night. I didn't end up spending much time there though, so it wasn't a big deal. I would have preferred healthier options for the food provided at MSRI. The lunch for week 1 was much better, and a little healthier.

The males were placed in dorm rooms that were right next to this open area where the campers would party until ~11, and I was working on Eastern Time, so that was frustrating. It would have been better if we could have been placed in a dorm room further away.

The food gets a 4 because the first week was a 5 and the 2nd was 3. The first week's caterers actually made vegetarian food. While the second week's just took the meat out of food. For example, the during the first week they'd have tofu instead of meat, or vegan patties instead of hamburgers. During the second week it was pasta with meat, or pasta. Chicken salad or hummus. It needed more protein.

The food at the dormitories could be better by possibly adding in a new station for international foods can rotate every day.

The beds in the Foothills dorm area really hard, and the showers are cold with basically no water pressure. The Foothills cafeteria is exactly what you'd expect from a college cafeteria. The lunch at MSRI was MUCH better during week 1. You should hire those guys every week!! I especially liked their amazing salads! Also, I really appreciated that they brought bottled water for us. The caterers during the second week didn't bring bottled water, and not many people want to drink soda every day. Additionally, the vegetarian options were much better during week 1.

The food options are extensive and cater excellently to vegetarians and vegans alike.

Coffee and tea breaks were very nice. The lunch from MSRI were good in general except for the chicken salad burger.

## **Thank you for completing this survey**

### **We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.**

Thanks for giving me the opportunity to attend this summer school. I have learn a lot.

Thank you, MSRI for bringing in this unique summer school in such a relevant topic, especially for those of us inclined more towards the Applied side of Applied Math! I hope another one will be held next year,

Don't be afraid to ask questions, and learn from your peers. Talk to the organizers and establish rapport with the TAs. They are very helpful and insightful in career planning advice as well.

Listen to their stories and learn as much as you can. Also, stay in touch with fellow participants!

There should definitely be another MSRI systems biology workshop. This was highly interactive and fruitful workshop for future students planning to work in the field of system biology.

I learned a lot from the school and was very glad to meet great friends.

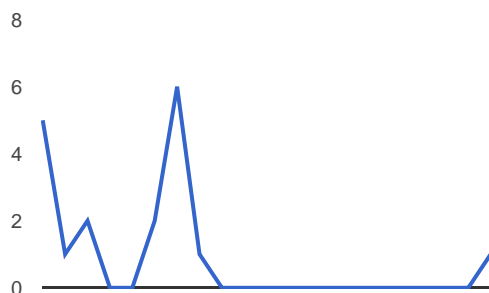
The students participating on the program were very from a wide range of very diverse backgrounds and this made my experience inspiring and enjoyable. I would like to thank MSRI very much for managing to bring together such a great group.

Steve and Lani did an amazing job organizing the summer school. They clearly put a lot of effort into getting the materials ready, and it made me want to match their effort with my own. I really appreciated how they were able to create a welcoming and dynamic environment that promoted as much learning as possible, but also allowed for us to build relationships that I expect will last well into the future.

I had a great experience, thanks for hosting :)

More information regarding travel policies needs to be given. The only mention of policy I can find is in an the invitation email sent March 3rd. My friend and I were not reimbursed for the full amount of our plane ticket even though we followed all supplied restrictions and guidelines. The only provided information was "In addition, MSRI will reimburse you for one economy round trip from your home town to Berkeley up to a limit of \$600." and the notice about having to fly a US carrier. We flew on a US carrier (Frontier) and our expenditures were well below the \$600, yet we were denied compensation for part of our ECONOMY ticket price.

## Number of daily responses



**Summer Graduate School**  
**Gaps between Primes and Analytic Number**  
**Theory**

July 13, 2015 - July 24, 2015

MSRI, Berkeley, CA, USA

Organizers:

**Dimitris Koukoulopoulos (Université de Montréal)**

**Emmanuel Kowalski (ETH Zuerich)**

**James Maynard (University of Oxford)**

**Kannan Soundararajan (Stanford University)**



MSRI SUMMER GRADUATE SCHOOL FINAL REPORT  
"GAPS BETWEEN PRIMES AND  
ANALYTIC NUMBER THEORY"  
JULY 13 TO 24, 2015

Organizers and Lecturers

- D. Koukoulopoulos (Montréal)
- E. Kowalski (Zürich, lead organizer)
- J. Maynard (Montréal–Oxford)
- K. Soundararajan (Stanford)

Teaching assistants

- Z. Brady (Stanford)
- B. Löffel (ETH Zürich)

Presentation

The objectives of this summer school were to present in detail the recent achievements of Y. Zhang, J. Maynard and others concerning gaps between primes, and their further applications concerning distribution of primes (including "large" gaps between primes). Almost no formal prerequisites in analytic number theory was expected from the students, and the courses developed from scratch all relevant material. An auxiliary goal was for the school to serve as introduction to the topics of the semester programme in analytic number theory which has been proposed to MSRI for the Spring 2017 semester, and which is organized by C. David, A. Granville, E. Kowalski, Ph. Michel, K. Soundararajan and T. Tao.

The contents of the school were as follows:

- Four 6-hour long minicourses, by the four lecturers:
  - (1) "Introduction to prime number theory,  $\zeta$  and L-functions, and the prime number theorem" (D. Koukoulopoulos)
  - (2) "The Bombieri-Vinogradov theorem and introduction to sieve theory" (K. Soundararajan)
  - (3) "The methods of Goldston, Pintz and Yıldırım and of Maynard-Tao for gaps between primes" (J. Maynard)
  - (4) "Distribution of arithmetic functions in arithmetic progressions and exponential sums over finite fields" (E. Kowalski).
- Extensive tutoring and exercise sessions led by the two TAs;
- Mini-projects and presentations that were suggested by the lecturers and prepared by small groups of students, with presentations during the last few days of the school. A majority of students participated in one of these, and a few more advanced graduate students presented work from their ongoing PhD theses.

- A presentation and discussion by F. Su (Harvey-Mudd College), current president of the MAA, on “Life as a faculty member”.

#### Contents of the minicourses

Introduction to prime number theory,  $\zeta$  and L-functions, and the prime number theorem (D. Koukoulopoulos)

These lectures, held for the most part during the first week, were designed to introduce students to the basic analytic theory of the distribution of primes, up to and including the Siegel-Walfisz Theorem. Not only are these results used as fundamental tools in the other courses, but this was also the occasion to present concretely many basic ideas and methods of analytic number theory, especially for those students with background in other fields.

The presentation used the modern approach recently devised by D. Koukoulopoulos himself (building on ideas of Granville and Soundararajan) that avoids the use of complex function theory beyond its most elementary aspects. Although this more classical approach (due essentially to Hadamard and de la Vallée Poussin) is important in its own right, the choice allowed the lecturer to give essentially full proofs without requiring any “black box”.

The Bombieri-Vinogradov theorem and introduction to sieve theory (K. Soundararajan)

The goal of this lecture series was to present, again in full detail, the proof of the Bombieri-Vinogradov theorem, which is another main ingredient in the recent progress on gaps between primes. The result was also clearly situated in its context as an unconditional alternative to the Generalized Riemann Hypothesis. Both as a prerequisite and as additional topics, the course also introduced sieve methods and some of their applications, especially the large sieve in its arithmetic and analytic forms.

The methods of Goldston, Pintz and Yıldırım and of Maynard-Tao for gaps between primes (J. Maynard)

The original work of Y. Zhang proving the existence of bounded gaps between primes depended on two essential tools: (1) the method of Goldston, Pintz and Yıldırım for “detecting” small gaps; (2) an extension of the Bombieri-Vinogradov Theorem beyond the range allowed by the large sieve. However, J. Maynard (and independently T. Tao) discovered that a more efficient implementation of the first part could be used to circumvent the second (so that only the Bombieri-Vinogradov Theorem was needed). In fact, the method of Maynard and Tao was able to deduce much stronger statements on bounded intervals containing many primes. All of these topics, including some of the most recent developments concerning large gaps, were discussed in depth in this minicourse.

Distribution of arithmetic functions in arithmetic progressions and exponential sums over finite fields (E. Kowalski)

## MSRI GRADUATE SCHOOL

Although the distribution theorems of Y. Zhang on primes in arithmetic progressions are not necessary anymore for proving the existence of bounded gaps, they retain considerable interest in view of the importance of the study of arithmetic functions in arithmetic progressions to large moduli, beyond the range allowed by the large sieve or the Generalized Riemann Hypothesis. This minicourse presented some general problems and results concerning this research area, especially with respect to the multiple divisor functions. In particular, it explained using examples how such questions naturally lead to exponential sums over finite fields, and to the Riemann Hypothesis over finite fields. A survey of the latter was presented, highlighting in particular the statement and application of a general form of Deligne's Theorem, as a quasi-orthogonality statement for certain special functions over finite fields.

## Student Presentations

Among the presentations given by the students were the following topics:

- Probabilistic number theory (e.g., Erdős-Kac Theorem);
- The asymptotic ternary Goldbach problem;
- Stepanov's proof of special cases of the Riemann Hypothesis over finite fields;
- Introduction to modular forms;
- Some consequences of the Riemann Hypothesis;
- Introduction to the circle method;
- Primes of the form  $x^2 + ny^2$ .

as well as some more talks presenting their PhD projects by already advanced graduate students.

## Student feedback

The mathematical background and level of the students was very varied, ranging from beginning graduate students in fields unrelated to analytic number theory to very advanced students close to the completion of their PhDs.

From the discussions and interactions of the lecturers and TAs with the students, it seems that the lectures were well followed. The many exercises prepared by the TAs were particularly appreciated, and a number of students requested that the exercise sheets be posted on the web page of the school.

The TAs had extensive interactions with the students during the exercise and discussion sessions that were held most of the afternoons, and that were also used to prepare the student presentations. The following feedback comes from these interactions, as reported by the TAs:

- With respect to the exercise sessions, it was a challenge that the students had very different backgrounds. Some were already familiar with the material and the techniques, while for others almost everything was completely new.

- It was very good that the students could give small talks. Since they were relatively free in choosing the topic, they could choose something which matched their skill level.
- It was important that the exercises covered a variety of topics, so that every student could choose what they needed to practice. It was not expected that all students could solve all exercises, although the best ones probably did most of them.
- For less experienced students, exercises focusing on specific topics were most helpful.
- The discussion sessions were times when students could solve exercises, look up material that they did not understand during the lectures, prepare their short, and ask question to the TAs.
- Although most it was felt that most students learnt a lot, there were a few who, having only recently started their PhD, did seem to be a bit lost.
- The atmosphere in the exercise sessions was very good. In particular, some of the less experienced students felt a bit uncomfortable asking questions in the presence of the professors; some also feared a bit to give a talk in front of the professors, but most of them agreed to present something, even if it was not very advanced, and seemed to have good experiences from this exercise.

The TAs also pointed out that a potential improvement to the way the school was organized would have been to be able to prepared exercises in advance, especially with respect to preparing solutions before the beginning of the school. Unfortunately, such coordination is not easy, especially in a summer school of this kind with four fairly interdependent topics.

<b>Organizers</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Dimitris	Koukoulopoulos	Université de Montréal
Emmanuel	Kowalski	Eidgenössische TH Zürich-Hönggerberg
James	Maynard	University of Oxford
Kannan	Soundararajan	Stanford University
<b>Teaching Assistants</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Zarathustra	Brady	Stanford University
Benny	Loeffel	Eidgenössische TH Zürich-Hönggerberg

<b>Participants</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Charles	Alley	University of Illinois at Chicago
Yang	An	Columbia University
Andrea	Arauz	University of California, Riverside
David	Armour	Baylor University
Juan	Auli	San Francisco State University
chandan	biswas	University of Wisconsin-Madison
Chen	Chen	University of Nevada
Kwok Chi	Chim	Technische Universität Graz
Richard	Frnka	Louisiana State University
Zachary	Harrison	Arizona State University
Catherine	Hsu	University of North Carolina
Hang	Huang	University of Wisconsin-Madison
Daniel	Hudson	University of Victoria
Joseph	Hughes	University of California
Monsikarn	Jansrang	Central Michigan University
Aashita	Kesarwani	Tulane University
Kim	Klinger-Logan	University of Minnesota Twin Cities
Frank	Kloster	University of California, Riverside
Watson	Ladd	University of California, Berkeley
Matt	Lam	Harvey Mudd College
Paul	Lewis	Columbia University
Zane	Li	University of California
Misty	Long	Kansas State University
Tianyi	Mao	CUNY, Graduate Center
Nathan	McNew	Dartmouth College
Xianchang	Meng	University of Illinois at Urbana-Champaign
Mehrzad	Monzavi	University of Texas
Ngai fung	Ng	Purdue University
Abhishek	Parab	Purdue University
Hans	Parshall	University of Georgia
Sarah	Peluse	Stanford University
James	Phillips	University of Virginia
David	Richman	University of Michigan
Adrian	Scheerer	Technische Universität Graz
Lee	Troupe	University of Georgia
Ling-Sang	Tse	University of Toronto
Leila	Vaden	University of Oregon
Eric	Wawerczyk	University of Notre Dame
Matthew	Welsh	Rutgers University
Shuntaro	Yamagishi	University of Waterloo
Ruixiang	Zhang	Princeton University

## Officially Registered Student Information

<b>Participants</b>		<b>47</b>
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<b>Gender</b>		<b>47</b>
<b>Male</b>	74.47%	35
<b>Female</b>	25.53%	12
<b>Declined to state</b>	0.00%	0

<b>Ethnicity*</b>		<b>53</b>
<b>White</b>	47.17%	25
<b>Asian</b>	35.85%	19
<b>Hispanic</b>	3.77%	2
<b>Pacific Islander</b>	0.00%	0
<b>Black</b>	0.00%	0
<b>Native American</b>	0.00%	0
<b>Mixed</b>	5.66%	3
<b>Declined to state</b>	7.55%	4

\* ethnicity specifications are not exclusive

# 31 responses

31 responses/47 Participants = 65%

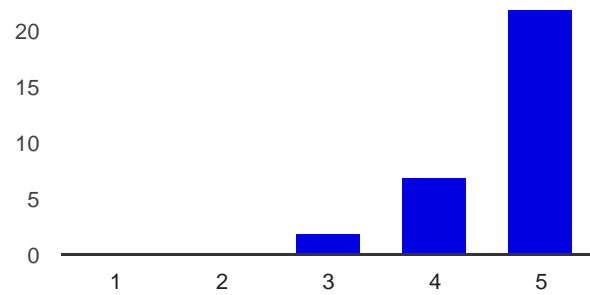
[View all responses](#)   [Publish analytics](#)

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## Summary

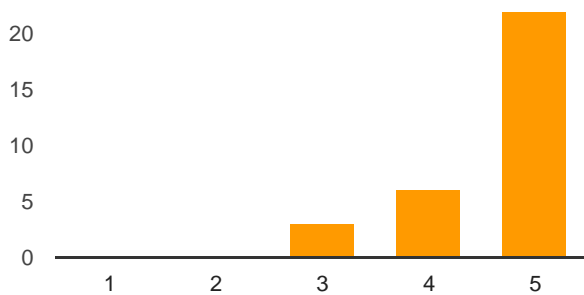
### Topic presentation and organization

The various topics within the summer school integrated into a coherent picture



Not at all: 1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>2</b>	6.5%
4	<b>7</b>	22.6%
Very much: 5	<b>22</b>	71%

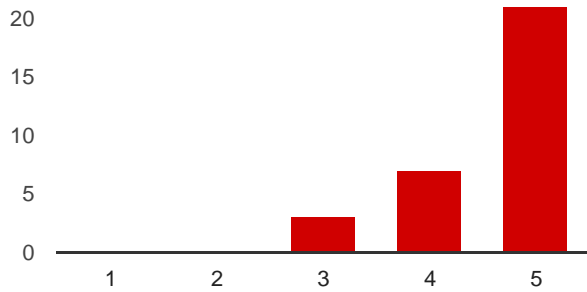
The faculty speakers were generally clear and well organized in their presentation





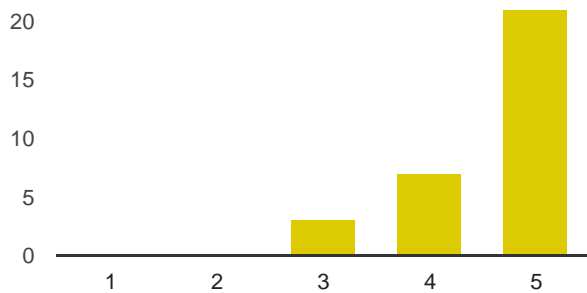
Not at all: 1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>3</b>	9.7%
4	<b>6</b>	19.4%
Very much: 5	<b>22</b>	71%

### The school was intellectually stimulating



Not at all: 1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>3</b>	9.7%
4	<b>7</b>	22.6%
Very: 5	<b>21</b>	67.7%

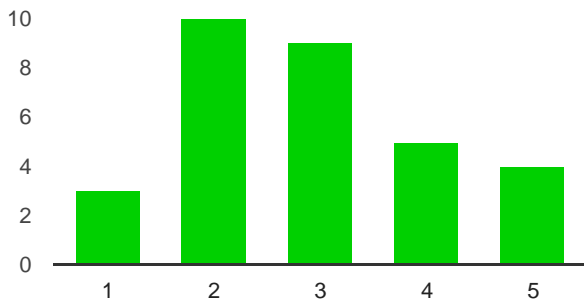
### The overall experience of the school was worthwhile



Not at all: 1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>3</b>	9.7%
4	<b>7</b>	22.6%

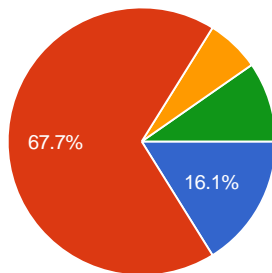
Very: 5    **21**    67.7%

### The TA sessions were helpful



Not at all: 1	<b>3</b>	9.7%
2	<b>10</b>	32.3%
3	<b>9</b>	29%
4	<b>5</b>	16.1%
Very much: 5	<b>4</b>	12.9%

### The amount of material presented was:



Too much	<b>5</b>	16.1%
Just the right amount	<b>21</b>	67.7%
Not enough	<b>2</b>	6.5%
No opinion	<b>3</b>	9.7%

### Additional comments on the topic presentation and organization

Everything was excellent. I just hope we can have a third week to cover the materials left about Zhang's proof (it is hard and long, but you won't have an easy chance to learn and understand it if your thesis is not on any directly relevant topic). I have read both Maynard and Zhang's papers and admire both. And in this summer school I understood both papers much better thanks to the

speakers. But it was yet not enough for the whole picture. That's why I would like an extra week. I am a bit disappointed that faculty did not suggest enough (actually probably none at all) interesting open problems, hard or easy, for us to work on. The projects were like reading and we have to find stuff to work on on our own. Though this is understandable as this topic is fairly new.

Everything was great except for the TA sessions. The TAs seemed unprepared and unable to encourage conversation.

I thought the presentations were really good! It really helped me to understand the material throughout the workshop. It was clear and had right amount of material. I learned a lot and I really enjoyed my overall experience at this summer school!

The 4 lecturers were fantastic. It was an honor to have the chance to learn from them. In the future I think a more structured discussion hour would be helpful.

The latter lectures by Dimitris Koukoulopoulos were at a level and speed a bit beyond the audience.

The lectures eventually moved faster than I was able to keep up with, but I used the online video recordings to go back and learn things I didn't catch the first time around during lecture. Really glad to have that resource! Some TA sessions could have benefitted from a more structured presentation style; it sometimes felt like the TAs did not prepare that much for the problem sessions.

The topics worked well together and there was much interplay between different talks. I feel that the whole two weeks were well planned and prepared.

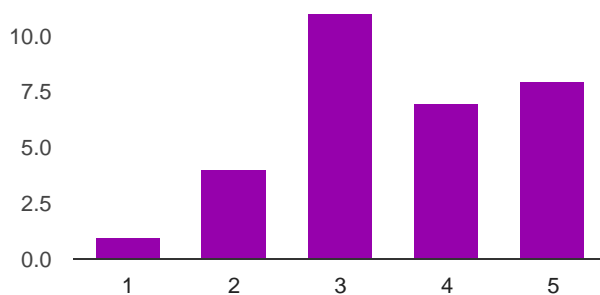
Sound and Kowalski were extremely well prepared and clear. I learned quite a bit from their lectures.

The TA's were not well prepared. Some exercises were not correct, with mistakes that were not simple typos. The lectures were good.

It would be helpful if the lecturers would announce the topics a day in advance so we could skim the the material to prepare.

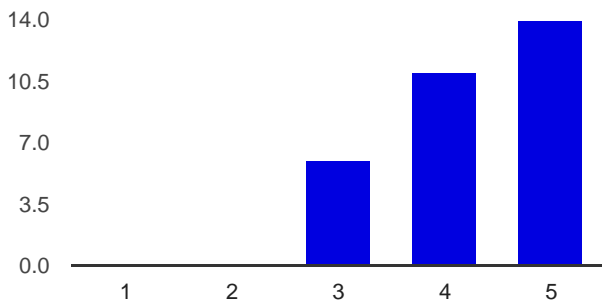
## Personal assessment

### I was well prepared to benefit from the school



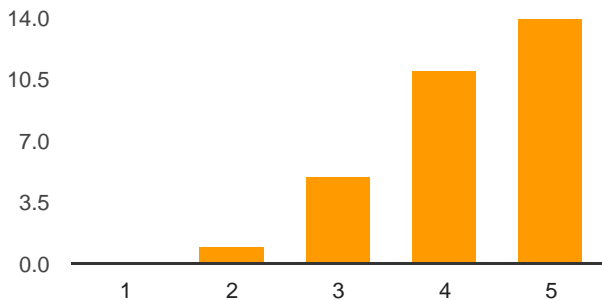
Not at all: 1	<b>1</b>	3.2%
2	<b>4</b>	12.9%
3	<b>11</b>	35.5%
4	<b>7</b>	22.6%
Very: 5	<b>8</b>	25.8%

**My interest in the subject matter was increased by the school**



Not at all: 1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>6</b>	19.4%
4	<b>11</b>	35.5%
Very much: 5	<b>14</b>	45.2%

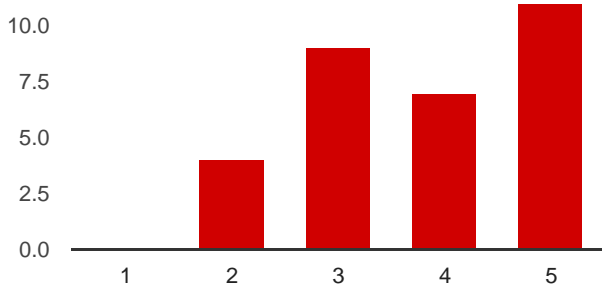
**The school helped me meet people with similar scientific interests**



Not at all: 1	<b>0</b>	0%
2	<b>1</b>	3.2%
3	<b>5</b>	16.1%

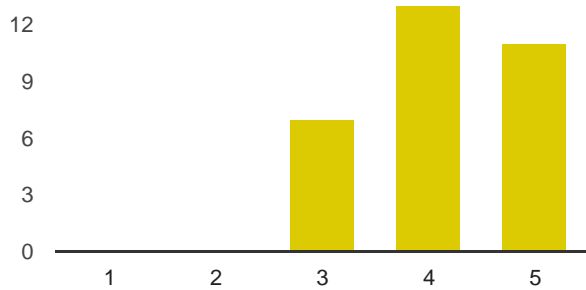
4    **11**    35.5%  
 Very much: 5    **14**    45.2%

**It is likely that I will work in the area of the school subject in the future**



Not at all: 1    **0**    0%  
                   2    **4**    12.9%  
                   3    **9**    29%  
                   4    **7**    22.6%  
 Very: 5    **11**    35.5%

**How would you evaluate your interaction with other participants?**



not satisfactory: 1    **0**    0%  
                           2    **0**    0%  
                           3    **7**    22.6%  
                           4    **13**    41.9%  
 above satisfactory: 5    **11**    35.5%

**Additional comments on your personal assessment**

The summer school was great! Since it is a very important topic, I thought that there would be more grad students attending. It would have been better if there were more attendees, since then it would be easier to find other students at your level to discuss the math with.

I am very satisfied. You can see I did not prepared well to benefit much as this was what I was working on a year ago, not now. However the clear presentation and interaction with others inspired me a lot in this direction, which was unexpectedly amazing.

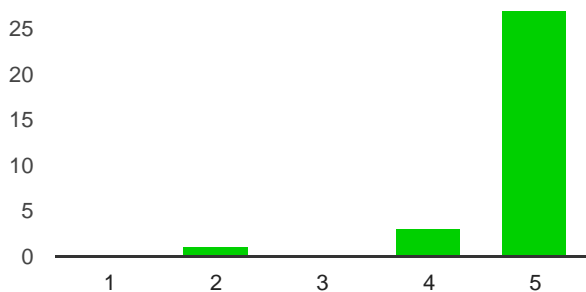
I had very little experience in analytic number theory before this summer school, and I think as a result of that I fell behind in the second week. But I am very much interested in this field after learning [some of] the material from this summer school.

Most of the others were very agreeable and I look forward to seeing them at other conferences.

This topic is somewhat tangential to my field but overall I think that the experience was quite helpful.

## MSRI Venue

### I found the MSRI staff helpful



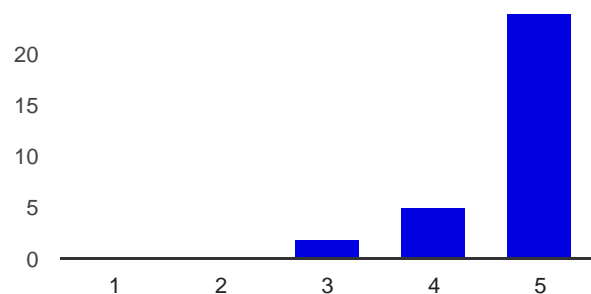
Not at all: 1	<b>0</b>	0%
2	<b>1</b>	3.2%
3	<b>0</b>	0%
4	<b>3</b>	9.7%
Very: 5	<b>27</b>	87.1%

### The MSRI physical facilities were conducive for such a school



Not at all: 1	<b>0</b>	0%
2	<b>1</b>	3.2%
3	<b>2</b>	6.5%
4	<b>3</b>	9.7%
Very: 5	<b>25</b>	80.6%

### The MSRI computer facilities were adequate for such a school



Not at all: 1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>2</b>	6.5%
4	<b>5</b>	16.1%
Very: 5	<b>24</b>	77.4%

### Additional comments on the MSRI venue

loved the library! and the views, of course

Great location.

Having to walk 5 minutes for a cigarette was annoying, but this is my only complaint.

I don't know how MSRI got the venue at that location, but they are very lucky. The surroundings are beautiful, the building is great, and the library is spectacular in the number of books and journals.

I found it very difficult to work at msri. The library is very nice but either we should be allowed to take books into area's with chalkboards and where we can eat and drink coffee while reading, or there should be chalkboards in the library and we should be allowed to bring coffee into the library. Also the quality of the coffee was very low. Furthermore, there is no cellphone reception

which made it difficult for me to stay and work as i was trying to stay in contact with my family.

It is great. People were telling me the material in the library was not comprehensive enough. I personally found it fine. It was a bit annoying that we only had 2 computers with access to most electronic scientific literature. But other aspects of the whole venue are next to perfect.

Mathematicians turn coffee into theorems. It was great to have some, but i think there should be more of a variety because the coffee served was pretty bad. I also would have liked to have coffee in the lecture hall during the presentations.

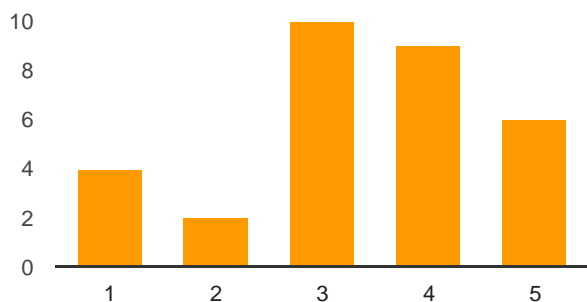
I am in love with the facilities at MSRI. The venue is beautiful.

MSRI was amazing, especially the library. I hope to come back.

Beautiful! Thank you for hosting!

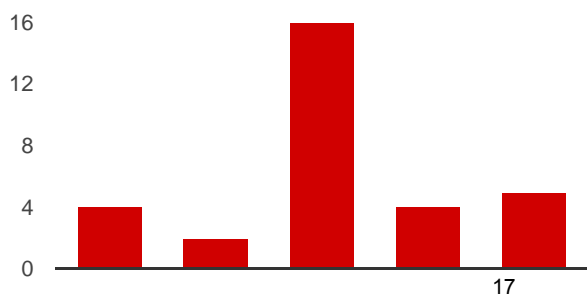
## Accommodation and Food

### The summer school accommodation



not satisfactory: 1	<b>4</b>	12.9%
2	<b>2</b>	6.5%
3	<b>10</b>	32.3%
4	<b>9</b>	29%
above satisfactory: 5	<b>6</b>	19.4%

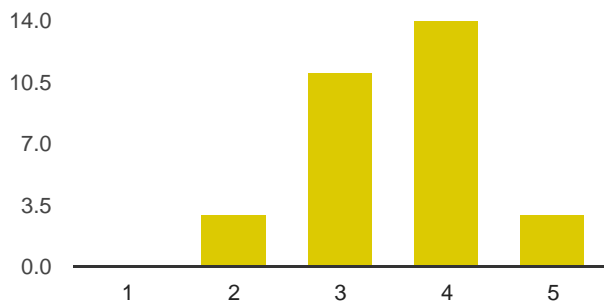
### The food at the dormitories





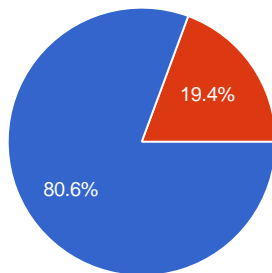
not satisfactory: 1	<b>4</b>	12.9%
2	<b>2</b>	6.5%
3	<b>16</b>	51.6%
4	<b>4</b>	12.9%
above satisfactory: 5	<b>5</b>	16.1%

### The food provided at MSRI



not satisfactory: 1	<b>0</b>	0%
2	<b>3</b>	9.7%
3	<b>11</b>	35.5%
4	<b>14</b>	45.2%
above satisfactory: 5	<b>3</b>	9.7%

### Did you prefer the lunch provided at MSRI in week one or week two



Week 1	<b>25</b>	80.6%
Week 2	<b>6</b>	19.4%

### Additional comments on accommodation and food

The dorms are fine. It was a bit annoying that we don't have indoor restrooms. Also the soundproof was poor so I can hear people talking loudly late in the night in our lounge. I believe

they moved when I complained to them. Other aspects were good. The lunch in week 2 was much worse than the lunch in week 1 and I personally think the standard in week 2 should be improved. The food we had in week 1 was amazing though. They should at least have fresh water for week 2.

The dorms at Foothills are very nice. The cafeteria food is just that, cafeteria food. The first catering service for lunch seemed to think more about what would satisfy the majority of the people. They provided salad for every meal in case the main course did not look appealing, their sandwich strategy was "build your own" (which I appreciated more than the ready made sandwiches in week 2), and they even made Coq au Vin on the Friday. The second week was closer to cafeteria food and had less variety.

Both weeks were equally fine in my opinion.

I am a grown man. I had to sleep in a room with three other men, without a refrigerator or microwave. There was no privacy and it was impossible to do work because it was so uncomfortable. I could not even sit up in my bed or roll over without hitting the ceiling. The food made me feel ill and generally was of the lowest quality, further impeding my ability to work. By the second week i had stopped eating in the dining hall except to drink some coffee, which i had no way to prepare in my dorm suite. Again, the food at the dorms made me ill. It was completely unacceptable. Future accommodations should include private rooms, with at least a common and easily accessible refrigerator, microwave, and coffee maker or electric kettle. Also, most of my roommates were morning people, while i enjoy staying up late to work and talk about problems. It would be nice if participants could be grouped according to their preferred working hours so as not to disturb each other.

It got rather noisy sometimes where I was staying. My room in the dormitory was on the ground floor by a street and there were people talking near my window when I wanted to go to bed...

The dorm beds are awful, but I guess that's to be expected. The food at dinner (in the dorm cafeteria) seemed like it had been cooked hours before hand (which, considering that when I looked at the menus online lunch and dinner at the cafeteria were the same, that may well have been the case). Worst of all though, was the fact that the dorm room was infested with ants (before we arrived). It was very unpleasant, especially with ants crawling all over the walls while I tried to take a shower. Overall the accommodations really detracted from what should've been a fantastic two weeks.

The lunch menu was slightly better the first week, though I thought that the lunch for the second week was much healthier and less oily.

lunch both weeks was quite good.

The vegetarian options during week 2 were not very good. The lunch was often something unhealthy.

Sleeping in the dorms was a complete nightmare. There were several high school camps staying there, and almost every night a different group would have a huge party with loud music in the rec room across from our suite. These parties routinely went to 11 PM or later. There were nights where even with ear-plugs I could hear every word of the music they were playing. If there wasn't music, then it was just high school kids screaming for hours and hours (somehow.) Several times I went down and asked the adults in charge if they could turn down the music (or

at least not point the speakers right at our window) because people were trying to sleep, and my reasonable requests were met with rudeness. I complained to the front desk people and they said that they would reprimand the groups, but nothing changed. There were so many camp groups that even if they could somehow identify what group it was from my complaints, the next night there would just be another horrible party with different people. It was so bad that I made the multiple-hour long public transportation journey home to my apartment in the middle of the program to try to catch up on sleep. Not being able to get enough sleep really impacted how much I was able to get out of the program because it's hard to think when you're sleep-deprived. The residents at the dorm were very loud late at night.

week 2 lunch at MSRI is much worse.

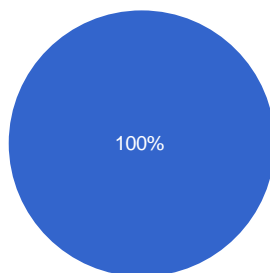
The two caterers were about the same to me. I thought the first day (make your own sandwiches) and barbeque were subpar.

## Thank you for completing this survey

**We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.**

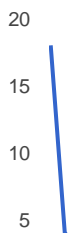
Thanks for the investigation! One last thing: the 8:40am hill line is usually packed. Maybe we can have a shuttle for us exclusively next time?

Better coffee and better food are the main things that need improvement. Once again, the food in the dorms made me ill. I could not eat it. This led to me spending considerable money trying to find acceptable food, which i then had no way to store in my room because i did not have a refrigerator.



Option 1 12 100%

## Number of daily responses



## **CRM-PIMS Summer School in Probability**

June 15, 2015 - July 11, 2015

**MONTREAL, CANADA**

Organizers:

**Louigi Addario-Berry (McGill University)**

**Louis-Pierre Arguin (Université de Montréal)**

**Alexander Fribergh (Université de Montréal)**

**Lea Popovic (Concordia University)**

Final Report  
CRM-PIMS Summer School in Probability  
June 15-July 10 2015



## Summary

The CRM-PIMS Summer School in Probability took place in Montreal for the first time from June 15 to July 10, 2015. The lectures were held at McGill University, McConnell Engineering building. The details of the organization can be found on the school website:

<http://problab.ca/ssprob2015/>

A grand total of 115 participants attended the school including the speakers. The demographics were very diverse with a strong Canadian, American and European contingent. Most of the participants (95) were Ph.D. students. The funding of the School came from PIMS, CRM, MSRI, Clay Institute, NSF, and the Montreal Probability Group (CRM probability laboratory).

The program of the school included four days of courses Monday, Tuesday, Thursday and Friday with one free day on Wednesday. There were two major courses of six hours per week that were given by Alice Guionnet (MIT) and Remco van der Hofstad (TU Eindhoven). There were also

three mini-courses of three hours each given by Shankar Bhamidi (North Carolina, Chapel Hill), Jonathan Mattingly (Duke) and Louigi Addario-Berry (McGill). A one-hour guest lecture was also given by Peter Winkler (Dartmouth). The scientific content of these lectures are detailed below. Each day of the school included around four to five hours of lectures. The students seemed to appreciate the free day on Wednesday to assimilate the materials. The participation by the students was, in our opinion and in the opinion of the lecturers, quite extraordinary. The students asked many questions at every lecture and followed the material until the end. This is to the merit of the lecturers, especially Guionnet and van der Hofstadt, who had prepared detailed lecture notes (with exercises) beforehand allowing the students to follow along. In addition of the senior lectures, the schedule included twenty-seven short talks (30 minutes) by the participants. These participants were mostly advanced PhD students that were presenting their thesis work. It was widely acknowledged by the organizers and the senior participants that the quality of the presentation of the short talks as well as their scientific content were of very high quality. The subjects of the short talks are discussed in more details below.

### Scientific Highlight

The course of Alice Guionnet was entitled *Random matrices, free probability, and the enumeration of maps*. Random matrices are random variables taking values in spaces of matrices. The study of random matrices has undergone major breakthroughs in the recent years, especially in the study of universal properties of their spectrum. Guionnet started the course by showing different methods to prove the convergence of the spectral measure based on the computation of moments. The other was analytical and based on the convergence of the Stieltjes measure. She then discussed how the fluctuations of the spectral measure can be studied by refining these methods. She also mentioned recent results on the universal local fluctuations of the eigenvalues for the beta-ensemble which is a general class of random matrices. She briefly discussed the applications of free probability to the problem of convergence for joint moments of products of matrices. Finally, she concluded the course by connecting the problem of finding the fine asymptotics of linear statistics of random matrices (Wigner matrices and beta-ensembles) to the topological expansion that arises when developing generating functions of these statistics. The problem of enumerating maps (or geometries) then corresponds to the control of these statistics using the so-called loop equations.

The course of Remco van der Hofstadt was on the subjects of *High-dimensional Percolation and Random Graphs*.

Percolation is one of the most important models of modern probability. Percolation is a simple models exhibiting phase transition. On a graph, every edge chooses to be open with probability  $p$ . One can then study the probability of connections of two vertices on open edges. The goal of the lectures was to develop general techniques to prove common behaviors for percolation in high-dimension. The lectures started by studying percolation on a tree and branching random walks. The relevant connective properties were derived for this mean-field model. Van der Hofstadt then showed a recent proof of Dominil-Copin and Tassion on the uniqueness of the phase transition. The lecture then proceeded to the proof of mean-field behavior of percolation in high-dimension using the *lace expansion* to prove the so-called triangle condition. Recent results by Fitzner and van der Hofstadt were presented that brings the upper critical dimension (above which mean-field behavior is expected) from 19 to 11. The conjecture for the upper critical dimension is  $d=6$ .

The mini-courses of three hours each were by Addario-Berry (*Random minimum spanning trees*), Shankar Bhamidi (*Dynamic random network models*), and Mattingly (*Stabilization by noise*).

Addario-Berry gave an introduction to the probabilistic study of minimum spanning trees, from the perspective of coalescent theory. There are three basic and natural random discrete coalescent procedures, corresponding to constant, additive, and multiplicative gelation kernels. The first of these corresponds to Kingman's coalescent; the second to the additive coalescent. The multiplicative case turns out to precisely build mean-field random minimum spanning trees. After situating the minimum spanning tree problem in this manner, Addario-Berry presented a novel proof of Frieze's zeta(3) limit theorem for the weight of the minimum spanning tree, and introduced the link between minimum spanning trees and critical percolation.

Bhamidi's lectures were focussed on his recent work on universality for scaling limits of random network models. As part of a programme to study the metric structure of minimum spanning trees, Addario-Berry and coauthors recently derived the scaling limit of the critical Erdős-Rényi random graph. Bhamidi and his coauthors have shown that this scaling limit is also the limit for many other random graph models; he provided an introduction to this impressive line of research. In his final lecture, he also described his recent work on the superstar model – a random graph process designed to model networks in which there is “condensation”, or a small number of nodes which have macroscopic effects on the connectivity of the network.

Mattingly's lectures provided a beautiful introduction to techniques he and coauthors have recently developed to study the existence and uniqueness of invariant measures for Markov processes in infinite-dimensional state spaces. Mattingly presented techniques involving the use of Lyapunov and super-Lyapunov functions, and the use of Poisson equations to propagate Lyapunov functions between different parts of phase space. He closed by presenting his new proof, with Martin Hairer, of Harris's ergodic theory, and theorem addressing uniqueness of ergodic invariant measures in settings where different initial conditions lead to mutually singular diffusions.

The guest lecture by Peter Winkler was entitled “Permutons” and focused on the study of patterns emerging in random permutations.

The short talks covered a wide range of topics in modern probability. We attached the abstract for more details. As a glimpse, there were presentations on KPZ universality, Random Trees, Schramm-Loewner Evolution on the Ising model, Spin Glasses, SDE with singular drift, Random Walks in Random Environment, Random Graphs, Cover Times of Random Walks, etc.

## Conclusion

We believe that the 2015 CRM-PIMS Summer School in Probability was a great success considering the strong attendance and the wide range and deep scientific content of the lectures. This was the first school in the series of PIMS Probability schools to be organized in Montreal. We hope that the school will return in the near future, building on the success of this year and improving the organization based on the feedback of the participants. We are grateful for the opportunity to organize such an important event for the international probability community and

for the financial support provided by the PIMS, CRM, MSRI, Clay Institute, NSF, and the Montreal Probability Group (CRM probability laboratory).

### Local organizing committee

Louigi Addario-Berry, McGill University  
Louis-Pierre Arguin, Université de Montréal  
Alexander Fribergh, Université de Montréal  
Lea Popovic, Concordia University

Montreal, August 31, 2015



<b>Organizers</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Louigi	Addario-Berry	McGill University
Louis-Pierre	Arguin	Université de Montréal
Alexander	Fribergh	Université de Montréal
Lea	Popovic	Concordia University

<b>MSRI Supported Students</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Benson	Au	University of California, Berkeley
Jamil	Chaker	Universität Bielefeld
Lara	Du	University of Michigan
Alex	Gutierrez	University of Minnesota Twin Cities
Ching Wei	Ho	University of California, San Diego
Indrajit	Jana	University of California, Davis
Ke	Jin	University of Delaware
Nayeong	Kong	Temple University
Hanbaek	Lyu	Ohio State University
Yixiang	Mao	Harvard University
Robert	McAndrew	Ohio University
Chengwei	Qin	McMaster University
Matthew	Riebel	National Cryptologic School
Eddie	Tu	University of Tennessee
Sarah	Wolff	Dartmouth College
Sina	Yansori	University of Alberta
Alex	Young	University of Arizona
Zheng	Zhou	University of California, Santa Cruz

## Officially Registered Student Information

<b>Participants</b>		<b>18</b>
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<b>Gender</b>		<b>18</b>
<b>Male</b>	83.33%	15
<b>Female</b>	16.67%	3
<b>Declined to state</b>	0.00%	0

<b>Ethnicity*</b>		<b>18</b>
<b>White</b>	22.22%	4
<b>Asian</b>	66.67%	12
<b>Hispanic</b>	5.56%	1
<b>Pacific Islander</b>	0.00%	0
<b>Black</b>	0.00%	0
<b>Native American</b>	0.00%	0
<b>Mixed</b>	0.00%	0
<b>Declined to state</b>	5.56%	1

\* ethnicity specifications are not exclusive

# 13 responses

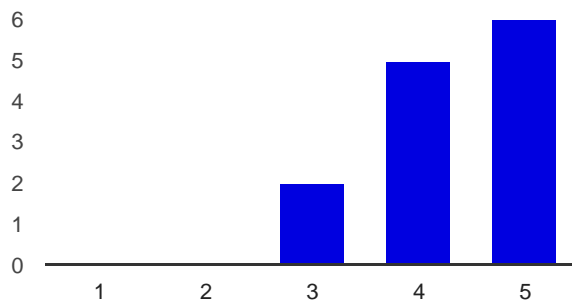
13 responses out of 18 students = %72  
[View all responses](#)   [Publish analytics](#)

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## Summary

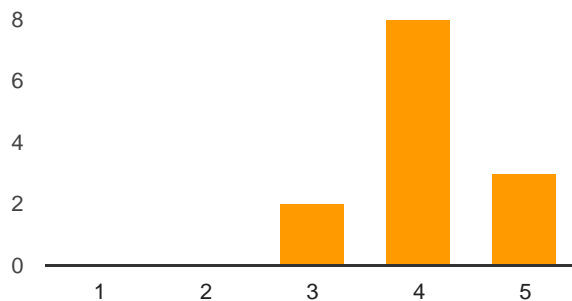
### Topic presentation and organization

The various topics within the summer school integrated into a coherent picture



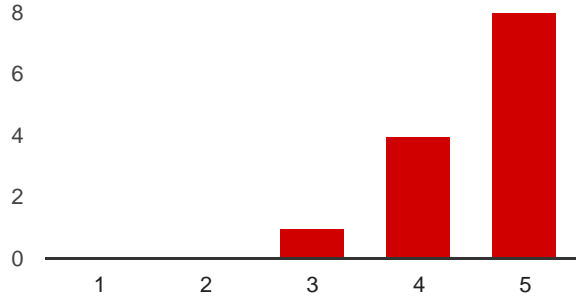
Not at all: 1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>2</b>	15.4%
4	<b>5</b>	38.5%
Very much: 5	<b>6</b>	46.2%

The faculty speakers were generally clear and well organized in their presentation



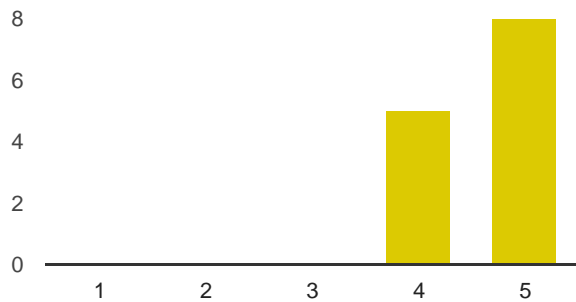
Not at all: 1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>2</b>	15.4%
4	<b>8</b>	61.5%
Very much: 5	<b>3</b>	23.1%

**The school was intellectually stimulating**



Not at all: 1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>1</b>	7.7%
4	<b>4</b>	30.8%
Very: 5	<b>8</b>	61.5%

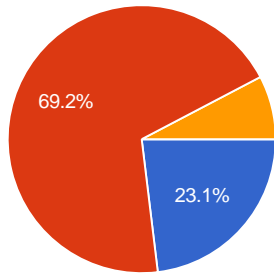
**The overall experience of the school was worthwhile**



Not at all: 1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>0</b>	0%
4	<b>5</b>	38.5%

Very: 5    **8**    61.5%

**The amount of material presented was:**



Too much	<b>3</b>	23.1%
Just the right amount	<b>9</b>	69.2%
Not enough	<b>1</b>	7.7%
No opinion	<b>0</b>	0%

**Additional comments on the topic presentation and organization**

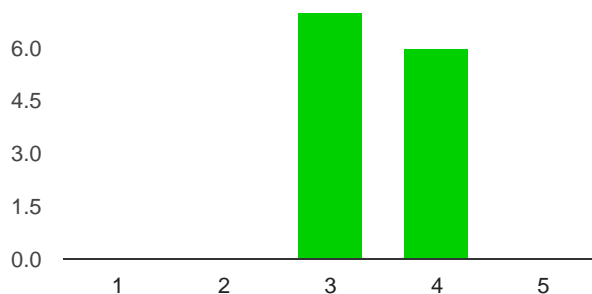
The organization is just great! The topics are nice, but one of the course was taught a little bit confusing.

Thanks for letting me write. It was a great summer school. Both the 'random matrix theory' and 'graph theory' are of my great interest. Currently I am working on the random matrix theory and it was really helpful to see that the tools can be used in graph theory too.

I had a difficult time understanding Alice Guillonet with the matrices course, including her rather sloppy notation on the board. The rest of the courses were great.

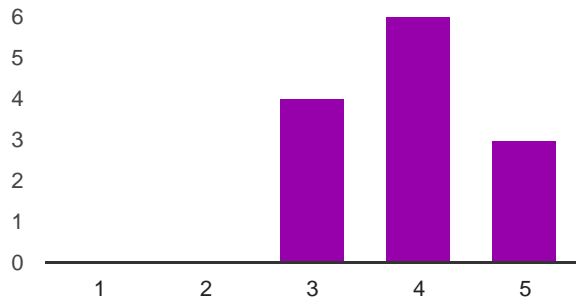
**Personal assessment**

**I was well prepared to benefit from the school**



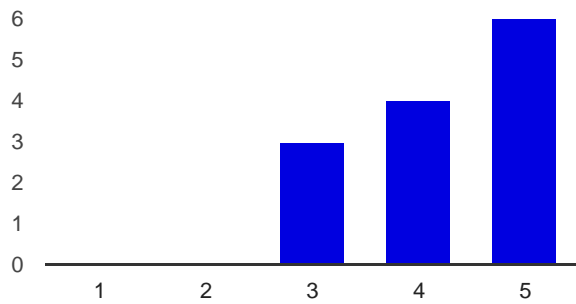
Not at all: 1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>7</b>	53.8%
4	<b>6</b>	46.2%
Very: 5	<b>0</b>	0%

**My interest in the subject matter was increased by the school**



Not at all: 1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>4</b>	30.8%
4	<b>6</b>	46.2%
Very much: 5	<b>3</b>	23.1%

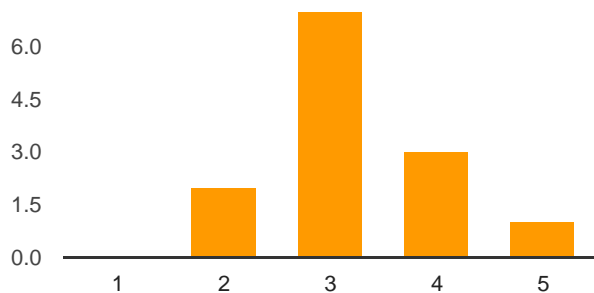
**The school helped me meet people with similar scientific interests**



Not at all: 1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>3</b>	23.1%
4	<b>4</b>	30.8%

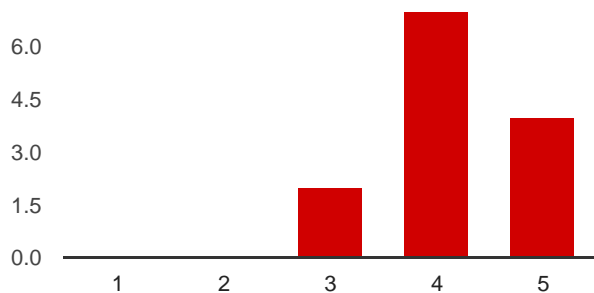
Very much: 5   **6**   46.2%

**It is likely that I will work in the area of the school subject in the future**



Not at all: 1   **0**   0%  
 2   **2**   15.4%  
 3   **7**   53.8%  
 4   **3**   23.1%  
 Very: 5   **1**   7.7%

**How would you evaluate your interaction with other participants?**



not satisfactory: 1   **0**   0%  
 2   **0**   0%  
 3   **2**   15.4%  
 4   **7**   53.8%  
 above satisfactory: 5   **4**   30.8%

**Additional comments on your personal assessment**

I may consider going back to school someday to earn a Ph.D. in some mathematical or scientific



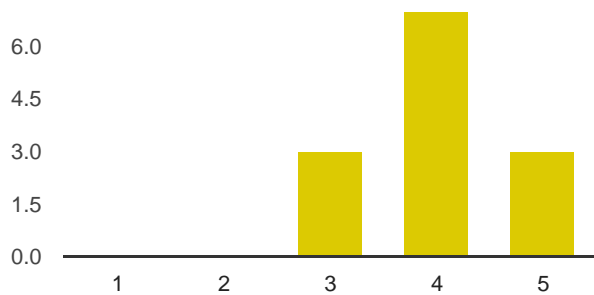
field.

I have learned a lot. I met several potential collaborators during the summer school.

Nice place for people with similar research interest to meet. I would be glad if there were some officially organized social events.

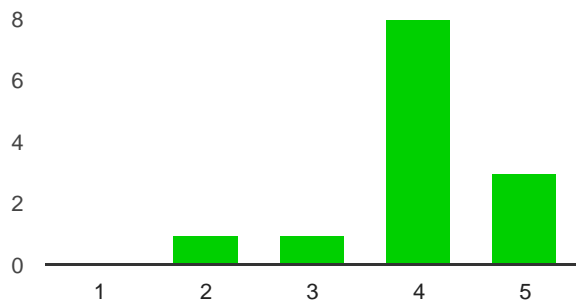
## Venue

### I found the onsite staff helpful



Not at all: 1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>3</b>	23.1%
4	<b>7</b>	53.8%
Very: 5	<b>3</b>	23.1%

### The physical facilities were conducive for such a school



Not at all: 1	<b>0</b>	0%
2	<b>1</b>	7.7%

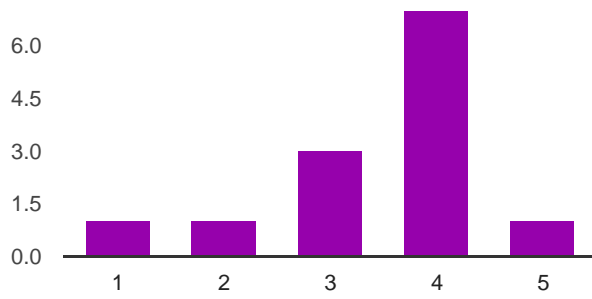
3	1	7.7%
4	8	61.5%
Very: 5	3	23.1%

### Additional comments on the venue

A nice place indeed!

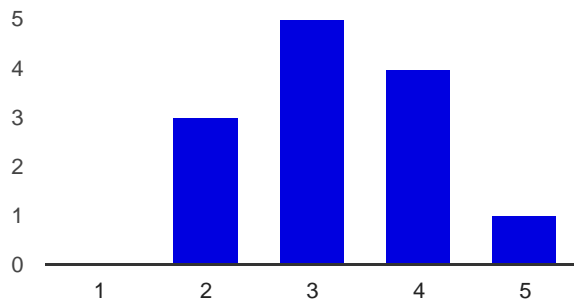
## Accommodation and Food

### The summer school accommodation



not satisfactory: 1	1	7.7%
	2	7.7%
	3	23.1%
	4	53.8%
above satisfactory: 5	1	7.7%

### The food provided



not satisfactory: 1	<b>0</b>	0%
2	<b>3</b>	23.1%
3	<b>5</b>	38.5%
4	<b>4</b>	30.8%
above satisfactory: 5	<b>1</b>	7.7%

### **Additional comments on accommodation and food**

The place for accommodation is convenient. For the food provided, if there could have been some varieties, I would like it better. But after all, both were good.

I would prefer different foods served each day, rather than coffee and croissants every day.

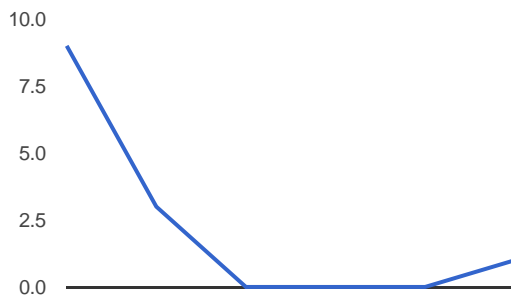
The accommodation was great and the food was okay. I was given a single bedroom apartment and the cooking facility was not that great.

### **Thank you for completing this survey**

**We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.**

I would say if there is some place provided for people to study after daily classes and on weekends, there would be much better for students to catch up with the materials provided in class; thus, it will give a more effective summer school for the participants.

### **Number of daily responses**



**Incompressible Fluid Flows at High Reynolds  
Number**

July 27, 2015 - August 07, 2015

MSRI, Berkeley, CA, USA

Organizers:

**Jacob Bedrossian (University of Maryland)**

**Vlad Vicol (Princeton University)**

**FINAL REPORT**  
**MSRI GRADUATE SUMMER WORKSHOP**  
**INCOMPRESSIBLE FLUID FLOWS AT HIGH REYNOLDS NUMBER**  
**JULY 27, 2015 – AUGUST 07, 2015**

JACOB BEDROSSIAN AND VLAD VICOL

**Goals.** The purpose of this two week workshop was twofold: to introduce graduate students to the basic principles and some of the fundamental mathematical results in the field of incompressible fluid mechanics; and then to expose them to several state-of-the-art methods and ideas for understanding incompressible fluid mechanics at high Reynolds number.

First, students were introduced to the mathematical foundations of the central equations in fluid mechanics: the Euler and the Navier-Stokes equations. Achieving this required discussing a number of basic tools from real, functional, complex, and harmonic analysis. This introduction was followed up with three focused courses on modern developments in fluid dynamics, all under the umbrella of high (or infinite) Reynolds number: one on boundary layers and the vanishing viscosity limit, by Vlad Vicol; another on mixing/hydrodynamic stability at high Reynolds number, by Jacob Bedrossian; and a the third one on Onsager’s conjecture and connections to turbulence, by guest lecturer Roman Shyvkoy.

**Organization of week 1.** In the first week, Jacob Bedrossian and Vlad Vicol each delivered a daily 1.5 hour lecture (totaling 10 lectures) on the fundamentals of mathematical fluid mechanics.

**Lecture series on fundamentals for the Euler and Navier-Stokes equations.** These lectures covered foundational topics, starting from the derivation of the equations, along with basic properties and invariants, continuing with the local and global well-posedness theories for 2D and 3D Euler and Navier-Stokes equations, and concluding with the theory of Leray-Hopf weak solutions, and Fujita-Kato mild solutions, fixed point arguments, and related concepts. Throughout these lectures, a number of exercises were assigned to the students, to complete and complement some of the ideas from the lectures. We believe that this basic, yet intense, course served its purpose: for the students who were absolutely new to the field, it has introduced them to the basic principles behind these topics, while for the students who were already starting to do research in the field, it has strengthened their background, which is essential for future research. Moreover, for all students this first week course provided the necessary background material for the three advanced courses taught in the second week.

**TA sessions on analysis review and problem sessions.** Each day’s lectures were supplemented with 2 hours in which the teaching assistants, Michele Coti Zelati and Hao Jia, provided the students with a fresh review of a selected topic in analysis that pertained either to the lectures of that or to those the following day. Examples of topics discussed in these sessions include: functional analysis, Fourier analysis, singular integral theory, and Littlewood-Paley theory. Moreover, TAs had the opportunity to discuss some of the homework problems that were assigned. We found though that students were a bit shy in asking

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*Date:* September 13, 2015.

questions regarding these homework problems. For the future, it may be interesting to look for ways to stimulate/reward students for completing homework sets.

**Organization of week 2.** During second week there were three parallel courses given on more advanced topics in high Reynolds number dynamics: Jacob Bedrossian gave 5 lectures (1.5 hours each) on mixing and hydrodynamic stability; Vlad Vicol gave 5 lectures (1.5 hours each) on boundary layer analysis and the Prandtl equations; while our guest lecturer Roman Shvydkoy gave 3 lectures (1.5 hours each) on Onsager's conjecture at high and infinite Reynolds number. These topics were selected since they are among the most active in the field today, and they present a lot of promise for further research in the coming years. Our goal was to give the students a bit more than an overview of current work in this field.

**Lecture series on the inviscid limit and boundary layer analysis.** Vlad Vicol's lectures were focused on the issue of the inviscid limit of the Navier-Stokes equations (infinite Reynolds number limit) in the presence of boundaries. Before turning to PDEs, the issue of singular limits in ODEs was addressed, with the idea of boundary layer correctors in mind. The students seemed to really like this digression into new features concerning equations they all seemed to be familiar with. This introduction was followed up with a discussion of the convergence of the Navier-Stokes to the Euler equations in the absence of boundaries, with an emphasis on the fact that the topology in which the convergence is measured, dramatically affects the rates of convergence. Next, the fundamental work of Kato on the equivalence between the inviscid limit in the energy space and of the emergence of wall turbulence was presented. This was followed up with 21st century developments on this classical work. The lecture series' last topic was the analysis of the Prandtl equations, which are the equations arising in classical boundary layer asymptotics. We concluded by presenting some of the open problems in the field.

**Lecture series on mixing and hydrodynamic stability.** Jacob Bedrossian's lectures addressed hydrodynamic stability and mixing at high Reynolds number, spanning results from three different centuries. The first lectures explored two different notions of stability: spectral and Lyapunov. Examples included the classical Rayleigh spectral stability criterion for shear flows with no inflection points, and Arnold's nonlinear stability theorem for shear flows in a channel. These fundamental examples were followed up with a more detailed analysis of mixing and dissipation in passive scalar flows at high Péclet number. This analysis included the introduction of the basic Fourier-analytic tools needed to address the nonlinear problem in the last two lectures. Even at the level of the linearized Euler and Navier-Stokes equations, these methods gave the students new insights, not available with the more classical soft tools. This lecture series concluded with the nonlinear 2D Euler equations near the Couette flow, and a brief discussion regarding the 2D and 3D Navier-Stokes equations near Couette flow at high Reynolds number.

**Lecture series on the Onsager conjecture.** Roman Shvydkoy's lectures discussed the problem of conservation of energy in fluid mechanics. The first lecture introduced the Onsager conjecture, and gave motivation for it to hold from the phenomenological theories of turbulence. Students with a strong liking in physics and applied math particularly enjoyed this part. The second lecture turned to making the conjecture mathematically rigorous, in terms of critical Besov space regularity. Moreover, the definition of Onsager criticality was checked in the particular case of the Burgers equations. The last lecture used Littlewood Paley analysis to prove the positive part of the Onsager conjecture in the context of the Euler equations, and to discuss mechanisms for energy balance restoration in Onsager critical

and supercritical spaces. This last lecture was indeed quite advanced, but it seemed that a good number of students were following up to the end.

**TA sessions on analysis review and problem sessions.** In the second week, the TAs resumed taking questions on the homework problems. However, since the students still were a bit too shy, Michele and Hao had the time to discuss a few special topics that did not make it into the main lectures, such the definition of the Stokes operator in bounded domains, vortex patches, and attractors.

**Evaluation of the success of the summer school.** Overall, our goal throughout the two weeks was to expose students to a number of new analysis tools that are not always taught in a graduate school curriculum, and to present them with different, yet complementary, perspectives on mathematical fluid mechanics. We hope that this has helped them solidify the footing needed in order to start research in the field.

**Lectures notes and exercises.** Along with the lectures, we have made an effort to offer the students typed up or scanned handwritten notes, which were posted on the MSRI website at the end of each day. In total: 122 typed pages for week 1's lectures, 59 handwritten pages + 52 typed pages + 13 typed pages for the three lectures in week 2. These lecture notes provided not only a review of lecture material, but also more detailed information on the background material, supplemental advanced materials, and many exercises meant to build fundamentals and expand understanding of the lectures. In conjunction with the video-taped lectures, we feel that these notes have served as a great resource to the students.

**The students.** We were a bit surprised by the big spread in the backgrounds of the students. An initial survey showed that some of them had not taken a course covering functional or harmonic analysis, while others were already doing research in fluids mechanics. To accommodate this diverse background we have tried to have the first three days of each week be geared towards the beginning graduate students, and the last two days towards the more advanced ones, which were a year or two years away from getting a PhD. Even so, we feel that because of this slight math language barrier some of the beginning students were having a hard time with the pace of the course. In order to help mitigate the issue, we believe it could be beneficial if there were a way to encourage some of the younger accepted students to read up on selected background material provided by the organizers in advance of the school. On the other end of the spectrum we had a voluntary guest 20 minute presentation from one of the graduate students, Theodore Drivas, concerning linking numbers in vortex tubes. Both the students and the organizers learned something new that day!

**Conclusion.** Given the extremely diverse backgrounds of the students, we have striven to have something new for everyone: be it the physical motivation for studying these questions, a completely different analysis method, a fresh point of view on a classical problem, some fresh-off-the-press results, or even some of the open questions in the field. We feel that from this point of view the school was a clear success.

DEPARTMENT OF MATHEMATICS AND CSCAMM, UNIVERSITY OF MARYLAND

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*URL:* <http://www.cims.nyu.edu/~jacob/>

DEPARTMENT OF MATHEMATICS, PRINCETON UNIVERSITY, NJ

*E-mail address:* vvicol@math.princeton.edu

*URL:* <http://web.math.princeton.edu/~vvicol/>

<b>Organizers</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Jacob	Bedrossian	University of Maryland
Vlad	Vicol	Princeton University
<b>Speakers</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Jacob	Bedrossian	University of Maryland
Roman	Shvydkoy	University of Illinois, Chicago
Vlad	Vicol	Princeton University





Mathematical Sciences Research Institute

## Incompressible Fluid Flows at High Reynolds Number

July 27- August 27, 2015

### Schedule

<b>Monday, July 27, 2015</b>			
8:45 AM - 9:00 AM	Simons Auditorium		MSRI Intro
9:00 AM - 10:30 AM	Simons Auditorium	Vlad Vicol	Lecture
10:30 AM - 11:00 AM	Atrium		Coffee Break
11:00 AM - 12:00 PM	Simons Auditorium		Teaching Assistant Session
12:00 PM - 1:30 PM	Atrium		Lunch
1:30 PM - 3:00 PM	Simons Auditorium	Jacob Bedrossian	Lecture
3:00 PM - 4:00 PM	Atrium		Tea
4:00 PM - 5:00 PM	Simons Auditorium		Teaching Assistant Session

<b>Tuesday, July 28, 2015</b>			
9:00 AM - 10:30 AM	Simons Auditorium	Vlad Vicol	Lecture
10:30 AM - 11:00 AM	Atrium		Coffee Break
11:00 AM - 12:00 PM	Simons Auditorium		Teaching Assistant Session
12:00 PM - 1:30 PM	Atrium		Lunch
1:30 PM - 3:00 PM	Simons Auditorium	Jacob Bedrossian	Lecture
3:00 PM - 4:00 PM	Atrium		Tea
4:00 PM - 5:00 PM	Simons Auditorium		Teaching Assistant Session

<b>Wednesday, July 29, 2015</b>			
8:30 AM - 10:00 AM	Simons Auditorium	Vlad Vicol	Lecture
10:00 AM - 10:30 AM	Atrium		Coffee Break
10:30 AM - 11:30 AM	Simons Auditorium		Teaching Assistant Session
11:30 AM - 2:00 PM	Tilden Park		BBQ Lunch
2:00 PM - 3:30 PM	Simons Auditorium	Vlad Vicol	Lecture
3:30 PM - 4:00 PM	Atrium		Tea
4:00 PM - 5:00 PM	Simons Auditorium		Teaching Assistant Session

<b>Thursday, July 30, 2015</b>			
9:00 AM - 10:30 AM	Simons Auditorium	Jacob Bedrossian	Lecture
10:30 AM - 11:00 AM	Atrium		Coffee Break
11:00 AM - 12:00 PM	Simons Auditorium		Teaching Assistant Session
12:00 PM - 1:30 PM	Atrium		Lunch
1:30 PM - 3:00 PM	Simons Auditorium	Jacob Bedrossian	Lecture
3:00 PM - 4:00 PM	Atrium		Tea
4:00 PM - 5:00 PM	Simons Auditorium		Teaching Assistant Session

<b>Friday, July 31, 2015</b>			
9:00 AM - 10:30 AM	Simons Auditorium	Jacob Bedrossian	Lecture
10:30 AM - 11:00 AM	Atrium		Coffee Break
11:00 AM - 12:00 PM	Simons Auditorium		Teaching Assistant Session
12:00 PM - 1:30 PM	Atrium		Lunch
1:30 PM - 3:00 PM	Simons Auditorium	Vlad Vicol	Lecture
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 5:00 PM	Simons Auditorium	Roman Shvydkoy	Lecture



Mathematical Sciences Research Institute

## Incompressible Fluid Flows at High Reynolds Number

July 27- August 27, 2015

### Schedule

<b>Monday, August 03, 2015</b>			
9:00 AM - 10:30 AM	Simons Auditorium	Vlad Vicol	Lecture
10:30 AM - 11:00 AM	Atrium		Coffee Break
11:00 AM - 12:00 PM	Simons Auditorium		Teaching Assistant Session
12:00 PM - 1:30 PM	Atrium		Lunch
1:30 PM - 3:00 PM	Simons Auditorium	Jacob Bedrossian	Lecture
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 5:00 PM	Simons Auditorium	Roman Shvydkoy	Lecture

<b>Tuesday, August 4, 2015</b>			
9:00 AM - 10:30 AM	Simons Auditorium	Vlad Vicol	Lecture
10:30 AM - 11:00 AM	Atrium		Coffee Break
11:00 AM - 12:00 PM	Simons Auditorium		Teaching Assistant Session
12:00 PM - 1:30 PM	Atrium		Lunch
1:30 PM - 3:00 PM	Simons Auditorium	Jacob Bedrossian	Lecture
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 5:00 PM	Simons Auditorium	Roman Shvydkoy	Lecture

<b>Wednesday, August 5, 2015</b>			
9:00 AM - 10:30 AM	Simons Auditorium	Vlad Vicol	Lecture
10:30 AM - 11:00 AM	Atrium		Coffee Break
11:00 AM - 12:00 PM	Simons Auditorium		Teaching Assistant Session
12:00 PM - 1:30 PM	Atrium		Lunch
1:30 PM - 3:00 PM	Simons Auditorium	Jacob Bedrossian	Lecture
3:00 PM - 4:00 PM	Atrium		Tea
4:00 PM - 5:00 PM	Simons Auditorium		Teaching Assistant Session

<b>Thursday, August 6, 2015</b>			
9:00 AM - 10:30 AM	Simons Auditorium	Vlad Vicol	Lecture
10:30 AM - 11:00 AM	Atrium		Coffee Break
11:00 AM - 12:00 PM	Simons Auditorium		Teaching Assistant Session
12:00 PM - 1:30 PM	Atrium		Lunch
1:30 PM - 3:00 PM	Simons Auditorium	Jacob Bedrossian	Lecture
3:00 PM - 4:00 PM	Atrium		Tea
4:00 PM - 5:00 PM	Simons Auditorium		Teaching Assistant Session

<b>Friday, August 7, 2015</b>			
9:00 AM - 10:30 AM	Simons Auditorium	Vlad Vicol	Lecture
10:30 AM - 11:00 AM	Atrium		Coffee Break
11:00 AM - 12:00 PM	Simons Auditorium		Teaching Assistant Session
12:00 PM - 1:30 PM	Atrium		Lunch
1:30 PM - 3:00 PM	Simons Auditorium	Jacob Bedrossian	Lecture
3:00 PM - 4:00 PM	Atrium		Tea
4:00 PM - 5:00 PM	Simons Auditorium		Teaching Assistant Session

<b>MSRI Supported Students</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Farhan	Abedin	Temple University
Eric	Albright	University of Utah
Do	An	Claremont Graduate University
Diana	Atanasova	Boston University
Jonathan	Bohn	Michigan State University
Mark	Bolding	Georgia Institute of Technology
Eric	Cooper	Boston University
Michele	Coti Zelati	University of Maryland
Tam	Do	Rice University
Theodore	Drivas	Johns Hopkins University
Quinton	Farr	University of Alberta
Eduardo	García Juárez	University of Seville
Eli	Goodfriend	Lawrence Berkeley National Laboratory
Cong	Gu	Texas A & M University
Siming	He	University of Maryland
Matthew	Hernandez	Princeton University
Alexi	Hoeft	Rutgers University
Kaitlyn	Hood	University of California
Madelyn	Houser	University of Delaware
Sameer	Iyer	Brown University
William	Jamieson	University of Nebraska
In-Jee	Jeong	Princeton University
Hao	Jia	University of Chicago
Zeliha	Kilic	University of North Carolina
Mykhailo	Kuian	Kent State University
Michael	Kumaresan	CUNY, Graduate Center
Jae Min	Lee	University of Colorado
Byungjoon	Lee	Seoul National University
Trevor	Leslie	University of Illinois at Chicago
Rachel	Levanger	Rutgers University
Beiyu	Lin	Washington State University
Sergei	Melkoumian	McMaster University
Cuong	Ngo	University of Kansas
Joshua	Padgett	Baylor University
Roseanna	Pealatore	Tulane University
Samuel	Pramodh	Harvey Mudd College
Andrew	Rzeznik	Massachusetts Institute of Technology
Yuanzhen	Shao	Vanderbilt University
Justin	Shaw	University of Waterloo
Shengyi	Shen	University of Victoria
Longmei	Shu	Georgia Institute of Technology
Melissa	Strait	North Carolina State University
Jing	Tiang	Texas A & M University
Giuseppe	Vacca	Università di Bari

<b>MSRI Supported Students</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Bin	Wang	The University of Kansas
Fei	Wang	University of Southern California
Xukai	Yan	Rutgers University
Hui	Yu	The University of Texas at Austin

## Officially Registered Student Information

<b>Participants</b>		<b>51</b>
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<b>Gender</b>		<b>51</b>
<b>Male</b>	72.55%	37
<b>Female</b>	27.45%	14
<b>Declined to state</b>	0.00%	0

<b>Ethnicity*</b>		<b>56</b>
<b>White</b>	46.43%	26
<b>Asian</b>	39.29%	22
<b>Hispanic</b>	1.79%	1
<b>Pacific Islander</b>	1.79%	1
<b>Black</b>	0.00%	0
<b>Native American</b>	0.00%	0
<b>Mixed</b>	5.36%	3
<b>Declined to state</b>	5.36%	3

\* ethnicity specifications are not exclusive

# 28 responses

28 responses out of 51 participants = 55% response rate

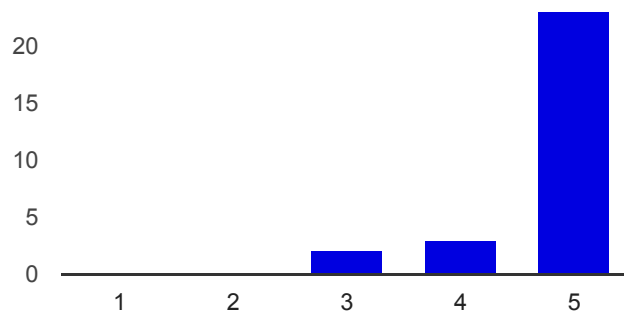
[View all responses](#)   [Publish analytics](#)

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## Summary

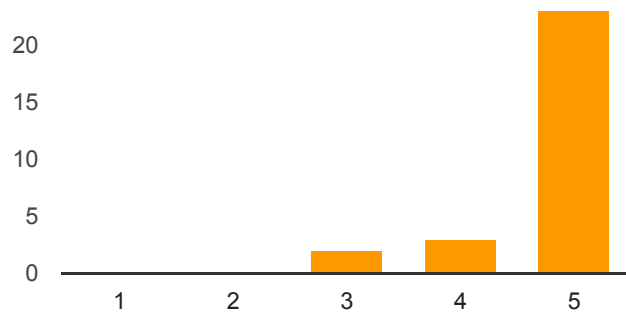
### Topic presentation and organization

The various topics within the summer school integrated into a coherent picture

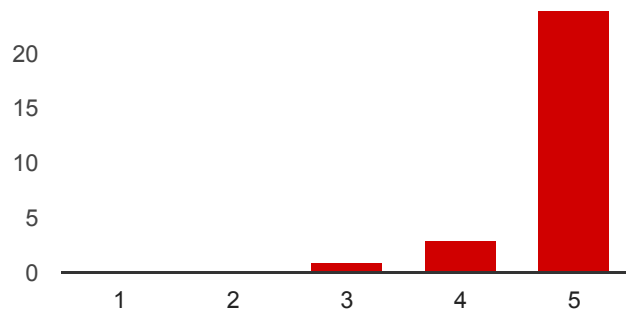


Not at all: 1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>2</b>	7.1%
4	<b>3</b>	10.7%
Very much: 5	<b>23</b>	82.1%

**The faculty speakers were generally clear and well organized in their presentation**

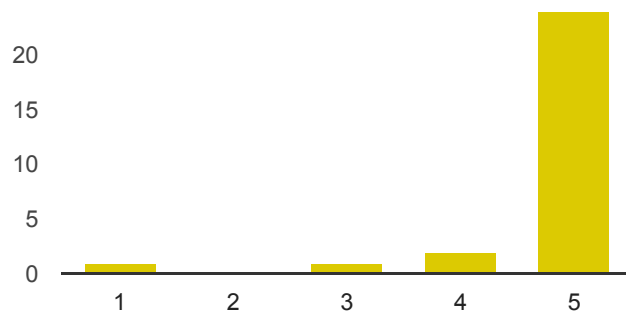


**The school was intellectually stimulating**



Not at all: 1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>1</b>	3.6%
4	<b>3</b>	10.7%
Very: 5	<b>24</b>	85.7%

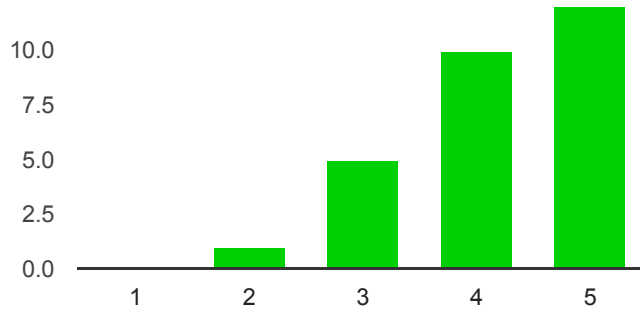
**The overall experience of the school was worthwhile**



Not at all: 1	<b>1</b>	3.6%
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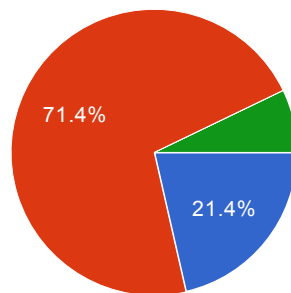
2	<b>0</b>	0%
3	<b>1</b>	3.6%
4	<b>2</b>	7.1%
Very: 5	<b>24</b>	85.7%

**The TA sessions were helpful**



Not at all: 1	<b>0</b>	0%
2	<b>1</b>	3.6%
3	<b>5</b>	17.9%
4	<b>10</b>	35.7%
Very much: 5	<b>12</b>	42.9%

**The amount of material presented was:**



Too much	<b>6</b>	21.4%
Just the right amount	<b>20</b>	71.4%
Not enough	<b>0</b>	0%
No opinion	<b>2</b>	7.1%

**Additional comments on the topic presentation and organization**



Wish there were more intuitive discussions/less math.

Very fast-paced, but informative.

I guess since I am asked to tell my opinions about the summer I definitely would like to tell how much I am super happy due to the fact that I am given the chance of attending this summer school. The professors and TA s were amazing, they were not only extremely clear about their points but also pretty supportive in the sense of making us think more and being able to ask any of our questions either during the lectures or the tea time or even for TA s during dinner time. I definitely now feel like as long as I would love to look for more interesting things in fluid dynamics either related to what I have been working on or something different under the same title, there are at least these professors who lectured us are the ones that I would ask for advice for research.

Honestly as a women researcher, I also have been to AWM sectional meeting and I have not felt this even there among that many women researchers. This summer school was literally amazing. I love doing math and it was all about fluid dynamics, I do not know what to say I just liked it very much. By the way, the way that we have been hosted on Berkeley dorm was also a very good idea so that I have had a chance to hang out with other graduate students who are doing math as well and we got a lot of chance to tell each other what we have been doing in our research . Not only that but also, we reviewed every day what we covered on that day at the summer school. As you may see, the level of my love in math and especially fluid dynamics has been accelerated. I definitely hope for the day that I will be writing my grant proposal for a summer school on my research topic in the near future. I again want to appreciate the people and the organizations and NSF that they gave me this opportunity.

The lecturers could have gone a bit faster in the 2nd week, but otherwise this was an incredibly useful and inspiring experience, and the supplementary notes posted online helped a lot.

The lectures were fantastic. Best presentation of this material I've come across

What excellent lecture notes made in conjunction with the lectures!

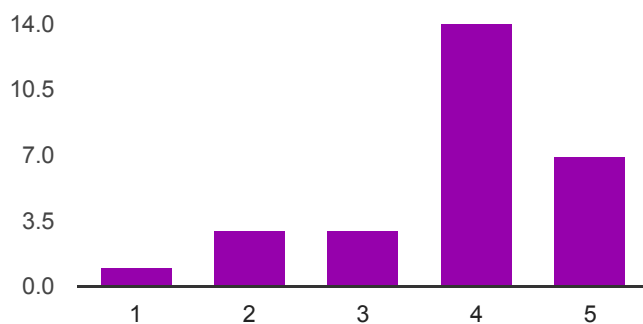
It would have been good to have a lecture where we did a wrap up and overview of what we had seen.

It was an amazing lecture!

It was fairly clear during the first week what the goals were; During the second week, less so.

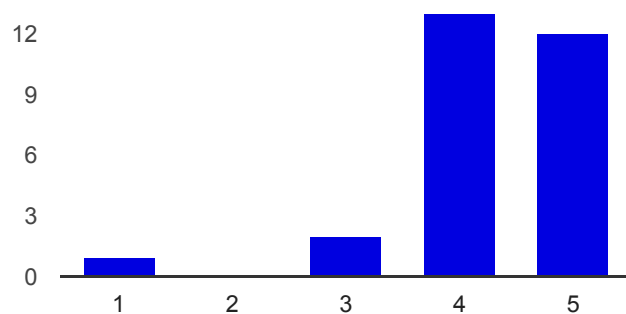
## **Personal assessment**

### **I was well prepared to benefit from the school**



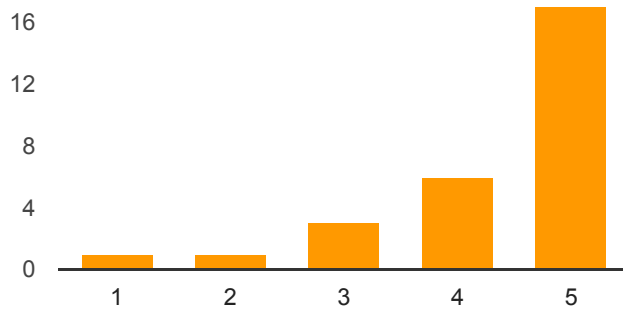
Not at all: 1	<b>1</b>	3.6%
2	<b>3</b>	10.7%
3	<b>3</b>	10.7%
4	<b>14</b>	50%
Very: 5	<b>7</b>	25%

**My interest in the subject matter was increased by the school**



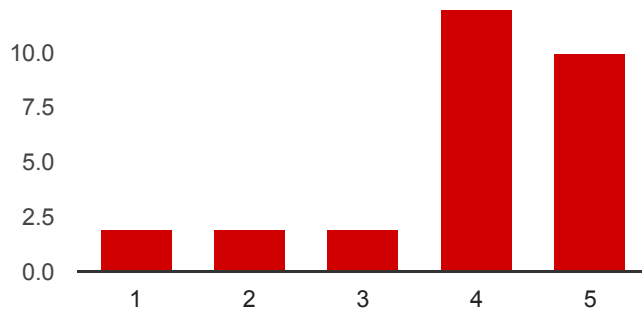
Not at all: 1	<b>1</b>	3.6%
2	<b>0</b>	0%
3	<b>2</b>	7.1%
4	<b>13</b>	46.4%
Very much: 5	<b>12</b>	42.9%

**The school helped me meet people with similar scientific interests**



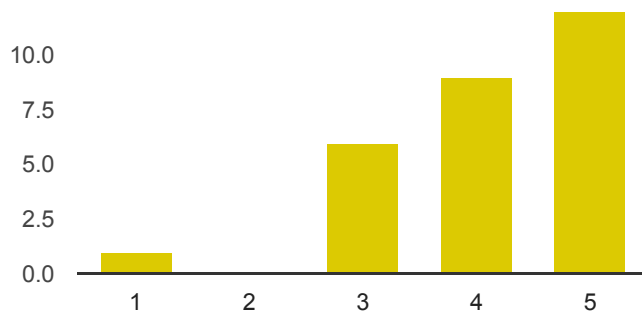
Very much: 5   **17**   60.7%

### It is likely that I will work in the area of the school subject in the future



Not at all: 1   **2**   7.1%  
2   **2**   7.1%  
3   **2**   7.1%  
4   **12**   42.9%  
Very: 5   **10**   35.7%

### How would you evaluate your interaction with other participants?



not satisfactory: 1	<b>1</b>	3.6%
	<b>2</b>	0%
	<b>3</b>	21.4%
	<b>4</b>	32.1%
above satisfactory: 5	<b>12</b>	42.9%

### Additional comments on your personal assessment

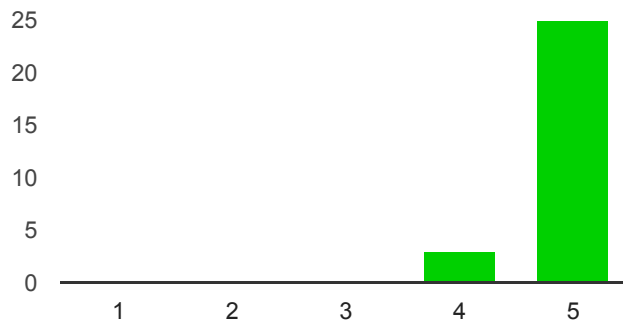
Mathematical prerequisites/background for this workshop should have been made much more clear. I was not prepared.

I am not sure these should be classified as "scientific interests", since they are mathematical and not necessarily "scientific".

Nice school! Lecturers were highly qualified and friendly. I got great experience and met people with the same scientific interests.

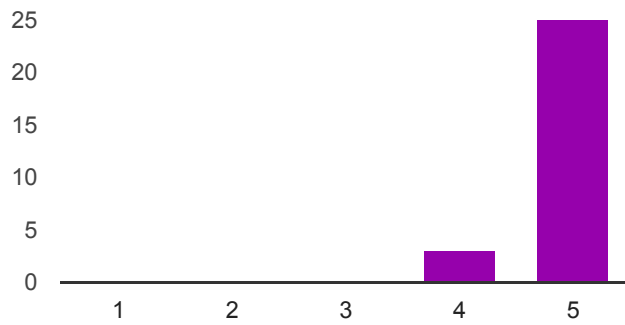
## MSRI Venue

### I found the MSRI staff helpful



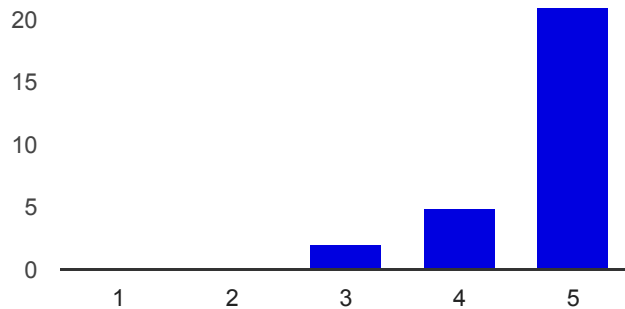
Not at all: 1	<b>0</b>	0%
	<b>2</b>	0%
	<b>3</b>	0%
	<b>4</b>	10.7%
Very: 5	<b>25</b>	89.3%

### The MSRI physical facilities were conducive for such a school



Not at all: 1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>0</b>	0%
4	<b>3</b>	10.7%
Very: 5	<b>25</b>	89.3%

### The MSRI computer facilities were adequate for such a school



Not at all: 1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>2</b>	7.1%
4	<b>5</b>	17.9%
Very: 5	<b>21</b>	75%

### Additional comments on the MSRI venue

MSRI is super awesome. The stuff was pretty nice , I felt the feeling that it is such a privilege for me that I have been taught at a place that all my favorite professors have been to , at some point in their career. In addition to that , the MSRI people were very clear to us about our reimbursement, library options, cafeteria usage. It was such a

friendly environment so that the only thing that you focus on is the math. I greatly appreciate.

It is a beautiful place that is very well-maintained. The air conditioning in the lecture hall made the room quite cold at times.

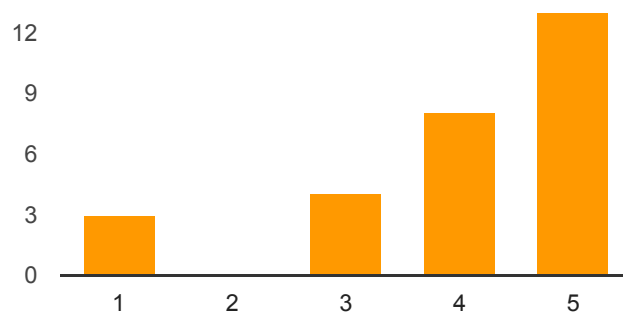
Gorgeous building! Modern and beautifully maintained by a caring staff. Library is marvelous. Love the wifi and printers. And the kitchen and fridge and mugs. Makes me feel at home there at the institute. Lots of caffeine available, too! And everyone can find a quiet spot to work in if they want.

This was an amazing venue. I wish it had more hours it was open.

The venue is fantastic. A perfect place for learning and doing math.

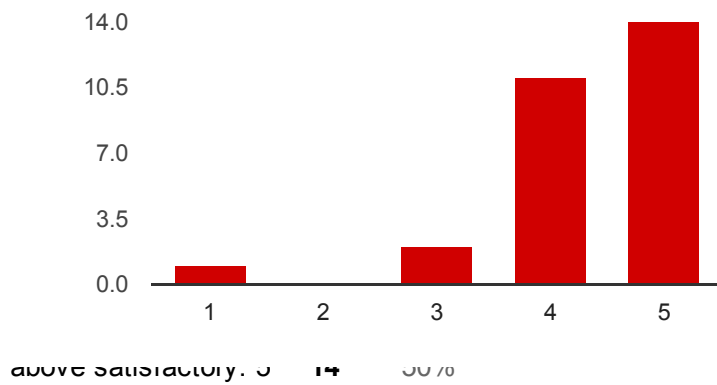
## Accommodation and Food

### The summer school accommodation

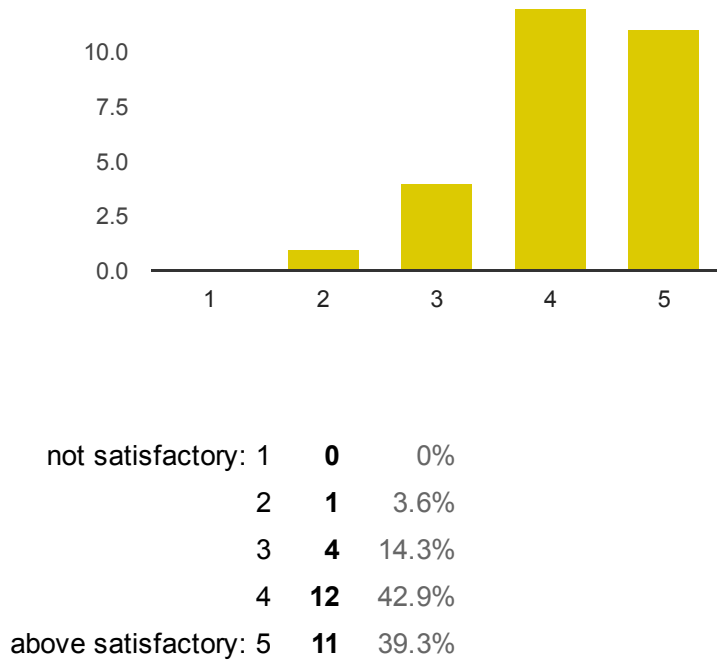


not satisfactory: 1	<b>3</b>	10.7%
2	<b>0</b>	0%
3	<b>4</b>	14.3%
4	<b>8</b>	28.6%
above satisfactory: 5	<b>13</b>	46.4%

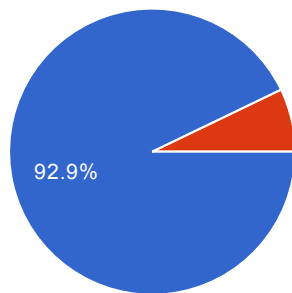
### The food at the dormitories



### The food provided at MSRI



### Did you prefer the lunch provided at MSRI in week one or week two



Week 1	<b>26</b>	92.9%
Week 2	<b>2</b>	7.1%

### Additional comments on accommodation and food

Need single room dorms, not shared. No soap was provided by cleaning staff. How is that possible?

Week 1 food was excellent as was Foothill facility. However, the beds/mattress/pillows at Foothill were uncomfortable. But the desk space and closet space were very good. it was just perfect.

The week 1 caterers were very friendly and jubilant, whereas the week 2 caterers were substantially less enthusiastic, and the vegan/gluten free options (although I did not try them) seemed to receive much less attention in the 2nd week.

The chef from the first week was the best

The second week catering was not up to par, especially for the alternative meals (two days of relatively plain pasta). The first week was truly phenomenal with two guys who were passionate about their work and easy to talk to. The dorm food was good at the cafeteria.

Week 2 food was horrible. Week one was much better.

2nd week's food was terrible!

The salads in week 1 were great. Week two had some good vegetarian options but sometimes it was lacking.

## **Thank you for completing this survey**

**We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.**

- Recommend reduce to 2 lectures/day + 1 tutorial/day. Too many presentations made it difficult to pay attention half-way through.

I had a great experience, so I cannot immediately think of any ways to improve it.

Thanks so much for having me!

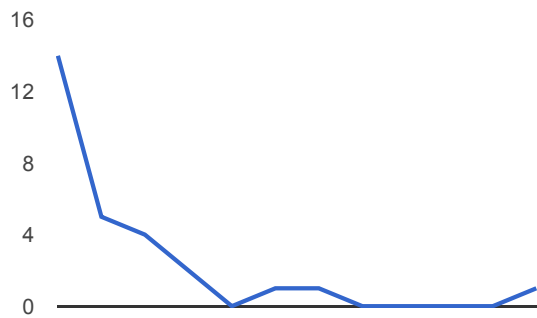
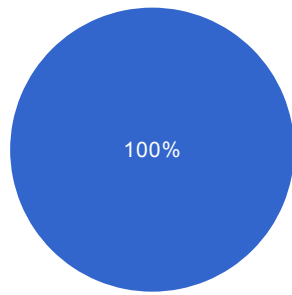
Thank goodness MSRI exists! It is mathematical heaven to me. I can wait to come back again soon.

It was a great experience. Thank you.

I would prefer the daily schedule to be more dense; perhaps shorten the lunch period to 1 hour and both breaks to 30 minutes each. One of the TA sessions could be cut as well. It would be nice to get out around 3 or 4 pm for various reasons, including but not limited to exhaustion and a desire to work on things.

Option 1    **5**    100%





**NIMS Summer School on Random Matrix  
Theory**

June 29, 2015 - July 10, 2015

National Institute For Mathematical Sciences,  
Daejeon, South Korea

Organizers:

**Jinho Baik (University of Michigan)**

# Summer/Winter School Report

## 1. 2015 MSRI-NIMS Summer School on Random Matrix Theory

**2. Date** : June 29, 2015(Mon) – July 10, 2015(Fri)

**Location** : NIMS

## 3. Participants (47 people)

	Professor	Researcher	Student	Etc.	Total
Speaker	4				4
Participant			43		43
Total					47

## 4. Expected Effect

The purpose of the summer school was to introduce random matrix theory to the graduate students. The random matrix theory has diverse applications in mathematics, physics, statistics, and engineering. Moreover, there are several different mathematical approaches to the random matrix theory. Even though random matrix theory is one of the most active areas of research in probability these days, there are not many graduate courses offered in universities. This is because the random matrix theory is a relatively new area in probability, which started in the 1950's in physics, and was developed extensively during the 1990's and 2000's in mathematics, and also because one needs a diverse background in mathematics in order to study random matrix theory. While the topic is probabilistic, the tools used in

studying random matrices include combinatorics, classical analysis, functional analysis, and stochastic analysis. The goal of this summer school is to focus on three specific methods of studying random matrix theory, and introduce the necessary tools in each method. Each of these methods was covered by a series of 8 lecturers, and each lecture series emphasized different aspect of the random matrix theory. One lecture series was concerned with the combinatorial aspect, another lecture series was about the Green's function approach to random matrix theory, while the third lecture series was focused on the exact computation of the probability density functions. By covering the basic aspects of these three different methods to the random matrix theory, the summer school emphasized the diverse mathematical ideas behind random matrix theory. In addition to the lectures, there were plenty of homework problems and there was a problem session each day during which the students presented their solutions to the homework problems.

The summer school provided a great opportunity for the graduate students to learn the introductory topics of the random matrix theory, to interact with some of the leading researchers in the field, and to network with other graduate students of similar research interest.

## **5. Comment for Summer/Winter School**

It was expected that there would be some difficulties for the Korean students and the US students to interact with each other. As the days go by, there were more and more interactions between during the coffee breaks and other social events. Nevertheless it is desired that there are more communications between them. One suggestion is that it is emphasized to the Korean students the importance of the social events, such as dinners and excursions, as a way to make a network with other students, especially those from overseas. One of the goals of the summer school is for the students to get to know other students of similar research interest, and this can be done through the coffee breaks and social events. Many Korean students lack this idea, and it should be mentioned to them at the beginning of the summer school.

Another suggestion is that it would be great if a representative of NIMS or CAMP to come at the beginning the summer school to give a welcome, and introduce the facility and the

staff so that the participants to know who they can ask help. For example, at MSRI, the MSRI director does this for every summer school. It will take about 10 minutes to do this.

Overall, the support from NIMS was excellent. There was always a staff member helping with various daily support, and it was very easy to find any help setting up the projector, or making copies of homework problems, etc. The generous financial support to the students' accommodations and local expenses were excellent.

1 Aug. 2015

Organizer      Jinho Beak

<b>Organizers</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Jinho	Baik	University of Michigan

<b>Speakers</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Jinho	Baik	University of Michigan

<b>MSRI Supported Students</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Chinmoy	Bhattacharjee	University of Southern California
Gerandy	Brito	University of Washington
Jacob	Carruth	University of Texas
Swee Hong	Chan	Cornell University
Onyebuchi	Ekenta	University of California, Berkeley
Kelsey	Houston-Edwards	Cornell University
Matt	Jacobs	University of Michigan
In Gun	Kim	University of Wisconsin-Madison
Marius	Lemm	California Institute of Technology
Richard	Lynch	University of Missouri
Mario	Palasciano	University of Toronto
Robert	Ravier	Duke University
Axel	Saenz	University of California, Davis
Nicolle	Sandoval	University of Southern California
Maria	Villar Lozano	University of Texas

## Officially Registered Student Information

<b>Participants</b>		<b>16</b>
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<b>Gender</b>		<b>15</b>
<b>Male</b>	72.55%	12
<b>Female</b>	27.45%	3
<b>Declined to state</b>	0.00%	0

<b>Ethnicity*</b>		<b>18</b>
<b>White</b>	46.43%	8
<b>Asian</b>	39.29%	4
<b>Hispanic</b>	1.79%	4
<b>Pacific Islander</b>	1.79%	0
<b>Black</b>	0.00%	1
<b>Native American</b>	0.00%	0
<b>Mixed</b>	5.36%	1
<b>Declined to state</b>	5.36%	0

\* ethnicity specifications are not exclusive



# 9 responses

9 responses out of 15 participants = 60% response rate

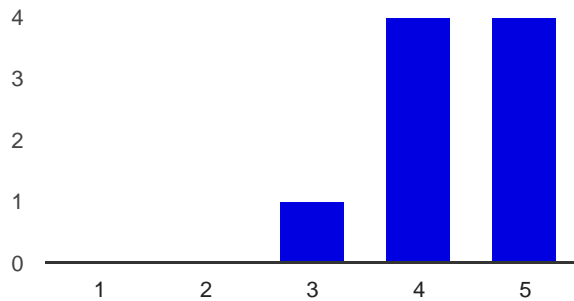
[View all responses](#)   [Publish analytics](#)

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## Summary

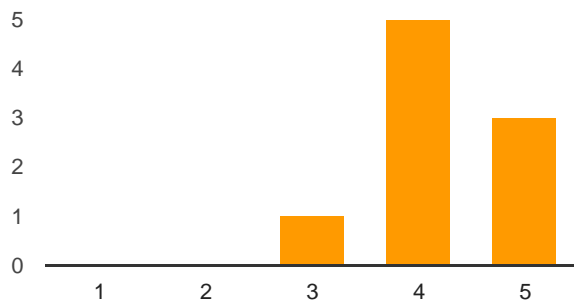
### Topic presentation and organization

The various topics within the summer school integrated into a coherent picture



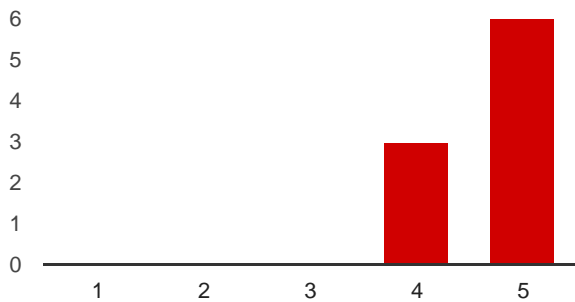
Not at all: 1	0	0%
2	0	0%
3	1	11.1%
4	4	44.4%
Very much: 5	4	44.4%

The faculty speakers were generally clear and well organized in their presentation



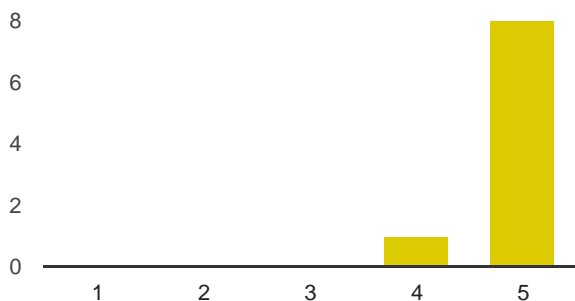
Not at all: 1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>1</b>	11.1%
4	<b>5</b>	55.6%
Very much: 5	<b>3</b>	33.3%

**The school was intellectually stimulating**



Not at all: 1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>0</b>	0%
4	<b>3</b>	33.3%
Very: 5	<b>6</b>	66.7%

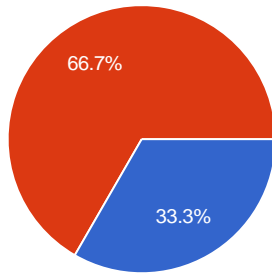
**The overall experience of the school was worthwhile**



Not at all: 1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>0</b>	0%
4	<b>1</b>	11.1%

Very: 5    **8**    88.9%

**The amount of material presented was:**

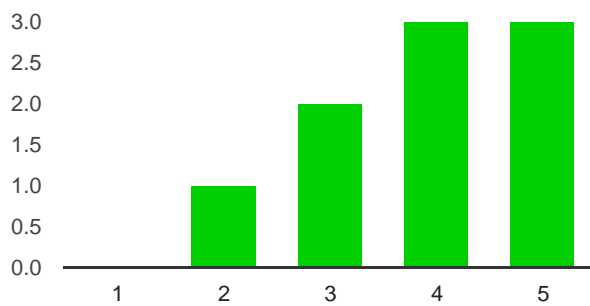


Too much	<b>3</b>	33.3%
Just the right amount	<b>6</b>	66.7%
Not enough	<b>0</b>	0%
No opinion	<b>0</b>	0%

**Additional comments on the topic presentation and organization**

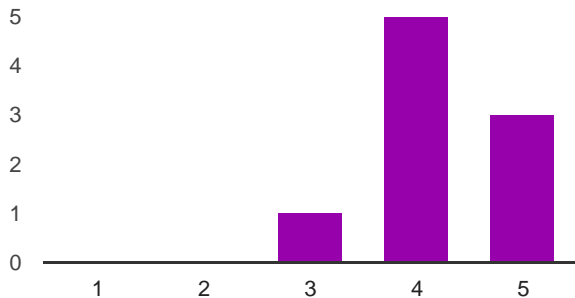
**Personal assessment**

**I was well prepared to benefit from the school**



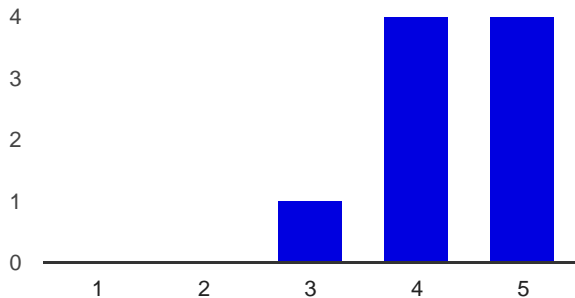
Not at all: 1	<b>0</b>	0%
2	<b>1</b>	11.1%
3	<b>2</b>	22.2%
4	<b>3</b>	33.3%
Very: 5	<b>3</b>	33.3%

### My interest in the subject matter was increased by the school



Not at all: 1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>1</b>	11.1%
4	<b>5</b>	55.6%
Very much: 5	<b>3</b>	33.3%

### The school helped me meet people with similar scientific interests



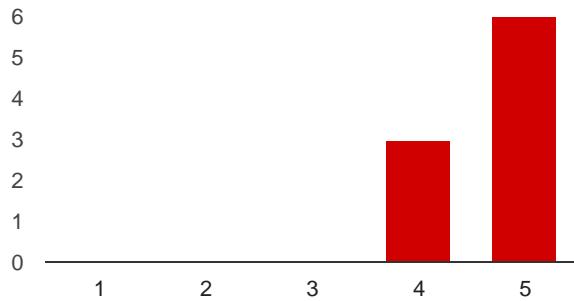
Not at all: 1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>1</b>	11.1%
4	<b>4</b>	44.4%
Very much: 5	<b>4</b>	44.4%

### It is likely that I will work in the area of the school subject in the future



Not at all: 1	<b>0</b>	0%
2	<b>1</b>	11.1%
3	<b>2</b>	22.2%
4	<b>2</b>	22.2%
Very: 5	<b>4</b>	44.4%

### How would you evaluate your interaction with other participants?



not satisfactory: 1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>0</b>	0%
4	<b>3</b>	33.3%
above satisfactory: 5	<b>6</b>	66.7%

### Additional comments on your personal assessment

## Venue

### I found the onsite staff helpful

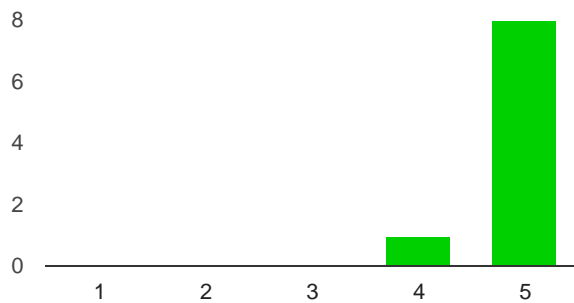
8

6



Not at all: 1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>0</b>	0%
4	<b>1</b>	11.1%
Very: 5	<b>8</b>	88.9%

### The physical facilities were conducive for such a school



Not at all: 1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>0</b>	0%
4	<b>1</b>	11.1%
Very: 5	<b>8</b>	88.9%

### Additional comments on the venue

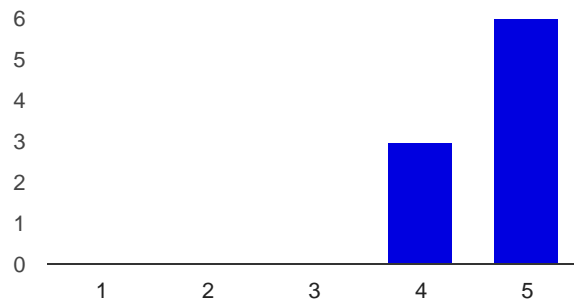
Awesome place!

## Accommodation and Food

### The summer school accommodation

not satisfactory: 1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>0</b>	0%
4	<b>3</b>	33.3%
above satisfactory: 5	<b>6</b>	66.7%

### The food provided



not satisfactory: 1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>0</b>	0%
4	<b>3</b>	33.3%
above satisfactory: 5	<b>6</b>	66.7%

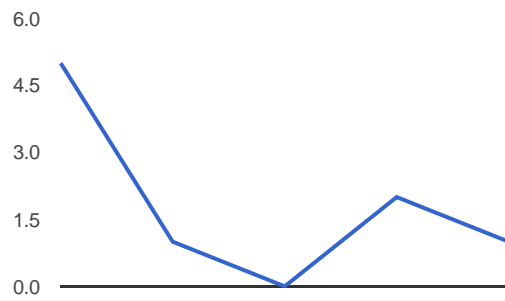
### Additional comments on accommodation and food

**Thank you for completing this survey**

**We welcome any additional comments or suggestions you may have to improve**

**the overall experience for future participants.**

## Number of daily responses





**Berkeley summer course in mining and  
modeling of neuroscience data**

July 06, 2015 - July 17, 2015

Redwood Center For Theoretical Neuroscience,  
Berkeley, CA, USA

Organizers:

**Ingrid Daubechies (Duke University)**

**Bruno Olshausen (University of California, Berkeley)**

**Christos Papadimitriou (University of California, Berkeley)**

**Fritz Sommer (University of California, Berkeley)**

**Jeff Teeters (University of California, Berkeley)**

## **Summary of 2015 Berkeley course in mining and modeling of neuroscience data**

The 2015 Berkeley course in mining and modeling of neuroscience data was held from July 6 – 17 at the Redwood Center for Theoretical Neuroscience (RCTN) at UC Berkeley. The course taught state-of-the-art techniques for analyzing and modeling neuroscience data sets. It was designed for students at the graduate level and researchers with background in a quantitative field such as engineering, mathematics, physics or computer science. It was sponsored by the National Science Foundation from a grant supporting activities at the data sharing repository CRCNS.org, the Helen Wills Neuroscience Institute, the Simons Institute for the Theory of Computing (SITC), the Computer Community Consortium and the Mathematical Science Research Institute (MSRI).

Students could be admitted through three avenues. Students could be admitted and be sponsored (i.e. have travel expenses reimbursed) through MSRI or the Simons Institute; or through CRCNS.org (non-sponsored). Three students attended through SITC, seven through MSRI and 26 through CRCNS.org. There were approximately 70 applicants. Even though the original plan was to accept about 25; because there were so many qualified applicants, 36 were admitted, and even so, many qualified applicants had to be turned away. In addition to the students, there were also 6 teaching assistants from RCTN.

The students came from the following locations and organizations:

United States (28):

AZ: University of Arizona

CA: UC-Berkeley (3), USC, UCSB, UCSC, UCSD, UCSF, UC-Davis (2), LBNL (2)

CO: University of Colorado - Boulder

GA: Georgia Institute of Technology (3)

IL: University of Illinois at Chicago

MI: Central Michigan University

MO: Washington University in St. Louis

PA: Carnegie Mellon University

NJ: Princeton

NY: Columbia University (1); Cornell University (1)

WA: University of Washington (2)

MA: Harvard (1); Harvard children's hospital (1)

Denmark: University of Copenhagen

United Kingdom: Oxford (1); Imperial College London (1)

Italy: University of Torino

Germany: University of Freiburg (1); Jülich Research Center (1); Max Planck Institute for Biological Cybernetics, Tuebingen (1)

Japan: Kyoto University

Organizers from the partner institutions were: Christos Papadimitriou (Simons Institute) and Ingrid Daubechies (MSRI, Duke). During the two-week course, main lectures and computer exercises were given during the day from 9:30 to about 5PM. Instructors were: Vitaly Feldman, IBM Almaden Research Center; Sonja Grün, Juelich Research Center, Germany; Robert Kass, Carnegie Mellon University, Pittsburgh; Maneesh Sahani, Gatsby Unit, University College London; Odelia Schwartz, University of Miami; Eric Shea-Brown, University of Washington; and Frederic Theunissen, UC Berkeley.

In addition to the main instruction given during the day, evening lectures were given by neuroscientists presenting their research using quantitative approaches. The evening lecturers were: Surya Ganguli, Stanford; Jack Gallant, UC Berkeley; Christoph Schreiner, UCSF; Felix Effenberger, Max-Planck-Institute for Mathematics in the Sciences, Leipzig Germany; Mark Goldman, UC Davis; Allie Fletcher, UC Santa Cruz; and Jose Carmena, UC Berkeley.

Social activities held during the course included:

- Course reception on evening of July 6.
- Trip to Exploratorium in San Francisco on evening of July 9.
- Trip to Muir Woods and the Golden Gate National Recreation are on Saturday, July 11.
- Dinner at the Freehouse restaurant in Berkeley on July 16.
- Breakfast every morning on days the course was held.

Of 20 students who completed an online survey given after the course, 70% rated the course as “excellent” (the highest possible rating; 1 on a scale of 1 to 5). The remaining 30% rated the course as “good” (2 on a scale of 1 to 5).

<b>MSRI Supported Students</b>		
<b>First Name</b>	<b>Last Name</b>	<b>Institution</b>
Thomas	Chartrand	University of California, Davis
Patrick	Greene	University of Arizona
Nonhle	Mdziniso	Central Michigan University
Benjamin	Reames	Auburn University
Kathleen	Smith	University of Colorado
Adam	Willats	Georgia Institute of Technology

## Officially Registered Student Information

<b>Participants</b>		<b>6</b>
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<b>Gender</b>		<b>6</b>
<b>Male</b>	72.55%	4
<b>Female</b>	27.45%	2
<b>Declined to state</b>	0.00%	0

<b>Ethnicity*</b>		<b>8</b>
<b>White</b>	46.43%	5
<b>Asian</b>	39.29%	1
<b>Hispanic</b>	1.79%	0
<b>Pacific Islander</b>	1.79%	0
<b>Black</b>	0.00%	1
<b>Native American</b>	0.00%	0
<b>Mixed</b>	5.36%	1
<b>Declined to state</b>	5.36%	0

\* ethnicity specifications are not exclusive

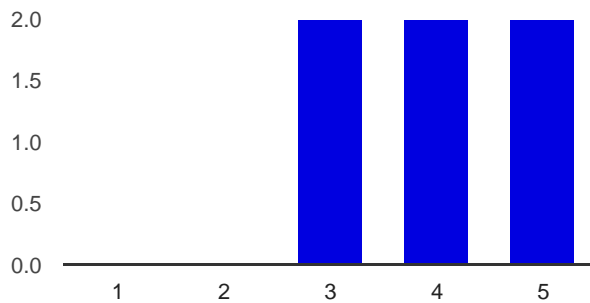
# 6 responses

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## Summary

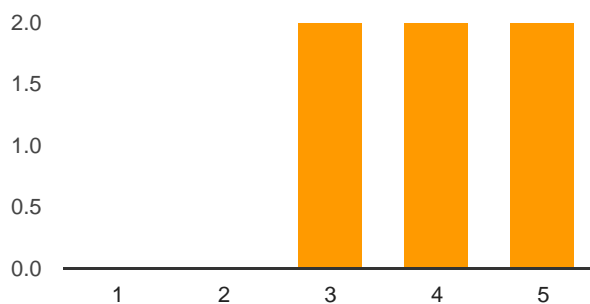
### Topic presentation and organization

The various topics within the summer school integrated into a coherent picture



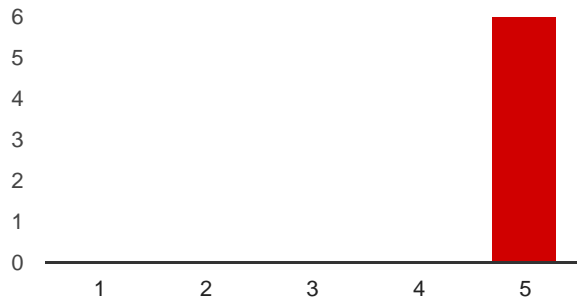
Not at all: 1	0	0%
2	0	0%
3	2	33.3%
4	2	33.3%
Very much: 5	2	33.3%

The faculty speakers were generally clear and well organized in their presentation



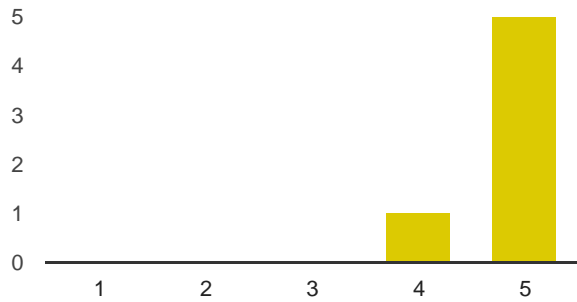
Not at all: 1	0	0%
2	0	0%
3	2	33.3%
4	2	33.3%
Very much: 5	2	33.3%

**The school was intellectually stimulating**



Not at all: 1	0	0%
2	0	0%
3	0	0%
4	0	0%
Very: 5	6	100%

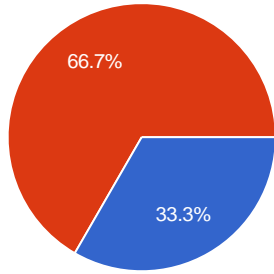
**The overall experience of the school was worthwhile**



Not at all: 1	0	0%
2	0	0%
3	0	0%
4	1	16.7%

Very: 5 5 83.3%

**The amount of material presented was:**



Too much	2	33.3%
Just the right amount	4	66.7%
Not enough	0	0%
No opinion	0	0%

**Additional comments on the topic presentation and organization**

Some speakers (Fred, Maneesh, Eric) were well organized and built on the previous topics, but others spent significant time going over basics already covered from a slightly different perspective. Would have been helpful to make sure all speakers know what fundamentals have been covered and when, and to follow a clearer progression between them.

Some of the speakers were better than others, but I learned at least a few interesting ideas and approaches from all of them.

I thought the topics were arranged in such a way that it was easy for a student learning neuroscience for the first time to follow.

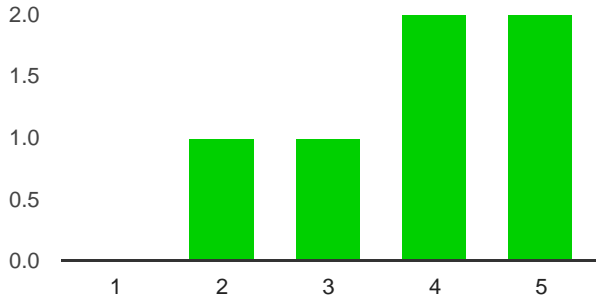
Organization of subject material varied somewhat between presenters. Furthermore, some subject material was covered twice, while other material was assumed to be covered by other presenters and was not. A thorough review of all the speakers' topics and materials (with a specific focus on eliminating redundancies and accounting for gaps) before the camp, could help greatly reduce this problem in the future.

The amount of material was very ambitious. The school would benefit from budgeting more time for working on the exercises/labs as a group, and generally from more group problem solving. More communication between presenters on the topics to be covered would also be helpful, as there was some confusion for later presenters on what had and had not been covered. It would have been helpful to have the recommended readings/slides for each speaker much earlier than a few days beforehand, especially given the absence of built in free time.

**Personal assessment**

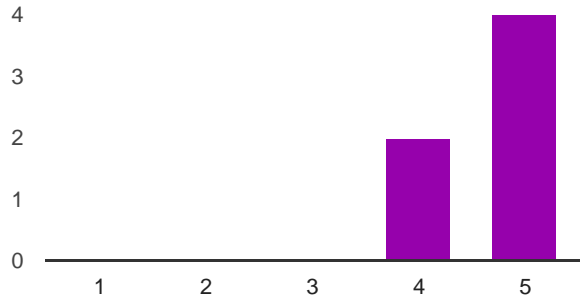


### I was well prepared to benefit from the school



Not at all: 1	<b>0</b>	0%
2	<b>1</b>	16.7%
3	<b>1</b>	16.7%
4	<b>2</b>	33.3%
Very: 5	<b>2</b>	33.3%

### My interest in the subject matter was increased by the school



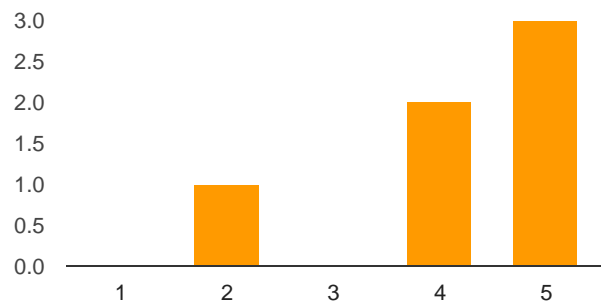
Not at all: 1	<b>0</b>	0%
2	<b>0</b>	0%
3	<b>0</b>	0%
4	<b>2</b>	33.3%
Very much: 5	<b>4</b>	66.7%

### The school helped me meet people with similar scientific interests



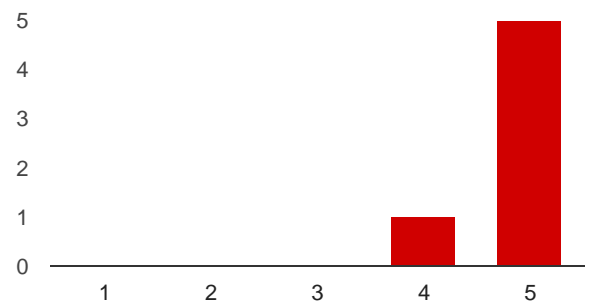
Not at all: 1	0	0%
2	1	16.7%
3	0	0%
4	0	0%
Very much: 5	5	83.3%

**It is likely that I will work in the area of the school subject in the future**



Not at all: 1	0	0%
2	1	16.7%
3	0	0%
4	2	33.3%
Very: 5	3	50%

**How would you evaluate your interaction with other participants?**



not satisfactory: 1	0	0%
2	0	0%
3	0	0%
4	1	16.7%
above satisfactory: 5	5	83.3%

### Additional comments on your personal assessment

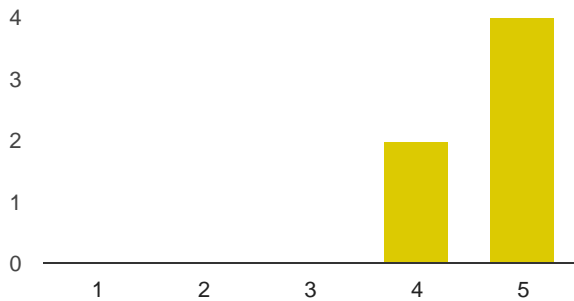
The school topics were excellent in that they concretely covered (at the level of using real data and writing code) how to apply mathematical techniques to neuroscience, which was exactly what I needed as an applied math student. The other participants in the school were all great, with many different backgrounds but all generally having decent mathematical knowledge which served as a common ground. I learned a lot by talking with the other students and had a fun time as well.

I've started reviewing the materials provided during the course and hope to have some improvement in my neuroscience expertise, which is my next academic goal.

As a mathematician, I felt that the school was really aimed at neuroscientists (albeit neuroscientists from a variety of backgrounds). There was not as much data mining or data modeling as I expected.

### Venue

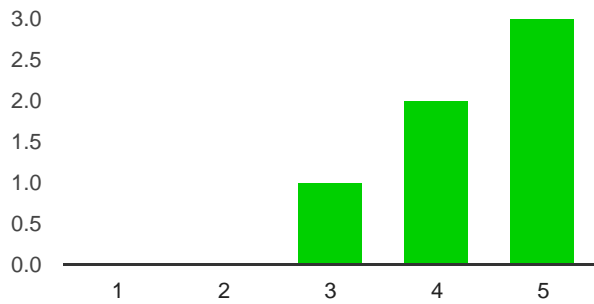
#### I found the onsite staff helpful



Not at all: 1	0	0%
2	0	0%
3	0	0%
4	2	33.3%

Very: 5    4    66.7%

### The physical facilities were conducive for such a school



Not at all: 1	0	0%
2	0	0%
3	1	16.7%
4	2	33.3%
Very: 5	3	50%

### Additional comments on the venue

I was overall pleased with the facilities/venue. The particular classroom we had for the lectures was quite cramped for ~40 people though, and windows would have been nice.

Evening seminar room was great! lecture room was a bit small for a large group to be there all day, especially when working on exercises and without windows.

Evans Hall and the Berkeley campus in general were both excellent. My only complaint would be the projector in the room where the evening lectures were held, which didn't display colors very well.

Thanks a lot for your help Jeff, Fritz and all the tutors.

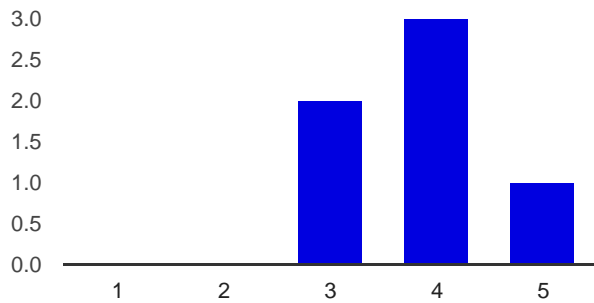
### Accommodation and Food

#### The summer school accommodation



not satisfactory: 1	0	0%
2	0	0%
3	0	0%
4	5	83.3%
above satisfactory: 5	1	16.7%

### The food provided



not satisfactory: 1	0	0%
2	0	0%
3	2	33.3%
4	3	50%
above satisfactory: 5	1	16.7%

### Additional comments on accommodation and food

The dorms were great, and the provided breakfast and dining hall dinners were above satisfactory. The organizers went out of there way to ensure there were plenty of food/drink options and that other accommodations were sufficient.

The dorms were generally clean and nice overall. There were some noisy middle school age kids staying at the dorms for a soccer camp or something, which was a little strange but not really a big deal.

**Thank you for completing this survey**

**We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.**

Overall the camp was a fantastic experience. It was intellectually stimulating as well as providing a useful environment for socializing with experts in the field and grad student peers in related areas. My main criticism is that some lectures could have benefited by being broken up with a lab component (this was very successful in the lectures in which there was a lab, and the impact of their absence was noticeable in the lectures which didn't include them) A secondary criticism is there was some redundancy and also some material incorrectly assumed to have already been covered. Furthermore, having a little more free time in the evenings, or having a schedule which included a longer break in the middle of the day (perhaps having afternoon lecture broken by an equivalent of the evening lectures) would facilitate reflection and re-consideration of that day's material during the evening. I often felt mentally tired enough from each days lecture that I didn't feel motivated to, for instance, fill in missing gaps from that days lab I hadn't completed. Once again, thanks so much for everyone who presented and helped organize the camp. My time was memorable, sparked some excellent conversations, and will surely help contribute to my academic career

Thank you for giving me the opportunity to study one of the new areas of study which applies a lot of the mathematics and statistics tools I've been learning all these years. I plan on continuing with my studies in neuroscience because of what I learned from this course.

**Number of daily responses**

