MSRI
Mathematical Sciences Research Institute

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Annual Progress Report
on the
Mathematical Sciences Research Institute
2013–2014 Activities
supported by
NSF Grant DMS-0932078
July 2015

Mathematical Sciences Research Institute
Annual Report for 2013–2014

1. Overview of Activities

This annual report covers MSRI projects and activities that occurred during the fourth year, 2013–14, of the NSF core grant DMS #0932078.

1.1 New Developments

The year 2013–14, was a busy and exciting year. We held four (4) one-semester programs: *Optimal Transport: Geometry and Dynamics* and *Mathematical General Relativity* were paired during the fall semester and *Algebraic Topology* and *Model Theory, Arithmetic Geometry and Number Theory* were held during the spring semester. All four programs were very popular, and their workshops well attended. All programs had stellar researchers. Four (4) of them, Lars Hasselholt, Ehud Hrushovski, Vincent Moncrief, and Cédric Villani were funded by the Clay Mathematics Institute.

Lars Hesselholt received an Alfred P. Sloan Fellowship in 1998 and addressed the International Congress of Mathematicians in 2002. He became a Foreign Member of the Royal Danish Academy of Sciences and Letters in 2012. In addition, he is an editor for three highly regarded journals: Documenta Mathematica, Nagoya Mathematical Journal, and Selecta Mathematica.

Ehud Hrushovski has been awarded too many fellowships and prizes to list them all here. Let us point out the Presidential Young Investigator award (1989–94), the Anna and Lajos Erdős Prize in Mathematics given by the Israel Mathematical Union (1994), the Rothschild Prize for outstanding Israeli academics who have made exceptional contributions to their fields (1998), and the 1998 Karp Prize of the Association for Symbolic Logic for his work on the Mordell-Lang Conjecture. In 2007 Hrushovski was elected Fellow of the American Academy of Arts and Sciences, and in 2008 he was elected to the Israel Academy of Sciences.

Vincent Moncrief is one of the most knowledgeable and accomplished researchers working at the confluence of mathematics and gravitational physics. He has been among the very top researchers in mathematical relativity for almost forty years, and he remains one of its most important leaders. In 2004, the Journal of Classical and Quantum Gravity (IOP Science) had a special issue, “A Spacetime Safari: Essays in Honour of Vincent Moncrief” dedicated to Prof. Moncrief’s contributions to mathematics and physics.

Cédric Villani is widely recognized as one of the most brilliant mathematical minds of his generation. He has received numerous prestigious prizes, including the 2010 Fields Medal for his proofs of nonlinear Landau damping and convergence to equilibrium for the Boltzmann equation. A year earlier, he received the Fermat Prize (2009) for his contributions to the theory of optimal transport and his studies of non-linear evolution equations. That same year, he received the Henri Poincaré Prize for his innovative work on kinetic theory and optimal transport with applications to dissipative physical systems and Riemannian geometry. As these two prizes demonstrate, Professor Villani's contribution to the theory of optimal transport is unique and of the highest quality.

Another seven (7) researchers, Wilfrid Gangbo, Francois Loeser, Michael Mandell, Robert McCann, Charles Rezk, Ludovic Rifford, and Sergei Starchenko, were MSRI's Eisenbud Professors and Simons Fellows.

All four programs had striking results to report. (See the program reports in the Appendix for more details.) Here are four such results, one from each program.

In Fall 2013, some researchers worked on applications of Optimal Transport to quantum and statistical physics. In particular, Maria Colombo (a graduate student), and Research Members Codina Cotar and Brendan Pass worked on the Density Functional Theory (DFT). DFT is a quantum mechanical theory of electrons which constitutes a large and very active research area in physics and chemistry. It has been recently shown that in a natural scaling limit, the celebrated Hohenberg-Kohn density functional from DFT reduces to an optimal transport problem in which the Coulomb cost models the self-repulsion of the electron cloud. In joint work with Gero Friesecke, Cotar and Pass, worked on a paper which combines methods from optimal transport and probability theory to provide new and improved conditions on N-representability. This is one of the main outstanding issues arising in DFT: it seeks to characterize those two-particle density matrices which can arise as projections from anti-symmetric N-particle wave functions.

One of the most fascinating results, from the Mathematical General Relativity program was the proof by Carlotto and Schoen that gravity can be screened away: it has been shown for the first time that it is possible to construct space-times where bodies do not feel mutual gravitational interactions for periods of time which can be made as large as desired. This should be contrasted with Newton's theory of gravitation, where the presence of any massive object is immediately felt, via the gravitational field, by all other massive objects.

During the Spring 2014 the Algebraic Topology members made several exciting discoveries. Among those, one result concerning Algebraic K-theory stands out. Homotopical methods are one of the best ways to understand the algebraic K-theory of rings, especially rings which are nilpotent extensions of other rings. The most important example of this sort is the sphere spectrum, a categorification of the integers. Blumberg and Mandell proved several very surprising and exciting results describing exactly how the algebraic K-groups of the sphere behave.

The second Spring 2014 program, Model Theory, also reports some spectacular results. The completion by Aschenbrenner, van den Dries, and Van der Hoeven, of the description of the first order theory of transseries, qualifies as a breakthrough, and a difficult one. Transseries provide a rich domain in which to do several kinds of mathematics. In his survey paper posted on ArXiv, Edgar states:

"*From the simplest point of view, transseries are a new kind of expansion for real-valued functions. But transseries constitute much more than that -- they have a very rich (algebraic, combinatorial, analytic) structure. The set of transseries is a large ordered field, extending the real number field, and endowed with additional operations such as exponential, logarithm, derivative, integral, composition. Over the course of the last 20 years or so, transseries have emerged in several areas of mathematics: asymptotic analysis, model theory, computer algebra, surreal numbers."*

To know that a first order description exists, and to have nailed down the axioms, informs future research in a deep way.

This year, the MSRI's annual ***Hot Topics workshop*** was on *Perfectoid Spaces and their Applications*, and was extremely popular, with nearly 200 participants. Three years ago Peter Scholze introduced perfectoid spaces. Since then he has used them to resolve an amazingly diverse set of major problems in arithmetic algebraic geometry. Perfectoid spaces are sophisticated objects, requiring many technical pre-requisites: Huber's adic spaces, the Faltings-Gabber-Ramero almost ring theory, the pro-etale site, etc. The aim of the workshop was to educate other mathematicians to work with perfectoid spaces, and at the same time to describe Scholze's startling applications of them. 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 2013–14, MSRI's overall expenditures totaled $7,771,684. Of this amount, $5,314,990 (68.4%) came from the NSF, $250,240 (3.2%) from the NSA, and the rest, $2,206,454 (28.4%) came from private funds such as, Simons Foundation, Clay Mathematical Institute, several private donors and other foundations, and MSRI's Endowment returns. For example, of the support for program members (long-term visitors) 89% came from the NSF and 11% from private funds. Of the support for workshop participants (short term visitors) 46% came from the NSF, 26% from the NSA, and 28% 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-five (35) Postdoctoral Fellows participated in our four scientific programs, of which twenty eight (28) were funded by the NSF Core Grant. Anna Sakovich and Vesna Stojanoska were the Viterbi postdoctoral Fellows; Pierre Simon was the first Strauch Fellow; Emanuel Indrei was the Huneke Fellow. 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 2013, 110 institutions nominated 277 graduate students for one of MSRI's summer schools. Of those 216 were accepted, and in the end, 184 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 Cortona, Italy. For most of the summer graduate workshops, enrollment is based on a first-come, first-served policy. The workshops 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 2014, the lead director was Dr. Herbert Medina of Loyola Marymount University, and the primary instructor

and research director was Dr. Victor Moll of Tulane University. The research topics for the summer were on Arithmetic Aspects of Elementary Functions, and the students worked in teams of three on various projects concerned with arithmetic properties of some classes of hypergeometric functions. Students wrote technical reports and presented the results of their research at the MSRI-UP Student Colloquium the last day of the program. Three posters from 2014 MSRI-UP were 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 2013–14 year, two events were supported by the Initiative: *Modern Math Workshop*, held in San Antonio, Texas and organized by the ICERM; and *Spring Opportunities*, held in Knoxville, Tennessee, and organized by the NIMBioS. The reports for those two workshops are part of the ICERM and NIMBioS annual reports.

Critical Iss ues in Mat hematics 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 *The role of the mathematics department in the mathematical preparation of teachers*. The workshop was heavily subscribed, with approximately 150 attendees all very engaged in the discussions. It was funded through grants from the Division of Education at the NSF.

Public Understanding of Mathematics.

Celebration of Mind, October 2013**.** This past October, MSRI welcomed approximately 80 puzzle-lovers of all ages to the second "Celebration of Mind" event that MSRI has hosted. Celebration of Mind is a worldwide celebration of the legacy of Martin Gardner, promoted by the Gathering 4 Gardner (G4G) foundation and held annually on or near his birthdate. The event began with a variety of talks and performances by Carlo Sequin, Cliff Stoll, Allen Knutson, and Jordan Gold, and featured engaging activities and presentations by the above, as well as Elwyn Berlekamp, Stan Isaacs, and Nancy Blachman, in addition to a wide selection of mathematical games, and a dessert reception.

Chicago Mercantile Exchange Prize. The 8th annual CME Group-MSRI Prize in Innovative Quantitative Applications was awarded to Bengt Holmstrom on October 21 in Chicago. Dr. Holmstrom is the Paul A. Samuelson Professor of Economics at the Massachusetts Institute of Technology with a joint appointment in MIT's Sloan School of Management. Dr. Holmstrom has made many breakthroughs in the study of incentive conflicts in organizations, and he has also developed important insights into the supply of and demand for liquidity and liquid assets. 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/20419.

Numberphile. Since January 2014, MSRI has supported Brady Haran's "Numberphile" channel on YouTube. The channel recently passed the mark of one million subscribers — the most for anything math related (Vi Hart's channel is the only close competitor). 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/text_index.html.

Not on The Test, MSRI and Berkeley City College (BCC) debuted a new lecture series, "Not on the Test: The Pleasures and Uses of Mathematics." Held in BCC's auditorium in downtown Berkeley, the series of six free, public talks was made possible through generous funding from the Simons Foundation. Topics included *Math in the Movies*; *Video Games for Mathematics*; *Verifying Greenhouse Gas Emissions*; *Music, Computing, People*; *Science Denialism*; and *Brain-Computer Interfaces*.

Public Lecture by Villani. On December 17 MSRI hosted a public lecture by Fields Medalist Cedric Villani, *Of triangles, gas, prices and men*. The talk was the story of an encounter of three distinct fields: non-Euclidean geometry, gas dynamics and economics. Some of the most fundamental mathematical tools behind these theories appear to have a close connection, which was revealed around the turn of the 21st century, and has developed strikingly since then.

1.2 Summary of Demographic Data for 2013–14 Activities

During the academic year 2013–14, MSRI hosted 271 program members, of which 28 were Postdoctoral Fellows, 1489 workshop participants, and 163 graduate students.

The Postdoctoral program was particularly successful and is described in detail in Section 3. Of the Fellows, 29% were female, 43% were U.S. Citizens or Permanent Residents, and 61% listed a U.S. university as home institution. Of those institutions, 29% are located in the Northeast, 35% in the West, 18% in the Midwest, and the remaining 18% in the South.

MSRI had a total of 271 long-term members. Members spent an average of 64 days at MSRI, with peak attendance in November for the fall semester and April for the spring semester. Of the members, 22% were female, 44% reported being U.S. Citizens or Permanent Residents and 48% listed a U.S. university as their home institution. Of those institutions, 26% are located in the Midwest, 28% in the West, 30% in the Northeast, and 16% in the South. Of the members, 62% had received a Ph.D degree on or after 2000, 25% received one between 1981 and 1999, and the remaining 13% had received a Ph.D. on or prior to 1980. Detailed demographic data can be found in Section 2.

In the 2013–14 workshops, MSRI hosted 1489 separate visits (some visitors attended multiple events). Of the workshop participants, 29% were female, 50% were U.S. Citizens or Permanent

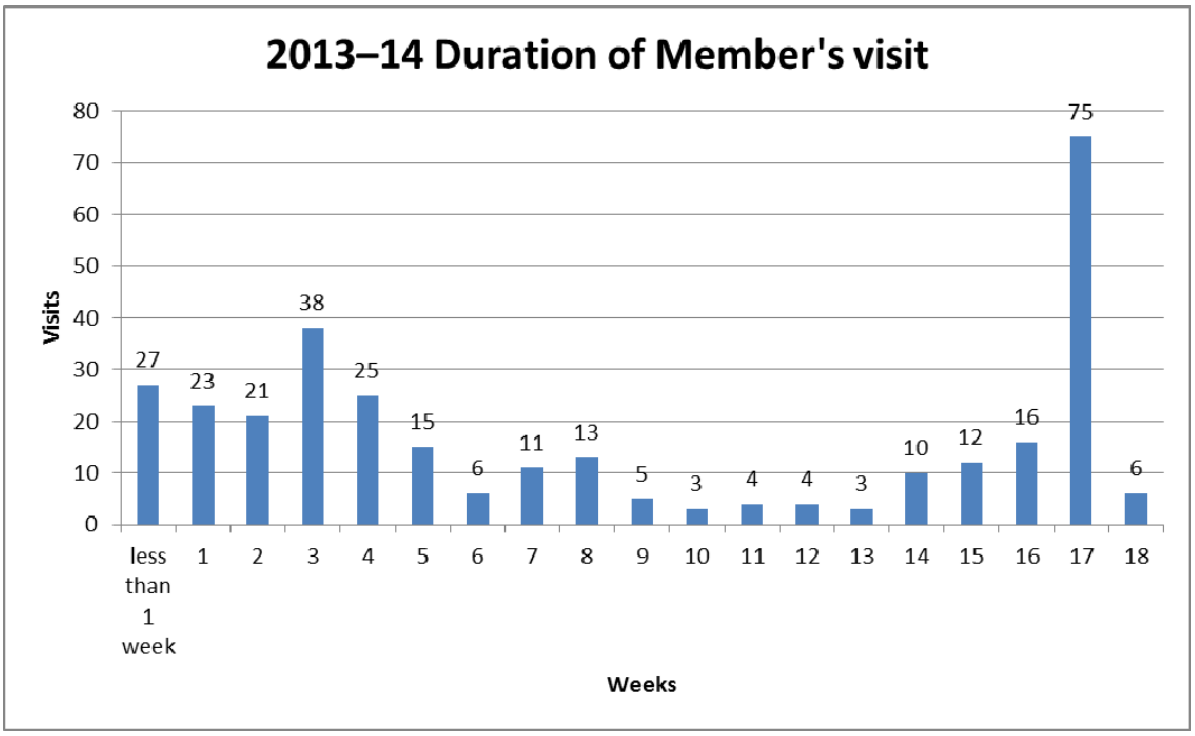
Residents, of which 8% reported being a member of an under-represented minority. In addition, 61% of the 1489 participants came from a U.S. institution. Demographic data on workshop participants can be found in Sections 2 and 4.

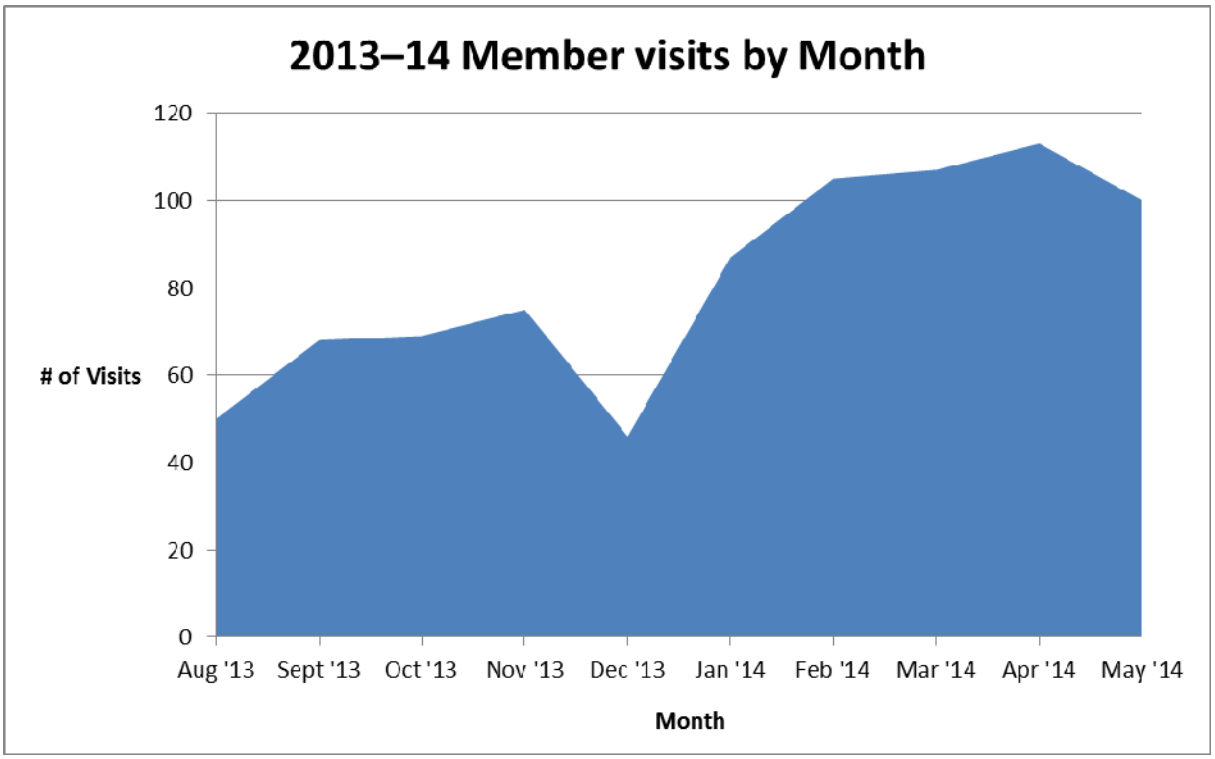
The Summer Graduate Schools of 2013 had 163 participants. Of those participants, 32% were female, 48% were U.S. Citizens or Permanent Residents and 88% students came from a U.S. institution. Demographic data on the participants of the summer graduate schools can be found in Section 4.2.

In the summer of 2013, 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 100% reported being a member of an under-represented minority. In addition, 100% participants came from a U.S. institution. Demographic data on MSRI-UP participants can be found in Section 5.2.

Member Visits Summary

All program members	Fall 2013	Spring 2014	2013–14	2004–14
Total Member Days	9031	11255	20286	170166
Total # of Visits	151	165	316	2390
Average # of Days per Visit	59.81	68.21	64.20	71.20
Average # of Months per Visit	2.0	2.3	2.1	2.4
All female program members	**Fall 2013**	**Spring 2014**	**2013–14**	**2009–14**
Total Member Days	1823	3137	4960	21463
Total # of Visits	39	40	79	309
Average # of Days per Visit	46.74	78.43	62.78	69.46
Average # of Months per Visit	1.6	2.6	2.1	2.3





1.3 Scientific Programs and their Associated Workshops

There were two major and one complementary programs for the MSRI fiscal year 2013–14, and 12 workshops were associated with them.

Note: Brief descriptions of scientific topics for each activity were reported in the Brief Report submitted in 2014. Full descriptions of each activity can be found the the Appendix Section of this Annual Report. In the lists of organizers of each activity below, an asterisk (*) denotes lead organizer(s).

Program 1: Mathematical General Relativity
August 19, 2013 - December 20, 2013
Organizers: Yvonne Choquet-Bruhat, Piotr Chrusciel (Universität Wien), Greg Galloway (University of Miami), Gerhard Huisken (Mathematisches Forschungsinstitut Oberwolfach), James Isenberg (University of Oregon), Sergiu Klainerman (Princeton University), Igor Rodnianski (Massachusetts Institute of Technology), Richard Schoen (Stanford University)*

Workshop 1: Connections for Women: Mathematical General Relativity
September 3, 2013 – September 4, 2013
Organizers: Beverly Berger (None), Lydia Bieri (University of Michigan), Iva Stavrov (Lewis and Clark College)*

Workshop 2: Introductory Workshop: Mathematical Relativity
September 09, 2013 - September 13, 2013
Organizers: Justin Corvino (Lafayette College), Greg Galloway (University of Miami), Hans Ringström (Royal Institute of Technology (KTH)*

Workshop 3: Initial Data and Evolution Problems in General Relativity
November 18, 2013 - November 22, 2013
Organizers: Piotr Chrusciel (Universität Wien), Igor Rodnianski (Massachusetts Institute of Technology)*

Program 2: Optimal Transport: Geometry and Dynamics
August 19, 2013 - December 20, 2013
Organizers: Luigi Ambrosio (Scuola Normale Superiore), Yann Brenier (École Polytechnique), Panagiota Daskalopoulos (Columbia University), Lawrence Evans (University of California, Berkeley), Alessio Figalli (University of Texas), Wilfrid Gangbo (Georgia Institute of Technology), Robert McCann (University of Toronto), Felix Otto (Max-Planck-Institut für Mathematik in den Naturwissenschaften), Neil Trudinger (Australian National University)*

Workshop 1: Connections for Women on Optimal Transport: Geometry and Dynamics
August 22, 2013 - August 23, 2013
Organizers: Sun-Yung Alice Chang (Princeton University), Panagiota Daskalopoulos (Columbia University), Robert McCann (University of Toronto), Maria Westdickenberg (RWTH Aachen)

Workshop 2: Introductory Workshop on Optimal Transport: Geometry and Dynamics
August 26, 2013 - August 30, 2013
Organizers: Luigi Ambrosio (Scuola Normale Superiore), Lawrence Evans (University of California, Berkeley), Alessio Figalli (University of Texas)*

Workshop 3: Fluid Mechanics, Hamiltonian Dy namics, and Numerical Aspects of Optimal Transportation
October 14, 2013 - October 18, 2013
Organizers: Yann Brenier (École Polytechnique), Michael Cullen (Met Office), Wilfrid Gangbo (Georgia Institute of Technology), Allen Tannenbaum (SUNY)*

Program 3: Model Theory, Arithmetic Geometry and Number Theory
January 20, 2014 - May 23, 2014
Organizers: Ehud Hrushovski (Hebrew University), François Loeser (Université de Paris VI (Pierre et Marie Curie)), David Marker (University of Illinois), Thomas Scanlon (University of California, Berkeley), Sergei Starchenko (University of Notre Dame), Carol Wood (Wesleyan University)*

Workshop 1: Introductory Workshop: Model Theory, Arithmetic Geometry an d Number Theory
February 03, 2014 - February 07, 2014
Organizers: Elisabeth Bouscaren (Centre National de la Recherche Scientifique (CNRS)), Antoine Chambert-Loir (Université Paris-Sud (Orsay)), Rahim Moosa (University of Waterloo)*

Workshop 2: Connections for Women: Model Th eory a nd Its Interactions w ith Number Theory and Arithmetic Geometry
February 10, 2014 - February 11, 2014
Organizers: Kirsten Eisentraeger (Pennsylvania State University), Julia Gordon (University of British Columbia), Deirdre Haskell (McMaster University)

Workshop 3: Model Theory in Geometry and Arithmetic
May 12, 2014 - May 16, 2014
Organizers: Raf Cluckers (Université de Lille I (Sciences et Techniques de Lille Flandres Artois)), Jonathan Pila (University of Oxford), Thomas Scanlon (University of California, Berkeley)*

Program 4: Algebraic Topology
January 20, 2014 - May 23, 2014
Organizers: Vigleik Angeltveit (Australian National University), Andrew Blumberg (University of Texas), Gunnar Carlsson (Stanford University), Teena Gerhardt (Michigan State University), Michael Hill (University of Virginia), Jacob Lurie (Harvard University)*

Workshop 1: Connections for Women: Algebraic Topology
January 23, 2014 - January 24, 2014
Organizers: Julia Bergner (University of California), Teena Gerhardt (Michigan State University), Brooke Shipley (University of Illinois at Chicago)*

Workshop 2: Introductory Workshop: Algebraic Topology
January 27, 2014 - January 31, 2014
Organizers: Teena Gerhardt (Michigan State University), Jesper Grodal (University of Copenhagen), Kathryn Hess (École Polytechnique Fédérale de Lausanne (EPFL)), Michael Hill (University of Virginia)*

Workshop 3: Reimagining the Foundations of Algebraic Topology
April 07, 2014 - April 11, 2014
Organizers: Vigleik Angeltveit (Australian National University), Mark Behrens (Massachusetts Institute of Technology), Julia Bergner (University of California), Andrew Blumberg (University of Texas)*

Program 5: Complementary Program (2013-14)
August 19, 2013 - May 23, 2014

MSRI had a small Complementary Program comprised of nine researchers, Anders Bjorner (Royal Institute of Technology (KTH)), Jean Bourgain (Institute for Advanced Study), Valerio Capraro (University of Southampton), Joe Harris (Harvard University), Steven Kaliszewski (Arizona State University), Kate Okikiolu (University of California, San Diego), Irena Peeva (Cornell University), Frank-Olaf Schreyer (Universitat des Saarlandes), Michelle Wachs (University of Miami).

1.4 Scientific Activities Directed at Underrepresented Groups in Mathematics

Connections for Women Workshops
During the 2013–14 academic year, MSRI hosted four Connections for Women workhops, one for each scientific program. The goal of these workshops was to facilitate networks among women and members of underrepresented minorities. For more information regarding each workshop, please refer to Section 1.3 above.

Undergraduate Program: MSRI-UP 2013: Algebraic Combinatorics
June 15, 2013 – July 28, 2013
Organized by: 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)*

Mathematics Institutes' Modern Math Workshop at SACNAS
NSF supplemental grant DMS 1126721
Location: San Antonio, Texas
October 2, 2013 to October 3, 2013
Organized by Jeff Brock (ICERM, Ricardo Cortez (Tulane University), Ruth Crane (ICERM), Snehalata Huzurbazar (SAMSI, Statistical and Applied Mathematical Sciences Institute), Jill Pipher (ICERM), Ivelisse Rubio (University of Puerto Rico, Computer Science)

Please note: The report of this activity is included in ICERM's annual report, thus there is no report attached in Section 12-Appendix of this report.

1.5 Summer Graduate Schools (Summer 2013)

SGS 1: Algebraic Topology
June 17, 2013 - June 28, 2013
Organizers: Andrew Blumberg (University of Texas), Teena Gerhardt (Michigan State University), Michael Hill (University of Virginia)*

SGS 2: Seminaire de Mathem atiques Superieures 2013: Physics an d Mathematics of Lin k Homology
Location: Montreal, Canada
June 24, 2013 - July 05, 2013
Organizers: Sergei Gukov (California Institute of Technology), Mikhail Khovanov (Columbia University), Johannes Walcher (McGill University)

SGS 3: IAS/PCMI Summer 2013: Geometric Analysis
June 30, 2013 - July 20, 2013
Location: Park City, Utah
Organizers: Hubert Bray (Duke University), Greg Galloway (University of Miami), Rafe Mazzeo (Stanford University), Natasa Sesum (Rutgers University)

SGS 4: New Geometric Techniques in Number Theory
July 01, 2013 - July 12, 2013
Organizers: Toby Gee (Imperial College, London), Ariane Mezard (Institut de Mathématiques de Jussieu), David Nadler (University of California, Berkeley), Peter Scholze (Universität Bonn)*

SGS 5: Introduction to the Mathematics of Seismic Imaging
July 29, 2013 - August 09, 2013
Organizers: Gunther Uhlmann (University of Washington)

SGS 6: Mathematical General Relativity in Cortona, Italy
July 29, 2013 - August 09, 2013
Organizers: Justin Corvino (Lafayette College), Pengzi Miao (University of Miami), Giorgio Patrizio (Istituto Nazionale di Alta Matematica "Francesco Severi" (INdAM))

1.6 Other Scientific Workshops

Workshop 1: Bay Area Differential Geometry Seminar (BADGS) Fall 2013
Location: Stanford University
October 19, 2013
Organized by 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 2: Pacific Northwest and Bay Area Differential Geometry Seminar (BADGS) Winter 2014
Location: Stanford University
February 08, 2014 - February 09, 2014
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 3: Hot Topics: Perfectoid Spaces and their Applications
February 17, 2014 - February 21, 2014
Organizers: Sophie Morel (Princeton University), Peter Scholze (Universität Bonn), Richard Taylor (Institute for Advanced Study), Jared Weinstein (Boston University)*

1.7 Education & Outreach Activities

Workshop 1: Bay Area Circle for Teachers, Summer Workshop 2013
June 17, 2013 – June 21, 2013
Organized by BACT Director

Workshop 2: Mathematics Professional Development Institute 2013
July 08, 2013 – July 26, 2013
Organizers by Hung-Hsi Wu (University of California, Berkeley)

Workshop 3: Critical Issues in Mathematics Education 2014: The role of the mathematics department in the mathematical preparation of teachers
March 26, 2014 - March 28, 2014
Organizers: Deborah Ball (University of Michigan), Solomon Friedberg (Boston College), Jim Lewis (University of Nebraska-Lincoln), Despina Stylianou (City College, CUNY), Peter Trapa (University of Utah), Hung-Hsi Wu (University of California, Berkeley), Darryl Yong (Harvey Mudd College)*

1.8 Program Consultants List

Consultant Name(s)	Consultant Disciplinary Specialty	Consultant Employer	Activity Title
Mathias Beck	Discrete geometry	San Francisco State University	Bay Area Circle for Teachers
Alissa Crans	Topology	Loyola Marymount University	National Association of Math Circles
Ingrid Daubechies	Applied and Computational Mathematics	Duke University	Consultant for neuroscience workshop
Robbert Dijkgraaf	Math physics	Institute for Advanced Study	Math festivals
Moris Kalka	Differential geometry	Tulane University	Summer Graduate Schools
Gloria Law	Immigration law	Self	Immigration service for members
William Macallum	Education	University of Arizona	Educational workshops
Bruno Olshausen	Neuroscience	Redwood Center for Theoretical Neuroscience, UC Berkeley	Consultant for neuroscience workshop
Mark Saul	Education	Education Development Center	Great Circles
Tatiana Shubin	Number theory	San Jose State University	Bay Area Circle for Teachers
Zvesda Stankova	Algebraic geometry	Mill College	Math Circles
Sam Vandervelde	Number theory	St. Lawrence University	Math Circles
Board of Trustees (BOT) 31 members	See Section 10: Committee Membership		Advise and decide on MSRI administration
Scientific Advisory Committee (SAC) 10 members	See Section 10: Committee Membership		Advise and decide on scientific programs
Human Resources Advisory Committee (HRAC) 9 members	See Section 10: Committee Membership		MSRI - UP and advise on diversity efforts
Educational Advisory Committee (EAC) 18 members	See Section 10: Committee Membership		Consultants for Educational activities

2. Program and Workshop Data

2.1 Program Participant List

(See email attached file)

2.2 Program Participant Summary

Programs	# of Members	# of Citizens & Perm. Res.	%	# of Female	%	# of Minorities [1]	%	US Home Institution	%
Mathematical General Relativity	67	29	*43.3%*	11	*16.4%*	0	*0.0%*	33	49.3%
Optimal Transport: Geometry and Dynamics	58	17	*29.3%*	15	*25.9%*	5	*33.3%*	22	37.9%
Model Theory, Arithmetic Geometry and Number Theory	73	30	*41.1%*	19	*26.0%*	2	*7.1%*	28	38.4%
Algebraic Topology	66	40	*60.6%*	13	*19.7%*	2	*5.3%*	42	63.6%
Complementary Program 2013-14	7	4	*57.1%*	2	*28.6%*	0	*0.0%*	4	57.1%
Total # of Distinct Members	**271**	**120**	***44.3%***	**60**	***22.1%***	**9**	***8.3%***	**129**	***47.6%***

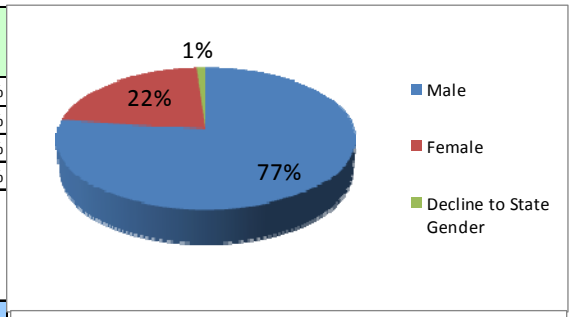
[1] *Minorities are US citizen who declare themselves American Indian, Black, Hispanic, or Pacific Islander. Minority percentage is calculated by dividing the number of Minorities by the total number of US citizer*

2.3 Program Participant Demographic Data

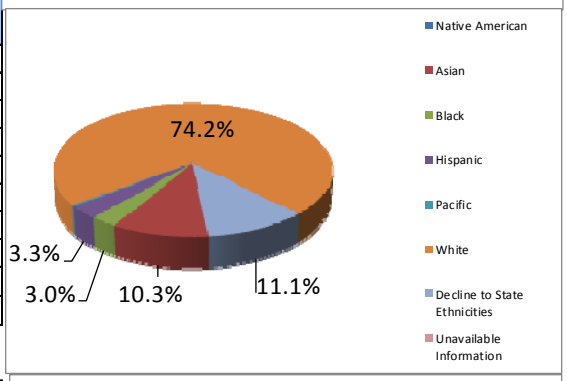
2013–14 Program Members Demographic Summary

Gender	#	% (No Decl.)*	%
# of Members	271		100.0%
Male	208	77.61%	76.8%
Female	60	22.39%	22.1%
Decline to State Gender	3		1.1%

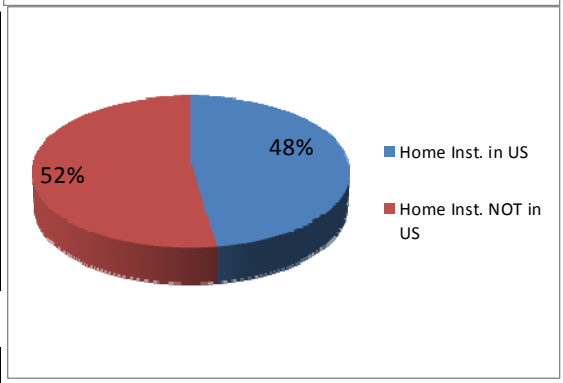
Members are distinct within each academic year.



Ethnicities	#	% (No Decl.)*	%
Native American	0	0.00%	0.0%
Asian	28	11.34%	10.3%
Black	8	3.24%	3.0%
Hispanic	9	3.64%	3.3%
Pacific	1	0.40%	0.4%
White	201	81.38%	74.2%
Decline to State Ethnicities	30		11.1%
Unavailable Information	0		0.0%
Minorities	9		8.3%

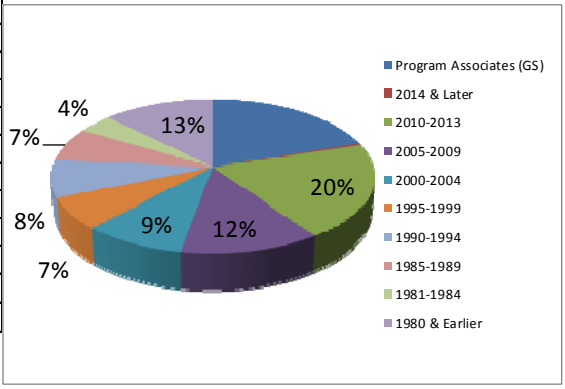


Citizenships	#		%
US Citizens & Perm. Residents	120		44.3%
Foreign	151		55.7%
Unavailable information	0		0.0%
# of Members	271		100.0%
US Citizens	108		39.9%
Perm Residents	12		4.4%
Home Inst. in US	129		47.60%



Year of Ph.D	#		%
Program Associates (GS)	54		19.9%
2014 & Later	1		0.4%
2010-2013	54		19.9%
2005-2009	34		12.5%
2000-2004	25		9.2%
1995-1999	18		6.6%
1990-1994	21		7.7%
1985-1989	19		7.0%
1981-1984	11		4.1%
1980 & Earlier	34		12.5%
Unavailable Info.	0		0.0%
Total # of Members	271		100.0%

**Statistic Calculation based on all members who did not decline to state.*

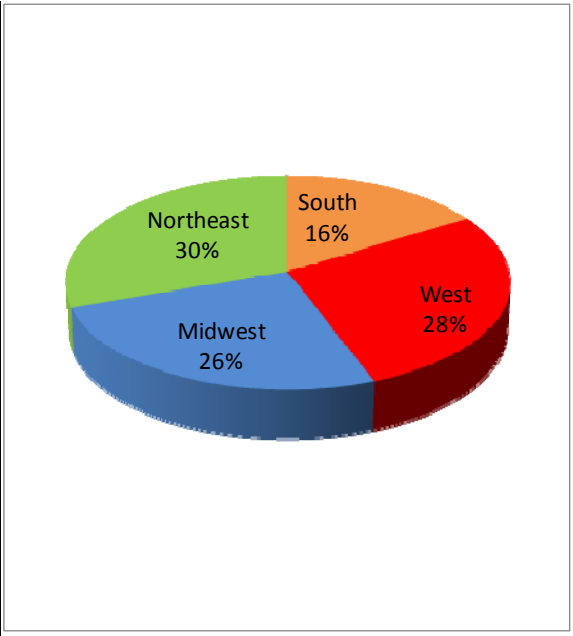


Programs:
Model Theory, Arithmetic Geometry and Number Theory
Mathematical General Relativity
Optimal Transport: Geometry and Dynamics
Algebraic Topology
Complementary Program 2013-14

2013–14 Program Members Home Institution Classified by States

**Regions based on US Census classification*

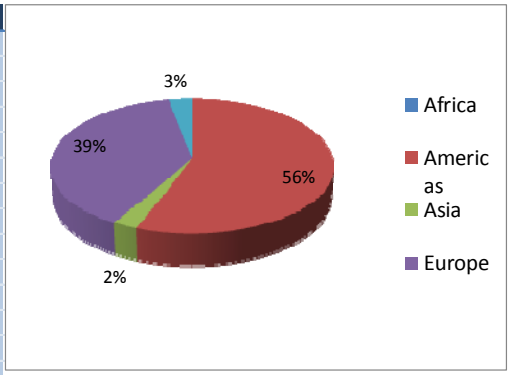
State	#	%	2007 Census Population
South	**21**	**16.3%**	**36.6%**
AL	-	0.0%	1.5%
AR	-	0.0%	0.9%
DE	-	0.0%	0.3%
DC	-	0.0%	0.2%
FL	3	2.3%	6.1%
GA	4	3.1%	3.2%
KY	-	0.0%	1.4%
LA	-	0.0%	1.4%
MD	3	2.3%	1.9%
MS	-	0.0%	1.0%
NC	1	0.8%	3.0%
OK	-	0.0%	1.2%
SC	-	0.0%	1.5%
TN	-	0.0%	2.0%
TX	7	5.4%	7.9%
VA	3	2.3%	2.6%
WV	-	0.0%	0.6%
West	**36**	**27.9%**	**23.2%**
AK	1	0.8%	0.2%
AZ	1	0.8%	2.1%
HI	-	0.0%	0.4%
ID	-	0.0%	0.5%
MT	1	0.8%	0.3%
CA	26	20.2%	12.1%
CO	-	0.0%	1.6%
NV	-	0.0%	0.9%
NM	-	0.0%	0.7%
OR	5	3.9%	1.2%
UT	-	0.0%	0.9%
WA	2	1.6%	2.1%
WY	-	0.0%	0.2%
Midwest	**33**	**25.6%**	**22.0%**
IL	17	13.2%	4.3%
IN	10	7.8%	2.1%
IA	-	0.0%	1.0%
KS	-	0.0%	0.9%
MI	3	2.3%	3.3%
MN	1	0.8%	1.7%
MO	-	0.0%	1.9%
ND	-	0.0%	0.2%
NE	-	0.0%	0.6%
OH	1	0.8%	3.8%
SD	-	0.0%	0.3%
WI	1	0.8%	1.9%
Northeast	**39**	**30.2%**	**18.1%**
CT	5	3.9%	1.2%
ME	-	0.0%	0.4%
MA	13	10.1%	2.1%
NH	1	0.8%	0.4%
NJ	4	3.1%	2.9%
NY	11	8.5%	6.4%
PA	5	3.9%	4.1%
RI	-	0.0%	0.4%
VT	-	0.0%	0.2%
Other	**-**	**0.0%**	**0%**
PR	-	0.0%	0%
Other	-	0.0%	0%
Total	**129**	**100%**	**100%**



2013–14 Program Members Home Institution Classified by Countries

**Regions based on United Nations classification*

Region	Area	Country	Total
Americas	**North America**	Canada	20
		United States	129
	North America Total		149
	South America	Argentina	1
		Colombia	1
	South America Total		2
Americas Total			**151**
Asia	**Eastern Asia**	China	2
		Japan	1
	Eastern Asia Total		3
	Western Asia	Israel	4
	Western Asia Total		4
Asia Total			**7**
Europe	**Northern Europe**	Denmark	4
		England	19
		Ireland	1
		Norway	2
		Sweden	6
	Northern Europe Total		32
	Southern Europe	Italy	5
		Spain	1
	Southern Europe Total		6
	Western Europe	Austria	4
		Belgium	3
		France	32
		Germany	21
		Netherlands	1
		Switzerland	6
	Western Europe Total		67
Europe Total			**105**
Oceania	**Australia and New Zealand**	Australia	5
		New Zealand	3
	Australia and New Zealand Total		8
Oceania Total			**8**
Grand Total			**271**



2.4 Workshop Participant List

(See email attached file)

2.5 Workshop Participant Summary

Workshops	# of Participants	# of Citizens & Perm. Res.	%	# of Female	%	# of Minorities[1]	%	US Home Institution	%
13 Scientific Workshops									
Connections for Women on Optimal Transport: Geometry and Dynamics	43	14	*32.6%*	23	*53.5%*	4	*33.3%*	21	48.8%
Connections for Women: Algebraic Topology	79	48	*60.8%*	50	*63.3%*	4	*8.7%*	54	68.4%
Connections for Women: Mathematical General Relativity	46	20	*43.5%*	21	*45.7%*	0	*0.0%*	27	58.7%
Connections for Women: Model Theory and Its Interactions with Number Theory and Arithmetic Geometry	68	26	*38.2%*	41	*60.3%*	1	*4.3%*	36	52.9%
Fluid Mechanics, Hamiltonian Dynamics, and Numerical Aspects of Optimal Transportation	69	31	*44.9%*	12	*17.4%*	3	*11.5%*	33	47.8%
Hot Topics: Perfectoid Spaces and their Applications	192	79	*41.1%*	22	*11.5%*	1	*1.5%*	115	59.9%
Initial Data and Evolution Problems in General Relativity	111	46	*41.4%*	12	*10.8%*	0	*0.0%*	60	54.1%
Introductory Workshop on Optimal Transport: Geometry and Dynamics	101	31	*30.7%*	25	*24.8%*	7	*26.9%*	55	54.5%
Introductory Workshop: Algebraic Topology	171	104	*60.8%*	43	*25.1%*	7	*7.0%*	119	69.6%
Introductory Workshop: Mathematical Relativity	73	37	*50.7%*	15	*20.5%*	0	*0.0%*	47	64.4%
Introductory Workshop: Model Theory, Arithmetic Geometry and Number Theory	135	56	*41.5%*	38	*28.1%*	6	*11.5%*	67	49.6%
Model Theory in Geometry and Arithmetic	120	45	*37.5%*	27	*22.5%*	4	*9.8%*	50	41.7%
Reimagining the Foundations of Algebraic Topology	126	71	*56.3%*	28	*22.2%*	4	*5.9%*	79	62.7%
All 13 Workshops Total	**1,334**	**608**	***45.6%***	**357**	***26.8%***	**41**	***7.5%***	**763**	***57.2%***
1 Education & Outreach Workshops									
Critical Issues in Mathematics Education 2014: The role of the mathematics department in the mathematical preparation of teachers	155	140	*90.3%*	75	*48.4%*	16	*12.0%*	144	92.9%
All Education & Outreach Total	**155**	**140**	***90.3%***	**75**	***48.4%***	**16**	***12.0%***	**144**	***92.9%***
All 14 Workshops Total	**1,489**	**748**	***50.2%***	**432**	***29.0%***	**57**	***8.4%***	**907**	***60.9%***

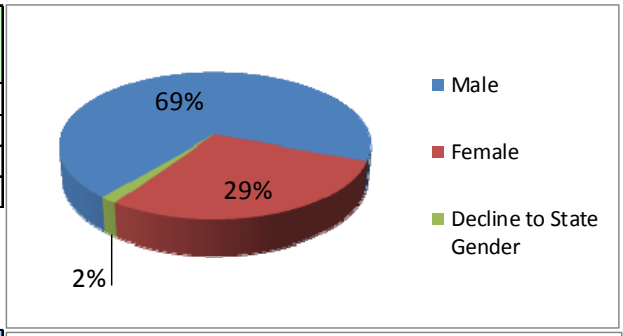
[1] *Minorities are US citizens who declare themselves American Indian, Black, Hispanic, or Pacific Islander. Minority percentage is calculated by dividing the number of Minorities by the total number of US citizens.*

2.6 Workshop Participant Demographic Data

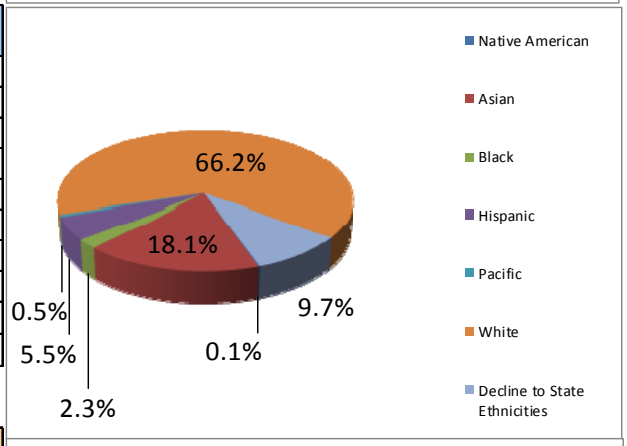
2013–14 Workshop Participants Demographic Summary

Gender	#	% (No Decl.)*	%
# of Participants	1489		100.0%
Male	1034	70.53%	69.4%
Female	432	29.47%	29.0%
Decline to State Gender	23		1.5%

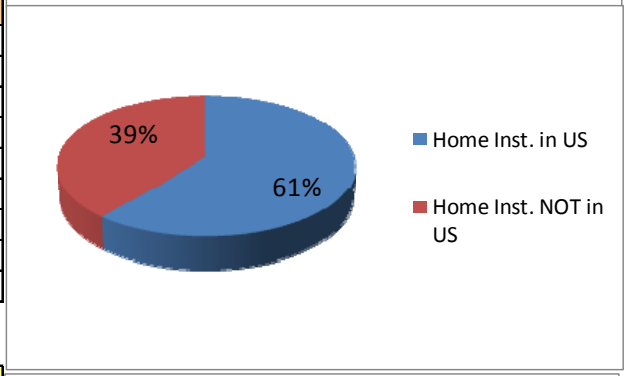
**Statistic Calculation based on participants' visits.*



Ethnicities	#	% (No Decl.)*	%
Native American	2	0.14%	0.1%
Asian	270	19.54%	18.1%
Black	34	2.46%	2.3%
Hispanic	82	5.93%	5.5%
Pacific	8	0.58%	0.5%
White	986	71.35%	66.2%
Decline to State Ethnicities	145		9.7%
Unavailable Information	0		0.0%
Minorities	57		8.4%

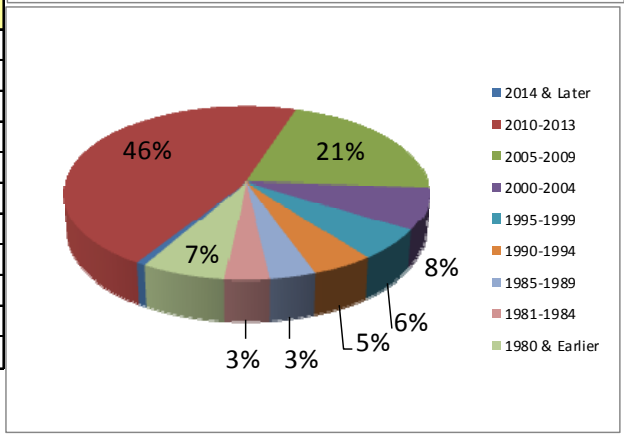


Citizenships	#		%
US Citizen & Perm. Residents	748		50.2%
Foreign	741		49.8%
Unavailable information	0		0.0%
# of Participants	1489		100.0%
US Citizen	680		45.7%
Perm Residents	68		4.6%
Home Inst. in US	907		60.91%



Year of Highest Degree	#		%
2014 & Later	11		0.7%
2010-2013	685		46.0%
2005-2009	310		20.8%
2000-2004	115		7.7%
1995-1999	89		6.0%
1990-1994	72		4.8%
1985-1989	55		3.7%
1981-1984	52		3.5%
1980 & Earlier	100		6.7%
Unavailable Info.	0		0.0%
Total # Participants	1489		100.0%

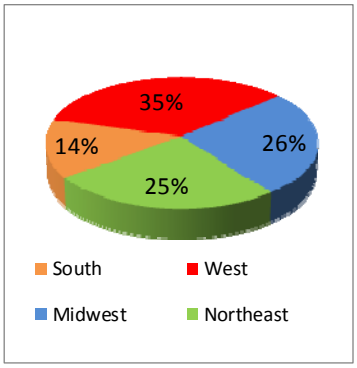
**Statistic Calculation based on all participants who did not decline to state.*



2013–14 Workshop Participants Home Institution Classified by States

**Regions based on US Census classification*

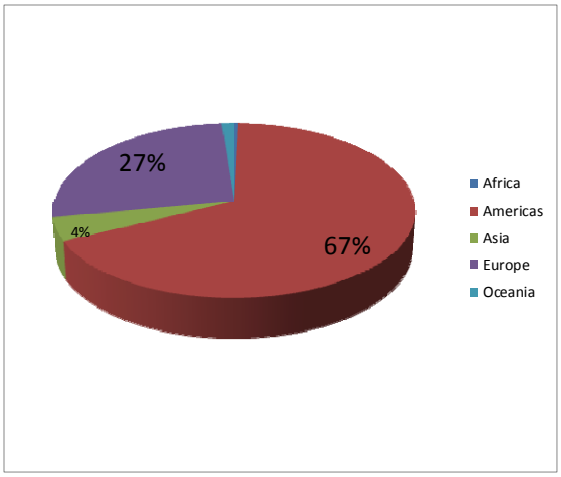
State	#	%	2007 Census Population
South	**129**	**14.2%**	**36.6%**
AL	1	0.1%	1.5%
AR	-	0.0%	0.9%
DE	-	0.0%	0.3%
DC	3	0.3%	0.2%
FL	7	0.8%	6.1%
GA	20	2.2%	3.2%
KY	4	0.4%	1.4%
LA	6	0.7%	1.4%
MD	21	2.3%	1.9%
MS	-	0.0%	1.0%
NC	9	1.0%	3.0%
OK	-	0.0%	1.2%
SC	-	0.0%	1.5%
TN	5	0.6%	2.0%
TX	32	3.5%	7.9%
VA	16	1.8%	2.6%
WV	5	0.6%	0.6%
West	**314**	**34.6%**	**23.2%**
AK	2	0.2%	0.2%
AZ	11	1.2%	2.1%
HI	2	0.2%	0.4%
ID	-	0.0%	0.5%
MT	4	0.4%	0.3%
CA	243	26.8%	12.1%
CO	4	0.4%	1.6%
NV	-	0.0%	0.9%
NM	4	0.4%	0.7%
OR	23	2.5%	1.2%
UT	8	0.9%	0.9%
WA	13	1.4%	2.1%
WY	-	0.0%	0.2%
Midwest	**233**	**25.7%**	**22.0%**
IL	115	12.7%	4.3%
IN	37	4.1%	2.1%
IA	2	0.2%	1.0%
KS	11	1.2%	0.9%
MI	25	2.8%	3.3%
MN	13	1.4%	1.7%
MO	-	0.0%	1.9%
ND	-	0.0%	0.2%
NE	6	0.7%	0.6%
OH	10	1.1%	3.8%
SD	-	0.0%	0.3%
WI	14	1.5%	1.9%
Northeast	**231**	**25.5%**	**18.1%**
CT	19	2.1%	1.2%
ME	-	0.0%	0.4%
MA	93	10.3%	2.1%
NH	4	0.4%	0.4%
NJ	37	4.1%	2.9%
NY	43	4.7%	6.4%
PA	33	3.6%	4.1%
RI	1	0.1%	0.4%
VT	1	0.1%	0.2%
Other	**-**	**0.0%**	**0%**
PR	-	0.0%	0%
Unavailable	-	0.0%	0%
Total	**907**	**100%**	**100%**



2013–14 Workshop Participants Home Institution Classified by Countries

**Regions based on United Nations classification*

Region	Area	Country	Total
Africa			**6**
	Middle Africa		**2**
		Angola	1
		Cameroon	1
	Northern Africa		**1**
		Egypt	1
	Western Africa		**1**
		Nigeria	1
	Southern Africa		**2**
		South Africa	2
Americas			**1003**
	Caribbean		**2**
		Haiti	1
		Jamaica	1
	Central America		**3**
		Mexico	3
	North America		**985**
		Canada	78
		United States	907
	South America		**13**
		Argentina	1
		Brazil	5
		Colombia	6
		Venezuela	1
Asia			**65**
	Eastern Asia		**39**
		China	2
		Japan	15
		KOREA, REPUBLIC OF	22
	South-central Asia		**7**
		India	5
		IRAN, ISLAMIC REPUBLIC OF	2
	Western Asia		**19**
		Israel	12
		Saudi Arabia	1
		Turkey	6
Europe			**397**
	Eastern Europe		**12**
		Czech Republic	3
		Poland	4
		Russian Federation	2
		Belarus	3
	Northern Europe		**103**
		Denmark	25
		England	54
		Finland	1
		Ireland	1
		Norway	11
		Sweden	11
	Southern Europe		**18**
		Italy	12
		Portugal	3
		Spain	3
	Western Europe		**264**
		Austria	9
		Belgium	10
		France	133
		Germany	81
		Luxembourg	2
		Netherlands	6
		Switzerland	23
Oceania			**18**
	Australia and New Zealand		**18**
		Australia	15
		New Zealand	3
Grand Total			**1489**



2.7 Program Publication List

(See email attached file)

2.8 Program Publication Work-In-Progress List

(See email attached file)

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 2013–14 academic year, MSRI selected 28 postdoctoral scholars with research interests in the programs that MSRI offers. Of those postdocs, 24 were funded by the NSF Core Grant, 2 by the Viterbi Endowment, 1 by the Huneke Endowment and 1 by the Strauch Post-Doctoral Fellowship Grant.

There were many more excellent postdoc applicants than we could fund with our NSF Postdoctoral Fellowship (PD) budget line. The program organizers used additional funds from their allocated NSF budget to support an additional 5 members who had earned their PhDs no more than five years ago. Those members were called "Postdoc Research Members" (PD/RMs as opposed to NSF Postdoctoral Fellows) and received a per diem of $3,000 per month. While they were not monetarily compensated at the same level as the NSF Postdoctoral Fellows, they received all other privileges. That is, all Postdocs were assigned a mentor upon their arrival, participated in a weekly Postdoc seminar, and were a vibrant part of the research community. They also had the same logistic privileges (office, library access, bus pass, etc…).

Of the 28 Postdoctoral Fellows at MSRI, eight (29%) were female, 12 (43%) were a U.S. Citizen or Permanent Resident, and 17 (61%) 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.

Mathematical General Relativity

Haber, Nick

Name: Nick Haber
Year of PhD: 2013
Institution of Ph.D.: Stanford
Dissertation Title: Microlocal analysis of Lagrangian submanifolds of radial points
Advisor: András Vasy

Institution prior to obtaining the MSRI PD fellowship: (was still in graduate school)

Institution where you are going after the MSRI PD fellowship: McGill
Position: Reseach Fellow
Anticipated length: 7 Months
Mentor: Dmitry Jakobson

Postdoctoral fellow's comments:

At MSRI I kicked off several projects, including three with new collaborators, two of which were at MSRI. I continued working to improve the results of my thesis for publication, and I was also applying for academic jobs.

Was your experience at MSRI beneficial?
Very much so.

Sakovich, Anna

Name: Anna Sakovich
Year of Ph.D.: 2013
Institution of Ph.D.: Royal Institute of Technology (Kungliga Tekniska Högskolan), Stockholm, Sweden
Dissertation title: A Study of Asymptotically Hyperbolic Manifolds in Mathematical Relativity
Ph.D. advisor: Mattias Dahl

Institution prior to obtaining the MSRI PD fellowship: Linköping University, Sweden
Position: Visiting Teacher

Institution where you are going after the MSRI PD fellowship: Max Planck Institute for Gravitational Physics (Albert Einstein Institute), Potsdam-Golm, Germany
Position: Postdoc
Anticipated length: 2 years
Mentor: Ulrich Menne

Postdoctoral fellow's comments:

During my stay at MSRI I have worked on the following papers:

1. "A Jang equation approach to positive mass theorem for asymptotically hyperbolic manifolds" (rough/draft, started before coming to MSRI): We show that a solution of the Jang equation exists on an asymptotically hyperbolic manifold. The properties of this solution can be used to reduce the proof of the positive mass theorem for hyperboloidal slices to the Riemannian positive mass theorem for asymptotically Euclidean manifolds.

2. "Notes on geometric inequalities for asymptotically null slices" (joint with Marcus Khuri, working notes, started at MSRI): We consider several geometric inequalities involving mass, area, charge, and angular momentum for asymptotically null initial data. We shown how to reduce each one to the known maximal (or time symmetric) case in the asymptotically flat setting.

3. "On the center of mass for asymptotically hyperbolic manifolds" (joint with Carla Cederbaum and Julien Cortier, working notes, started at MSRI): For asymptotically hyperbolic manifolds we study the relation between the center of mass of Neves-Tian defined via the unique foliation by constant mean curvature stable spheres and the center of mass of Chrusciel et al defined as a certain conserved quantity associated with Killing vector fields of the background metric.

continued on the next page…

4. "Proof of the Penrose inequality for asymptotically hyperbolic manifolds by a modified conformal flow" (joint with Mattias Dahl and Romain Gicquaud, working notes, started before coming to MSRI): We generalize the conformal flow introduced by Hubert Bray to prove the asymptotically hyperbolic Penrose inequality.

I have given two talks at conferences held within the program:

1. "On the mass of asymptotically hyperbolic manifolds" at Connection for Women: Mathematical General Relativity

2. "A Jang equation approach to positive mass theorem for asymptotically hyperbolic manifolds" at Initial Data and Evolution Problems in General Relativity

In addition, I have been actively participating in Christina Sormani's reading seminar "Converging spaces".

To sum up, my experience at MSRI was very beneficial.

Schlue, Volker

Name: Volker Schlue
Year of Ph.D: 2012
Institution of Ph.D.: University of Cambridge
Dissertation title: Linear waves on higher dimensional Schwarzschild black holes and Schwarzschild de Sitter spacetimes
Ph.D. advisor: Mihalis Dafermos

Institution prior to obtaining the MSRI PD fellowship: University of Toronto
Position at that institution: Postdoctoral Fellow
Mentor: Spyros Alexakis

Institution (or company) where you are going after the MSRI PD fellowship: Princeton University
Position: Visiting Postdoctoral Research Associate
Anticipated length: 7 months

Postdoctoral fellow's comments:

I've prepared a manuscript ("Global results for linear waves on expanding Kerr and Schwarzschild de Sitter cosmologies") for submission to a journal (CMP). Moreover, I've posted a paper in collaboration with Spyros Alexakis and Arick Shao in Toronto ("Unique continuation from infinity for linear waves").
I have benefited greatly from conversations with my mentor, Hans Lindblad; we have begun working on a project of interest to us both.

Vega, Carlos

Name: Carlos Vega
Year of Ph.D: 2013
Institution of Ph.D.: University of Miami
Dissertation title: New Approaches to Spacetime Rigidity and Splitting
Ph.D. advisor: Dr. Gregory J. Galloway

Institution prior to obtaining the MSRI PD fellowship: U. Miami
Position at that institution: Teaching Assistant
Mentor: G. J. Galloway

Institution where you are going after the MSRI PD fellowship: CUNY, Graduate Center
Position: Postdoc
Anticipated length: Spring 2014 only
Mentor: Christina Sormani

Postdoctoral fellow's comments:

In the first part of the program, I was focused primarily on a project my Ph.D. advisor, G. J. Galloway, and I had initiated previously, but had not had time to develop. We were able to establish two results, one which we anticipated originally, and a new one conceived at MSRI. This work, and possibly some extensions will go into a paper with the working title: paper: [A splitting result for generalized horospheres, with applications]

Around the middle of the program, I began devoting attention to my talk for the postdoctoral seminar. I wrote the talk from scratch, as I had not given a talk in this setting previously, and also so as to incorporate the new results mentioned above. Not having had much experience, I was a bit daunted going in, but it went well, and I got a positive response from the audience, both during and after the talk, as well as some constructive feedback. I think the experience was great practice, and has served to bolster my confidence speaking.

As mentioned above, I graduated last year. In fact, I finished rather rushed, and ultimately postponed a vigorous job search till this year. Following my talk, I began focusing on jobs, and developing application materials like my research and teaching statements. This has, unfortunately, involved a rather substantial time commitment.
Hans Ringström, my MSRI postdoctoral mentor, has been extremely supportive throughout the program, helping generally on the job front, giving me notes on my research statement, etc., as well as helping with and attending my talk. I had not met Dr. Ringström perviously, and consider this one of the great benefits of my experience at MSRI.

continued on the next page…

Following a talk of Christina Sormani on ‘convergence’', I asked her about convergence in the case of spacetimes, and was excited to hear she had a joint project with L. Andersson and R. Howard in this direction, in its early stages. After some preliminary discussions, I was very happy to have been welcomed to join this project. In fact, without a position lined up for the spring, I was planning on returning to U Miami to teach, but I am very excited to have been invited to join Dr. Sormani as postdoc at CUNY this spring to work on this project. Not only do I find this project of particular interest, I am very much looking forward to working with Dr.Sormani, who has been extremely encouraging, and with whom all of my preliminary contact has been very stimulating. Meeting Dr. Sormani, and the postdoctoral opportunity at CUNY this spring are certainly among the most profound benefits for which I am extremely grateful to have been able to visit MSRI this fall.

Wu, Haotian

Name: Haotian Wu
Year of Ph.D: May 2013
Institution of Ph.D.: The University of Texas at Austin
Dissertation title: Analysis of Ricci flow on noncompact manifolds
Ph.D. advisor: Dan Knopf

Institution prior to obtaining the MSRI PD fellowship: The University of Texas at Austin
Position: Ph.D. student

Institution where you are going after the MSRI PD fellowship: University of Oregon
Position: Visiting Assistant Professor
Anticipated length: three years.
Mentor: Jim Isenberg

Postdoctoral fellow’s comments:

I completed a paper titled "Dynamical stability of algebraic Ricci solitons" with Michael Bradford Williams at UCLA. This paper has been submitted.

Then I have been working on the asymptotic behavior of Type-II singularities in Ricci flow and the mean curvature flow on noncompact manifolds. These are ongoing projects.

Was your experience at MSRI beneficial?
The experience was very beneficial. I was able to explain my work with Williams to my mentor Jim Isenberg at MSRI and Jim's feedback helped to improve the paper. Jim suggested some problems that we will pursue while at University of Oregon. I also talked to Justin Corvino a lot and discussed some potential projects with him.

Zhou, Xin

Name: Xin Zhou
Year of Ph.D.: 2013
Institution of Ph.D.: Stanford University
Dissertation title: On the variational methods for minimal submanifolds
Ph.D. advisor: Richard Schoen

Institution (or company) where you are going after the MSRI PD fellowship: MIT
Position: CLE Moore Instructor
Anticipated length: 2 and half years

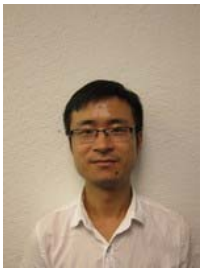
Postdoctoral fellow's comments:

I mainly followed my PhD researches on min-max theory of minimal submanifolds. Minimal submanifolds theory were studied extensively in General Relativity. My current research focuses on the existence and regularity theory of those submanifolds. I mainly conduct two projects during my visit to MSRI. The first project deals with the min-max geodesics with boundary lying on a constraint submanifolds in any Riemannian manifolds. The existence part is ready to publish, but I am still working on one application before publishing it. Another project deals with the min-max theory for minimal hypersurfaces with free boundary of an arbitrary Riemannian manifold with boundary. It is a joint work with Martin Li at MIT. We mainly did the curvature estimates part during my visit here. Besides these, I also talked with many experts of General Relativity. I consulted them my previous work on Mass angular momentum inequalities, which help a lot on my future study in that subject.

Was your experience at MSRI beneficial?

The experience is very beneficial. MSRI provides me a very quiet environment to think about those projects.

Optimal Transport: Geometry and Dynamics



Chen, Shibing

Name: Shibing Chen
Year of Ph.D: 2013
Institution of Ph.D.: University of Toronto
Dissertation title: Convex solutions to the power-of-mean curvature flow, conformally invariant inequalities and regularity results in some applications of optimal transportation

Ph.D. advisor: Robert McCann

Institution prior to obtaining the MSRI PD fellowship: University of Toronto
Position at that institution:
Mentor (if applicable): Robert McCann

Institution (or company) where you are going after the MSRI PD fellowship: Zhejiang University of Techonology
Anticipated length: Tenure-track
Mentor (if applicable): N/A

Postdoctoral fellow's comments:

I have been working on my Mentor Alessio Figalli on the regularity of solutions to optimal transport problem with general cost, we have made some progress.

Was your experience at MSRI beneficial?
My experience at MSRI benefits me a lot. I learned a lot of knowledges in different aspects of optimal transportation. I have also many opportunities to talk to excellent mathematicians in my research area.

Erbar, Matthias

Name: Matthias Erbar
Year of Ph.D: 2013
Institution of Ph.D.: University of Bonn
Dissertation title: Ricci curvature and gradient flows for jump processes
Ph.D. advisor: Karl-Theodor Sturm

Institution prior to obtaining the MSRI PD fellowship: University of Bonn, Institute for Applied Mathematics, Germany
Position at that institution: Postdoctoral researcher
Mentor: Karl-Theodor Sturm

Institution where you are going after the MSRI PD fellowship: Scuola normale superiore, Pisa, Italy
Position: Postdoctoral researcher
Anticipated length: 4 months
Mentor: Luigi Ambrosio

Postdoctoral fellow's comments:

I have participated in workshops at MSRI as well as at the Simons Institute. At MSRI I have continued collaborations with other visitors (Jan Maas, Martin Huesmann) and established new collaborations (Sajjad Lakzian, Prasad Tetali). We have worked on joint papers, so far no publication has been made.
My experience has been very positive and beneficial to my work.

Indrei, Emanuel

Name: Emanuel Indrei
Year of Ph.D: 2013
Institution of Ph.D.: University of Texas at Austin
Dissertation title: Optimal transport, free boundary regularity, and stability results for geometric and functional inequalities
Ph.D. advisor: Alessio Figalli

Institution prior to obtaining the MSRI PD fellowship: Australian National University
Position at that institution: Postdoctoral Fellow
Mentor (if applicable): Neil Trudinger

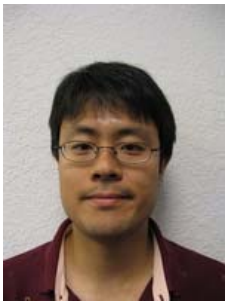
Institution (or company) where you are going after the MSRI PD fellowship: Carnegie Mellon University
Position: Postdoctoral Associate
Anticipated length: (if it is a tenure track position just write tenure-track) 3 years
Mentor (if applicable): Irene Fonseca and Giovanni Leoni

Postdoctoral fellow's comments:

I finished four projects at MSRI. One of these was initiated at MSRI. Two of these four projects have been submitted for publication and are available as preprints on the arXiv (the titles of all four are listed on my exit survey). The other two papers are being prepared for submission and should be available on the arXiv very soon.

Was your experience at MSRI beneficial?

Absolutely!! I have learned a lot of new mathematics and been extremely productive during my semester at MSRI and believe that this has a lot to do with the excellent working environment provided by MSRI. Moreover, my interaction with other MSRI members has been beneficial. I have met new collaborators through the MSRI program.



Kitagawa, Jun

Name: Jun Kitagawa
Year of Ph.D: 2011
Institution of Ph.D.: Princeton University
Dissertation title: Two Regularity Results in Optimal Transportation
Ph.D. advisor: Sun-Yung Alice Chang

Institution prior to obtaining the MSRI PD fellowship: University of British Columbia / Pacific Institute for the Mathematical Sciences (Vancouver, Canada)
Position: Postdoctoral Fellow
Mentor: Nassif Ghoussoub and Young-Heon Kim

Institution (or company) where you are going after the MSRI PD fellowship: University of Toronto (Toronto, Canada)
Position: Postdoctoral Fellow
Anticipated length: 1.5 years
Mentor: Robert McCann

Postdoctoral fellow's comments:

I have nearly completed a collaboration on the multi-marginal optimal transport problem with Brendan Pass, and have made significant progress on a project with Nestor Guillen concerning regularity theory. I also began a number of projects related to regularity and numerics with a number of people.

Was your experience at MSRI beneficial?
It was very beneficial in many aspects.

Maximo, Davi

Name: Davi Maximo
Year of Ph.D: 2013
Institution of Ph.D.: University of Texas at Austin
Dissertation title: On the blow-up of four-dimensional Ricci flow singularities
Ph.D. advisor: Dan Knopf

Institution prior to obtaining the MSRI PD fellowship: University of Texas at Austin
Position at that institution: Graduate Student
Mentor: Dan Knopf

Institution where you are going after the MSRI PD fellowship: Stanford University
Position: Szego Assistant Professor
Anticipated length: 3 years

Postdoctoral fellow's comments:

During his stay at MSRI, Maximo finished a paper, jointly with Ivaldo Nunes and Graham Smith, on the existence of free boundary minimal surfaces of prescribed topology inside suitably convex subsets of three-dimensional Riemannian manifolds with nonnegative Ricci curvature - including strictly convex domains of the Euclidean space R^3.

Together with Haotian Wu, he started investigating whether the moduli space of metrics with non-negative Ricci curvature and convex boundary on a three-dimensional ball is path connected. This would allow for an extension of his result with Nunes and Smith. Maximo has also started investigating rigidity questions for minimal submanifolds with free boundary in the ball with Alessio Figalli.

Maximo has participated at workshops at MSRI, gave a talk at the Geometry Seminar at UC Berkeley, and wrote a NSF proposal. Overall, he appreciated a lot his time at Institute and his interactions with other visitors. His visit was very beneficial for his proposal, which should set the tone for his research in the next couple of years.

Moore, Kristen

Name: Kristen Moore
Year of Ph.D: 2012
Institution of Ph.D.: Free University Berlin
Dissertation title: The evolution of hypersurfaces in asymptotically flat Riemannian Manifolds by their inverse null mean curvature
Ph.D. advisor: Gerhard Huisken

Institution prior to obtaining the MSRI PD fellowship: Potsdam University
Position: Postdoc

Institution where you are going after the MSRI PD fellowship: Stanford University
Position: Lecturer
Anticipated length: 6 months

Postdoctoral fellow's comments:

Research, attending/participating in conferences & seminars.

Was your experience at MSRI beneficial? Yes

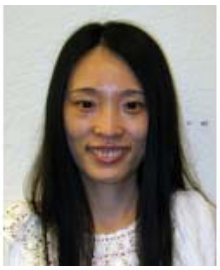
Sinaei, Zahra

Name: Zahra Sinaei
Year of Ph.D.: 2013
Institution of Ph.D.: École Polytechnique Fédérale de Lausanne
Dissertation title: Harmonic Maps on Smooth Metric Measure Spaces and on Riemannian Polyhedra
Ph.D. advisors: Marc Troyanov

Institution prior to obtaining the MSRI PD fellowship: École Polytechnique Fédérale de Lausanne
Position: Graduate student

Institution where you are going after the MSRI PD fellowship: Courant Institute of Mathematical Sciences
Position: Postdoctoral fellow

Fellow's Comments: None



Xiao, Ling

Name: Ling Xiao
Year of Ph.D.: 2013
Institution of Ph.D.: Johns Hopkins University
Dissertation title: Flow problems in Hyperbolic space
Ph.D. advisor: Joel Spruck

Institution prior to obtaining the MSRI PD fellowship: Johns Hopkins University
Position: Graduate student
Mentor: Joel Spruck

Institution where you are going after the MSRI PD fellowship: Johns Hopkins University

Fellow's Comments: None

Algebraic Topology

Ayala, David

Name: David Ayala
Year of Ph.D.: 2009
Institution of Ph.D.: Stanford University
Dissertation title: Geometric cobordism categories
Ph.D. advisor: Ralph Cohen

Institution prior to obtaining the MSRI PD fellowship: University of Southern California/Harvard
Position at that institution: Postdoctoral Fellow (NSF)
Mentor (if applicable): Eric Friedlander/Michael Hopkins

Institution (or company) where you are going after the MSRI PD fellowship: Montana State University
Position: Assistant professor
Anticipated length: Tenure-track

Postdoctoral fellow's comments:

I mostly focused on using the recent universal properties for K-theory to likewise construct TC, as well as the trace map, as well as showing this cyclotomic trace map is locally constant. I also focused on using ideas from rational homotopy theory to show a general formulation of Poincare' duality, that accounts for a number of dualities among topological field theories.

Was your experience at MSRI beneficial?
Extremely.

Bohmann, Anna Marie

Name: Anna Marie Bohmann
Year of Ph.D.: 2011
Institution of Ph.D.: University of Chicago
Dissertation title: Topics in Equivariant Stable Homotopy Theory
Ph.D. advisor: J. Peter May

Institution prior to obtaining the MSRI PD fellowship: Northwestern University
Position at that institution: Boas Assistant Professor (a postdoc position)
Mentor (if applicable): Paul Goerss

Institution (or company) where you are going after the MSRI PD fellowship: Northwestern University
Position: Boas Assistant Professor
Anticipated length: 1 further academic year
Mentor (if applicable): Paul Goerss

Postdoctoral fellow's comments:

While at MSRI, I both worked on ongoing research projects and discussed mathematics with other members of the program with an eye towards developing new projects and understanding current advances in research.
For example, Angelica Osorno and I finished our paper "An equivariant infinite loop space machine via Mackey functors" while in residence here---dedicated research time while in the same location was crucial in bringing this long term project to fruition. I also devoted a lot of my energy to advancing my previously established collaboration with Vigleik Angeltveit. We were able to fully sort out details we had been stuck on while we were both in residence, and are working on a preprint entitled "Graded Tambara functors."

In addition to working on these projects, I also spent time working on mathematical projects that are still in the early stages, including questions related to equivariant complex cobordism, model structures on equivariant infinity categories, equivariant symmetric monoidal categories, and constructing equivariant ring spectra. Crucial to this work were a variety of formal and informal mathematical conversations with John Greenlees, Dev Sinha, Mike Hill, Emily Riehl, Julie Bergner and Charles Rezk. I plan to develop some of these project into future papers, either solely or in collaboration.

I also regularly attended the open problems seminar and research seminar associated to the Algebraic Topology program.

Anna Marie Bohmann continued…

My experience at MSRI was definitely beneficial. As detailed above, being at MSRI allowed me to jump start my collaborations in a way that would be difficult while at my home institution. I also met or re-met several senior members of my field and had a chance to talk mathematics with them, which I think will be beneficial both in terms of establishing future collaborations but also in terms of being a visible presence in the field as I transition from postdoc status to a more permanent position.

In less tangible terms, I think that being at MSRI has given me an excellent opportunity to refocus my research program. Time without teaching or other obligations gave me a chance to feeling centered in my projects, and I am returning to Northwestern with a renewed sense of energy and accomplishment.

Grigoriev, Ilya

Name: Ilya Grigoriev
Year of Ph.D: 2013
Institution of Ph.D.: Stanford University
Dissertation title: Relations among characteristic classes of manifold bundles
Ph.D. advisor: Soren Galatius

Institution prior to obtaining the MSRI PD fellowship: University of Chicago
Position at that institution: L.E.Dickson Instructor
Mentor (if applicable): Benson Farb

Institution (or company) where you are going after the MSRI PD fellowship: University of Chicago
Position: L.E.Dickson Instructor
Anticipated length: Two more years
Mentor (if applicable): Benson Farb

Postdoctoral fellow's comments:

My experience at MSRI was extremely beneficial to me. I have worked with Soren Galatius and Oscar Randal-Williams on issues related to my thesis. I have also worked under supervision of Nathalie Wahl on a related but new topic related to characteristic classes and diffeomorphisms of three-dimensional manifold (my thesis work only deals with manifolds of dimension 4k+2).

Osorno, Angelica

Name: Angelica M. Osorno
Year of Ph.D.: 2010
Institution of Ph.D.: Massachusetts Institute of Technology
Dissertation title: An Infinite Loop Space Structure for K-theory of Bimonoidal Categories
Ph.D. advisor: Mark Behrens

Institution prior to obtaining the MSRI PD fellowship: Reed College
Position at that institution: Assistant Professor

Institution (or company) where you are going after the MSRI PD fellowship: Reed College
Position: Assistant Professor
Anticipated length: tenure-track

Postdoctoral fellow's comments:

While at MSRI I have made progress on 3 independent projects that I had already started when I came here. One of the projects is joint with Anna Marie Bohmann, who is another postdoc here, so we have been able to work on it at length. I have also started two other projects, one with Marc Stephan, who is a graduate student in the program. I have also had many useful conversations with other members of the program, which have led to better understanding and new perspectives.

Was your experience at MSRI beneficial?

It has. Having the time to work on my research, while being surrounded by the experts in the field was been very beneficial.

Stojanoska, Vesna

Name: Vesna Stojanoska
Year of Ph.D.: 2011
Institution of Ph.D.: Northwestern University
Dissertation title: Duality for topological modular forms
Ph.D. advisor: Paul Goerss

Institution prior to obtaining the MSRI PD fellowship: MIT
Position at that institution: C.L.E. Moore Instructor
Mentor (if applicable): Haynes Miller

Institution (or company) where you are going after the MSRI PD fellowship: Max Planck Institute for Mathematics, Bonn, Germany
Position: Advanced researcher
Anticipated length: 1 year

Postdoctoral fellow's comments:

- My research program with Julie Bergner, Ruth Joachimi, Kathryn Lesh, and Kirsten Wickelgren saw significant development; one paper was accepted for publication, one is about to be submitted, and another is in the works. The success was largely due to the fact that Bergner and Wickelgren were also MSRI members, while Joachimi and Lesh visited us here for a shorter period.
- With Kirsten Wickelgren, I have been co-leading a team of Women in Numbers, including Rachel Davis and Rachel Pries. In particular, we started working on a brand new project about topological obstructions to the existence of rational points on Fermat curves.
- I have made significant progress in my ongoing projects on duality, including finalizing a paper joint with Drew Heard. A considerable portion of this development is due to numerous conversations with a number of MSRI members.

Was your experience at MSRI beneficial? Yes, very much so.

Tanaka, Hiro

Name: Hiro Tanaka
Year of Ph.D.: 2013
Institution of Ph.D.: Northwestern University
Dissertation title: A Functor from Lagrangian cobordisms to the Fukaya category
Ph.D. advisor: Kevin Costello

Institution prior to obtaining the MSRI PD fellowship: Harvard University
Position at that institution: Benjamin Pierce Fellow (Post-doc)

Institution (or company) where you are going after the MSRI PD fellowship: Harvard University
Position: Benjamin Pierce Fellow / NSF Post-doc
Anticipated length: Four years (til 2018)
Mentor (if applicable): Jacob Lurie

Postdoctoral fellow's comments:

I made progress on my various research projects concerning Lagrangian cobordisms, Factorization homology, Bridgeland stability conditions, and K Theory.

Was your experience at MSRI beneficial? Absolutely.

Tilson, Sean

Name: Sean Tilson
Year of Ph.D.: 2013
Institution of Ph.D.: Wayne State University
Dissertation title: Power operations in the Kunneth and C_2-equivariant Adams spectral sequences with applications
Ph.D. advisor: Robert R. Bruner

Institution prior to obtaining the MSRI PD fellowship: Royal Institute of Technology (KTH), Sweden
Position at that institution: Postdoctoral Fellow
Mentor: Tilman Bauer & Wojciech Chachólski

Institution (or company) where you are going after the MSRI PD fellowship: Universität of Osnabrück
Position: Postdoc
Anticipated length: at least 2 years
Mentor: Oliver Röndigs & Markus Spitzweck

Postdoctoral fellow's comments:

I spent a lot of time thinking about new potential projects. I mostly worked on computing the action of the relevant power operations on a particular relative smash product. This was not successful. I tried several different methods.

Was your experience at MSRI beneficial?
I think so. Time will tell. I think the best part was forming relationships with certain people. This means I will be more likely to contact them in the future about mathematics.

Model Theory, Arithmetic Geometry and Number Theory

Andrews, Uri

Name: Uri Andrews
Year of Ph.D.: 2010
Institution of Ph.D.: UC Berkeley
Dissertation title: Amalgamation Constructions and Recursive Model Theory
Ph.D. advisor: Thomas W. Scanlon

Institution prior to obtaining the MSRI PD fellowship: University of Wisconsin - Madison
Position at that institution: Assistant Professor

Institution (or company) where you are going after the MSRI PD fellowship: University of Wisconsin - Madison
Position: Assistant Professor
Anticipated length: Tenure Track

Postdoctoral fellow's comments:

Was your experience at MSRI beneficial?
I worked on some problems in recursive model theory and in model theory. It is likely that two publications will emerge due to research conducted while at MSRI. One with Vincent Guingona (another participant in the program) giving a local characterization of VC-minimality and a second giving new information about the spectra of computable models of strongly minimal theories satisfying the Zilber trichotomy with infinite languages.

Bays, Martin

Name: Martin Bays
Year of Ph.D.: 2010
Institution of Ph.D.: Oxford University
Dissertation title: Categoricity Results for Exponential Maps of 1-Dimensional Algebraic Groups & Schanuel Conjectures and the CIT
Ph.D. advisor: Boris Zilber

Institution prior to obtaining the MSRI PD fellowship: McMaster University
Position at that institution: Postdoc

Institution (or company) where you are going after the MSRI PD fellowship: McMaster University
Position: Postdoc
Anticipated length: 6 months

Postdoctoral fellow's comments:

Broadly speaking: I discussed various things with various people, furthering a number of existing research projects and initiating some more, and enjoyed a prodigious number of talks. I don't know how much detail is wanted here, but briefly: Pierre Simon and I spent some time trying to get out an application of trichotomous ideas to pseudofinite structures; sadly our approach turned out to be fundamentally wrongheaded, and no theorem resulted. Still, I don't think the time was wasted. Meanwhile, I furthered an existing project with Anand Pillay and another with Juan-Diego Caycedo and Jonathan Kirby. With Rahim Mossa and Martin Hils, we started looking at a possible model theory of holomorphic dynamics; this led quickly to a hard problem in the model theory of compact complex manifolds on which we're still working.
Miscellaneous useful conversations have been had with others. Sadly no actual publications have resulted from any of this thus far.

Was your experience at MSRI beneficial?

Yes, very much so!

Thanks muchly for having me.

Chernikov, Artem

Name: Artem Chernikov
Year of Ph.D.: 8 Oct 2012
Institution of Ph.D.: Université Claude Bernard - Lyon 1
Dissertation title: "Sur les théories sans la propriété de l'arbre du second type"
Ph.D. advisor: Itaï Ben Yaacov

Institution prior to obtaining the MSRI PD fellowship: Université Paris Diderot - Paris 7
Position at that institution: Postdoc
Mentor (if applicable): Martin Hils

Institution (or company) where you are going after the MSRI PD fellowship: Université Paris Diderot - Paris 7
Position: Postdoc
Anticipated length: 1.5 years
Mentor (if applicable): Martin Hils

Postdoctoral fellow's comments:

Was your experience at MSRI beneficial?
Yes, the experience was extremely beneficial, I was in a perfect setting to continue some ongoing collaborations and to start new ones.
I have the following papers at various stages of preparation:

Title: Applications of model theory to extreme combinatorics
Coauthors: Sergei Starchenko
Status of Manuscript: Working Notes
Comment: The title is provisional, work in progress.

Title: Definably amenable groups in NIP
Coauthors: Pierre Simon
Status of Manuscript: Rough/Draft
Comment: The title is provisional, paper is close to finishing.

Title: On quantitative versions of Shelah's tree properties
Coauthors: Nick Ramsey
Status of Manuscript: Rough/Draft
Comment: Work in progress.

Dupuy, Taylor

Name: Taylor Dupuy
Year of Ph.D.: 2013
Institution of Ph.D.: University of New Mexico
Dissertation title: Deformations Classes Associated to Curves via Arithmetic Jet Spaces
Ph.D. advisor: Alexandru Buium

Institution prior to obtaining the MSRI PD fellowship: UCLA
Position at that institution: Adjunct Assistant Professor

Institution (or company) where you are going after the MSRI PD fellowship: Hebrew University
Position: Post-doc
Anticipated length: 2 years
Mentor (if applicable): Hrushovski

Postdoctoral fellow's comments:

Was your experience at MSRI beneficial?

My experience was very beneficial. I submitted two papers which I had been working on previously, one was a project in combinatorial number theory and one was related to my thesis. I made progress one two projects, one concerning the Kolchin Irreducibility Theorem and one concerning differential algebraic varieties on curves which are "categorical". The first project is joint work with James Freitag and Lance E. Miller and the second with James Freitag and Aaron Royer. Note that the second project is a collaboration between Algebraic Topology and Model Theory. There are several other problems I have been considering but nothing substantial enough to report on at this time.

Hill, Cameron

Name: Cameron Donnay Hill
Year of Ph.D.: 2010
Institution of Ph.D.: UC Berkeley
Dissertation title: Geometric Model Theory in Efficient Computability
Ph.D. advisor: Leo Harrington (and Thomas Scanlon)

Institution prior to obtaining the MSRI PD fellowship:
U. of Notre Dame (postdoc) at time of application; Wesleyan University immediately before the beginning of the workshop.
Position at that institution: Assistant Professor of Mathematics (Wes.)
Mentor: Lou van den Dries

Institution (or company) where you are going after the MSRI PD fellowship: Wesleyan University
Position: Assistant Professor of Mathematics
Anticipated length: Tenure-track.

Postdoctoral fellow's comments:

I continued work on classifying model-theoretic dividing-lines via Ramsey theory and generalized indiscernibles; a paper on that subject is in preparation (joint with V. Guingona and L. Scow).

I rethought and reworked my previous investigations of 0,1-laws for classes of finite structures that have generic models. Conversations with A. Kruckman (current student of T. Scanlon) and Ward Henson were/are very important in this. A paper is in preparation.

I began thinking about model-theoretic framework for polynomial invariants of graphs, hypergraphs, and similar structures. Conversations with Sean Tilson and with Scanlon and van den Dries (on model-theoretic Euler characteristics) were/are very important in this development. This is a work in progress.

Was your experience at MSRI beneficial? Very much so.

Simon, Pierre (Strauch PD)

Name: Pierre Simon
Year of Ph.D.: 2011
Institution of Ph.D.: Université Paris-Sud, Orsay, France
Dissertation title: Ordre et stabilité dans les théories NIP
Ph.D. advisor: Elisabeth Bouscaren

Institution prior to obtaining the MSRI PD fellowship: Hebrew University, Jerusalem, Israel
Position at that institution: Post-doc
Mentor (if applicable): Ehud Hrushovski

Institution (or company) where you are going after the MSRI PD fellowship: Université Claude Bernard, Lyon, France
Position: Researcher at CNRS
Anticipated length: tenure

Postdoctoral fellow's comments:

During my stay at MSRI I have started a number of projects in collaboration with various members, though not all those projects have been successful. With Martin Bays (PD fellow), we worked on a topic new to both of us: pseudofinite structure in algebraic geometry, but have not succeeded in proving what we aimed for. With Artem Chernikov (PD fellow) and Martin Hils (research member), we started a project on ultra products of p-adic fields on which we have made good progress and which we intend to pursue. I have collaborated also with Silvain Rideau (visitor) and helped him prove a theorem he had been working on for some time. I also had some very interesting discussions with Ehud Hrushovski, which opened opportunities for new collaboration between us.

My stay at the MSRI has been very beneficial. It gave me the opportunity to collaborate with researches from both Europe and the Americas. Although my work there has not led to new publications, a few projects were initiated, which I am sure will lead to interesting results in the future.

Thomas, Margaret

Name: Margaret Thomas
Year of Ph.D.: 2009
Institution of Ph.D.: University of Oxford, UK
Dissertation title: "Convergence and Parameterization in O-Minimal Structures"
Ph.D. advisor: Prof. Alex J. Wilkie

Institution prior to obtaining the MSRI PD fellowship: University of Konstanz, Germany
Position at that institution: Zukunftskolleg Research Fellow

Institution (or company) where you are going after the MSRI PD fellowship: University of Konstanz, Germany
Position: Zukunftskolleg Research Fellow
Anticipated length: until May 31 2016 (2 further years)

Postdoctoral fellow's comments:

Completed and submitted article "Rational values of Weierstrass zeta functions" (joint with Gareth O. Jones). Worked on existing research project "Parameterization and Algebraic Points in O-Minimal Structures" (concerning questions around mild parameterization and Wilkie's Conjecture) together with Ph.D. student, Derya Ciray, as well as identified new approaches to certain questions in this project together with Postdoc Mentor Sergei Starchenko, and Lou van den Dries. Identified several questions to pursue on ideas surrounding the Pila--Wilkie Theorem together with Sergei Starchenko, David Masser, Alex Wilkie and Umberto Zannier, as well as learning about a possible application of one of these questions from Jim Freitag, Barry Mazur and Tom Scanlon. Refereed and analysed a new proof of the Pila--Wilkie Theorem by Alex J. Wilkie. Discussed two new possible future lines of research, one on the Pila--Wilkie Theorem and tameness, together with Chris Miller and Georges Comte, another, on hyperexponential and Liouville functions, together with Alf Onshuus and Martin Bays. Gave three talks: "The Pila--Wilkie Theorem and Variations" (as part of the Introductory Workshop), "Counting Algebraic Points on Definable Sets" (as part of the Connections for Women workshop) and "Rational Points on Definable Sets" (for the Postdoc Seminar).

Was your experience at MSRI beneficial?

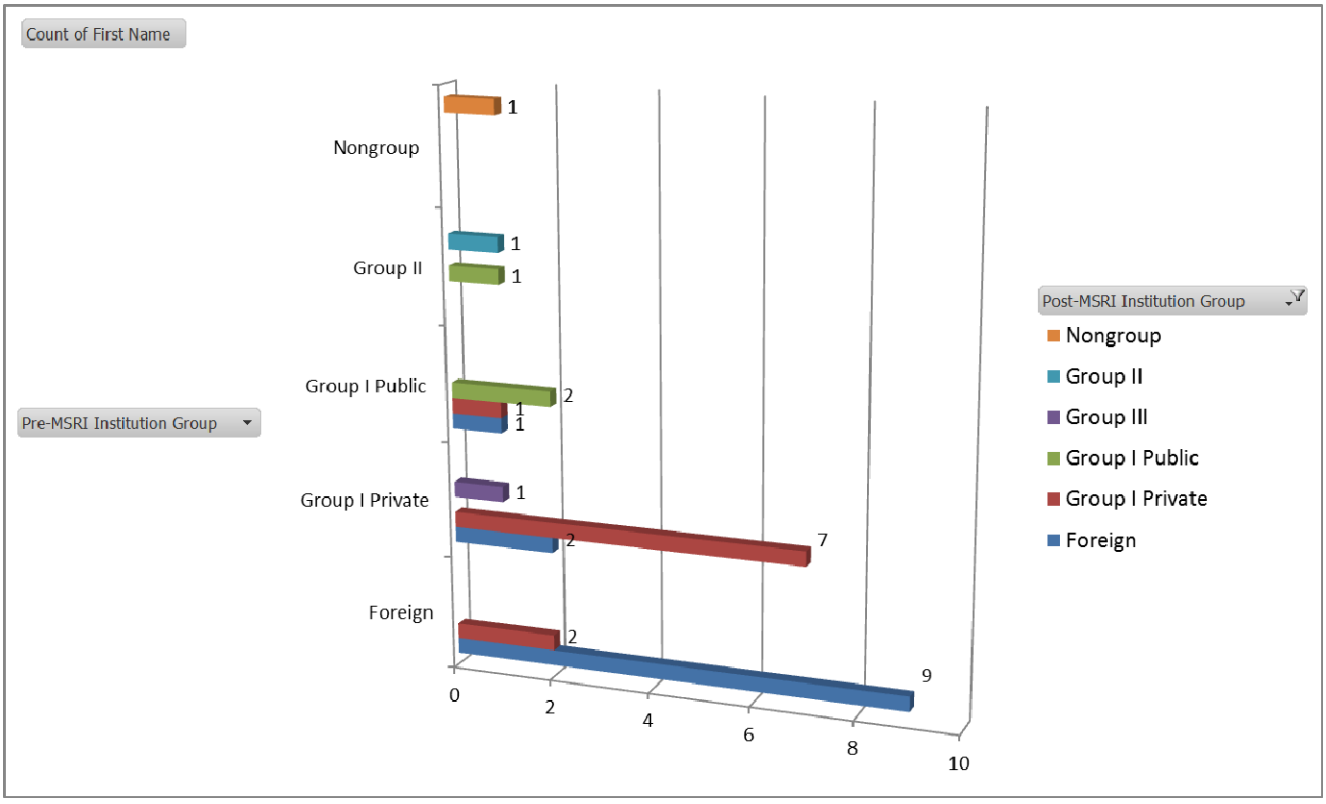
Yes. The opportunity to be surrounded by experts in my field of research, in particular those working on questions around the application of o-minimality to diophantine geometry and related topics, led to a swifter progress on identifying and refining suitable research questions to pursue than would have been possible elsewhere. The opportunity to interact with so many scholars in the discipline, to hear frequent seminars on the latest developments, to get to know other researchers and identify common interests, all helps to accelerate progress in the research field in general and in my own work in particular. Especially helpful was the interaction with my Postdoc Mentor, who was able to advise on every one of these aspects and more (to the extent of now being in a position to act as a reference letter writer). These benefits also have the promise to last well beyond the end of the MSRI semester - the collaborations and discussions that began here can be continued, the questions identified can lead to new results, the working connections established can be utilized in many ways. So the full benefit remains to be seen but undoubtedly there was a great deal, and I am grateful for having had the opportunity to participate for the duration.

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
Haber	Nick	Group I Private	Foreign	Stanford University	McGill University
Sakovich	Anna	Foreign	Foreign	Linkoping, Sweden	Max Planck, Germany
Schlue	Volker	Foreign	Group I Private	University of Toronto	Princeton University
Vega	Carlos	Group II	Group I Public	University of Miami	CUNY
Wu	Haotian	Group I Public	Group I Public	University of Texas, Austin	University of Oregon
Zhou	Xin	Group I Private	Group I Private	Massachusetts Institute of Technology	Massachusetts Institute of Technology
Chen	Shibing	Foreign	Foreign	University of Toronto	Zhejiang University of Technology
Erbar	Matthias	Foreign	Foreign	University of Bonn	Scuola Normale Superiore, Pisa
Indrei	Emanuel	Group I Private	Group I Private	Carnegie Mellon University	Carnegie Mellon University
Kitagawa	Jun	Foreign	Foreign	University of British Columbia	University of Toronto
Maximo	Davi	Group I Public	Group I Private	University of Texas, Austin	Stanford University
Moore	Kristine	Group I Private	Group I Private	Stanford University	Stanford University
Sinaei	Zahra	Foreign	Group I private	Ecole Polytechnique	NYU
Xiao	Ling	Group I Private	Group I Private	Johns Hopkins University	Johns Hopkins University
Ayala	David	Group I Private	Group III	USC	Montana State University
Bohmann	Anna Marie	Group I Private	Group I Private	Northwestern University	Northwestern University
Grigoriev	Ilya	Group I Private	Group I Private	University of Chicago	University of Chicago
Osorno	Angelica	Nongroup	Nongroup	Reed College	Reed College
Stojanoska	Vesna	Group I Private	Foreign	Massachusetts Institute of Technology	Max Planck, Germany
Tanaka	Hiro	Group I Private	Group I Private	Harvard University	Harvard University
Tilson	Sean	Foreign	Foreign	KTH, Sweden	Universitat of Osnabruck
Andrews	Uri	Group I Public	Group I Public	University of Wisconsin - Madison	University of Wisconsin - Madison
Bays	Martin	Foreign	Foreign	McMaster University	McMaster University
Chernikov	Artem	Foreign	Foreign	Université Paris Diderot - Paris 7	Université Paris Diderot - Paris 7
Dupuy	Taylor	Group I Public	Foreign	UCLA	Hebrew University
Hill	Cameron	Group II	Group II	Wesleyan University	Wesleyan University
Simon	Pierre	Foreign	Foreign	Hebrew University	Université Claude Bernard, Lyon, France
Thomas	Margaret	Foreign	Foreign	University of Konstanz, Germany	University of Konstanz, Germany

2013–14 Postdocs' Home Institution

(based on AMS Groupings)



Highlights

Of the 10 postdocs who came from Group I Private Insitutions, seven are currently at Group I Private Institutions. The others are divided among Group III and Foreign Institutions.

Of the four postdocs who came from Group I Public Institutions, two are currently at Group I Public Institutions, one at Group I Private and one at Foreign Institution.

Of the 11 postdocs who came from Foreign Institutions, nine returned to Foreign Institutions.

3.3 Postdoctoral Fellow Participant Summary

Programs	# of Postdocs	# of Citizens & Perm. Res.	%	# of Female	%	# of Minorities [1]	%	US Home Institution	%
Mathematical General Relativity	6	2	*33.3%*	1	*16.7%*	0	*0.0%*	4	66.7%
Optimal Transport: Geometry and Dynamics	8	2	*25.0%*	3	*37.5%*	0	*0.0%*	4	50.0%
Model Theory, Arithmetic Geometry and Number Theory	7	3	*42.9%*	1	*14.3%*	1	*33.3%*	3	42.9%
Algebraic Topology	7	5	*71.4%*	3	*42.9%*	1	*25.0%*	6	85.7%
Total # of Distinct Postdocs	**28**	**12**	***42.9%***	**8**	***28.6%***	**2**	***18.2%***	**17**	***60.7%***

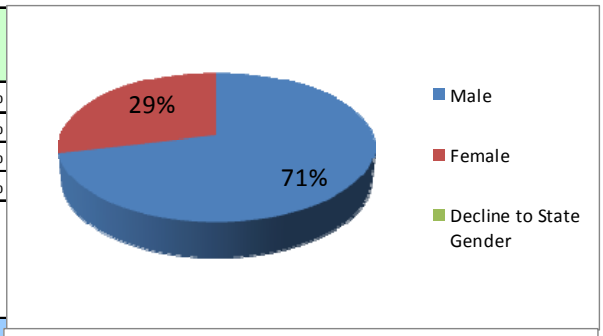
[1] *Minorities are US citizen who declare themselves American Indian, Black, Hispanic, or Pacific Islander. Minority percentage is calculated by dividing the number of Minorities by the total number of US citize*

3.4 Postdoctoral Fellow Demographic Data

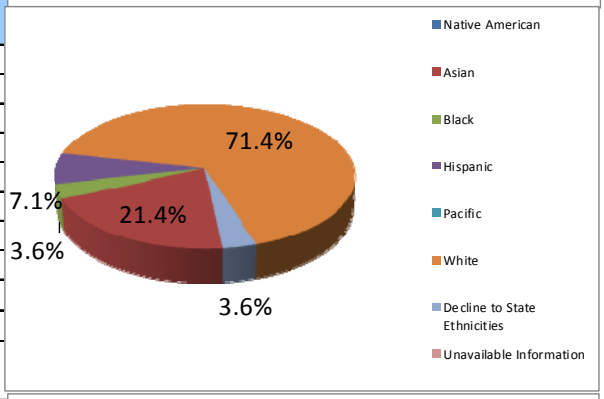
2013–14 Postdoctoral Fellows Demographic Summary

Gender	#	% (No Decl.)*	%
# of Postdocs	28		100.0%
Male	20	71.43%	71.4%
Female	8	28.57%	28.6%
Decline to State Gender	0		0.0%

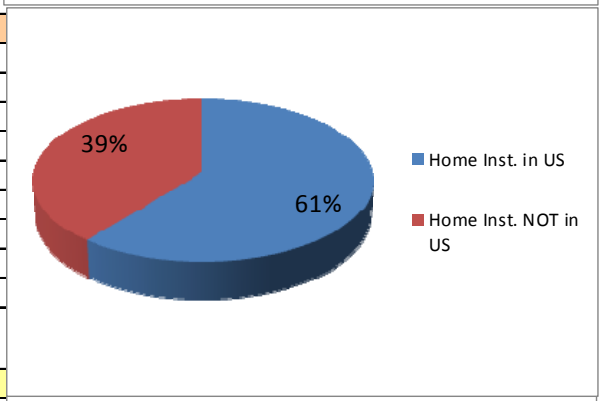
Members are distinct within each academic year.



Ethnicities	#	% (No Decl.)*	%
Native American	0	0.00%	0.0%
Asian	6	20.69%	21.4%
Black	1	3.45%	3.6%
Hispanic	2	6.90%	7.1%
Pacific	0	0.00%	0.0%
White	20	68.97%	71.4%
Decline to State Ethnicities	1		3.6%
Unavailable Information	0		0.0%
Minorities	2		18.2%

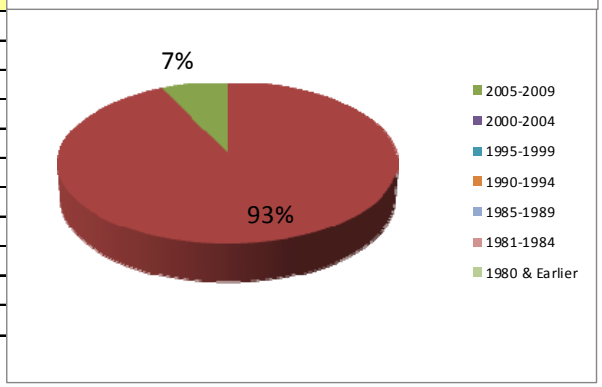


Citizenships	#		%
US Citizens & Perm. Residents	12		42.9%
Foreign	16		57.1%
Unavailable information	0		0.0%
# of Members	28		100.0%
US Citizens	11		39.3%
Perm Residents	1		3.6%
Home Inst. in US	17		60.71%



Year of Ph.D	#		%
2014 & Later	0		0.0%
2010-2013	26		92.9%
2005-2009	2		7.1%
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 Members	28		100.0%

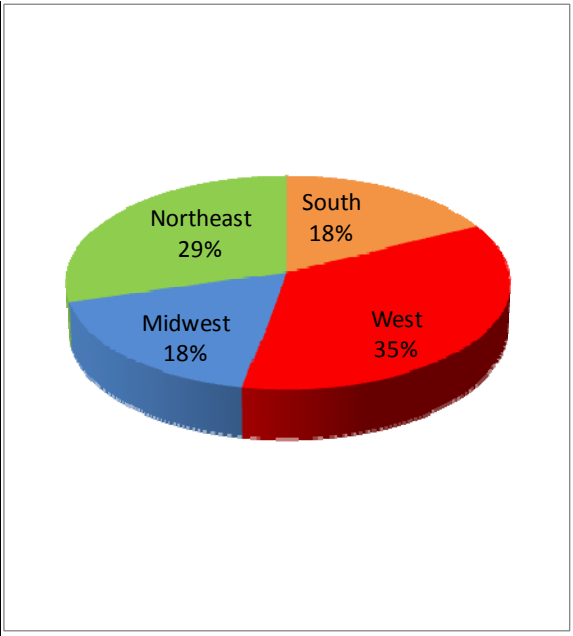
**Statistic Calculation based on all members who did not decline to state.*



2013–14 Postdoctoral Fellows Home Institution Classified by States

**Regions based on US Census classification*

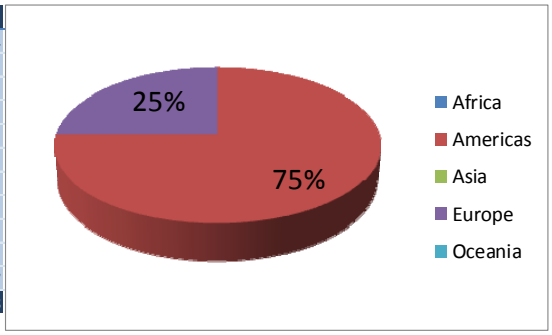
State	#	%	2007 Census Population
South	**3**	**17.6%**	**36.6%**
AL	-	0.0%	1.5%
AR	-	0.0%	0.9%
DE	-	0.0%	0.3%
DC	-	0.0%	0.2%
FL	1	5.9%	6.1%
GA	-	0.0%	3.2%
KY	-	0.0%	1.4%
LA	-	0.0%	1.4%
MD	1	5.9%	1.9%
MS	-	0.0%	1.0%
NC	-	0.0%	3.0%
OK	-	0.0%	1.2%
SC	-	0.0%	1.5%
TN	-	0.0%	2.0%
TX	1	5.9%	7.9%
VA	-	0.0%	2.6%
WV	-	0.0%	0.6%
West	**6**	**35.3%**	**23.2%**
AK	-	0.0%	0.2%
AZ	-	0.0%	2.1%
HI	-	0.0%	0.4%
ID	-	0.0%	0.5%
MT	1	5.9%	0.3%
CA	4	23.5%	12.1%
CO	-	0.0%	1.6%
NV	-	0.0%	0.9%
NM	-	0.0%	0.7%
OR	1	5.9%	1.2%
UT	-	0.0%	0.9%
WA	-	0.0%	2.1%
WY	-	0.0%	0.2%
Midwest	**3**	**17.6%**	**22.0%**
IL	2	11.8%	4.3%
IN	-	0.0%	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	5.9%	1.9%
Northeast	**5**	**29.4%**	**18.1%**
CT	1	5.9%	1.2%
ME	-	0.0%	0.4%
MA	3	17.6%	2.1%
NH	-	0.0%	0.4%
NJ	-	0.0%	2.9%
NY	-	0.0%	6.4%
PA	1	5.9%	4.1%
RI	-	0.0%	0.4%
VT	-	0.0%	0.2%
Other	**-**	**0.0%**	**0%**
PR	-	0.0%	0%
Other	-	0.0%	0%
Total	**17**	**100%**	**100%**



2013–14 Postdoctoral Fellows Home Institution Classified by Countries

**Regions based on United Nations classification*

Region	Area	Country	Total
Americas	**North America**	Canada	4
		United States	17
	North America Total		21
Americas Total			**21**
Europe	**Northern Europe**	Sweden	2
	Northern Europe Total		2
	Western Europe	France	2
		Germany	2
		Switzerland	1
	Western Europe Total		5
Europe Total			**7**
Grand Total			**28**



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
Freitag	James	Group I Public	Group I Public	University of California, Berkeley	University of California, Berkeley
Krieger	Holly	Group I Private	Group I Private	Massachusetts Institute of Technology	Massachusetts Institute of Technology
Malliaris	Maryanthe	Group I Private	Group I Private	University of Chicago	University of Chicago
Topaz	Adam	Group I Public	Group I Public	University of California, Berkeley	University of California, Berkeley
Beheshti	Shabnam	Group I Public	Group I Public	Rutgers University	Rutgers University
Dyatlov	Semyon	Group I Private	Group I Private	Massachusetts Institute of Technology	Massachusetts Institute of Technology
Ettinger	Boris	Group I Private	Group I Private	Princeton University	Princeton University
Ifrim	Mihaela	Foreign	Group I Public	McMaster University	University of California, Berkeley
Meier	Caleb	Group I Public	Group I Public	University of California, San Diego	University of California, San Diego
Yang	Shiwu	Foreign	Foreign	University of Cambridge	University of Cambridge
Lakzian	Sajjad	Foreign	Foreign	Universitat Bonn	Universitat Bonn
Pass	Brendan	Foreign	Foreign	University of Alberta	University of Alberta
Somersille	Stephanie	Group II	Group II	Dartmouth College	Dartmouth College
Wang	Yi	Group I Private	Group I Private	Stanford University	Stanford University
Xue	Jinxin	Group I Private	Group I Private	University of Chicago	University of Chicago
Hirsh	Joseph	Group I Private	Group I Private	Massachusetts Institute of Technology	Massachusetts Institute of Technology
Riehl	Emily	Group I Private	Group I Private	Harvard University	Harvard University

3.6 Postdoctoral Research Member Summary

Programs	# of Members	# of Citizens & Perm. Res.	%	# of Female	%	# of Minorities [1]	%	US Home Institution	%
Mathematical General Relativity	6	2	*33.3%*	2	*33.3%*	0	*0.0%*	4	66.7%
Optimal Transport: Geometry and Dynamics	5	1	*20.0%*	2	*40.0%*	1	*100.0%*	3	60.0%
Model Theory, Arithmetic Geometry and Number Theory	4	4	*100.0%*	2	*50.0%*	0	*0.0%*	4	100.0%
Algebraic Topology	2	2	*100.0%*	1	*50.0%*	0	*0.0%*	2	100.0%
Complementary Program 2013-14	0	0	*0.0%*	0	*0.0%*	0	*0.0%*	0	0.0%
Total # of Distinct Members	**17**	**9**	***52.9%***	**7**	***41.2%***	**1**	***11.1%***	**13**	***76.5%***

[1] *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 2013–14, 722 graduate students visited MSRI to participate in our workshops (505 graduate students), summer graduate schools (163 graduate students), and programs (54 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 six Summer Graduate Schools that took place during the 2013 summer. Altogether 52 lecturers and 163 graduate students participated in these workshops. Of those graduate students, 32% 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.

SGS 1: Algebraic Topology
June 17, 2013 - June 28, 2013
Organizers: Andrew Blumberg (University of Texas), Teena Gerhardt (Michigan State University), Michael Hill (University of Virginia)*

SGS 2: Seminaire de Mathem atiques Superieures 2013: Physics an d Mathematics of Lin k Homology
Location: Montreal, Canada
June 24, 2013 - July 05, 2013
Organizers: Sergei Gukov (California Institute of Technology), Mikhail Khovanov (Columbia University), Johannes Walcher (McGill University)

SGS 3: IAS/PCMI Summer 2013: Geometric Analysis
June 30, 2013 - July 20, 2013
Location: Park City, Utah
Organizers: Hubert Bray (Duke University), Greg Galloway (University of Miami), Rafe Mazzeo (Stanford University), Natasa Sesum (Rutgers University)

SGS 4: New Geometric Techniques in Number Theory
July 01, 2013 - July 12, 2013
Organizers: Toby Gee (Imperial College, London), Ariane Mezard (Institut de Mathématiques de Jussieu), David Nadler (University of California, Berkeley), Peter Scholze (Universität Bonn)*

SGS 5: Introduction to the Mathematics of Seismic Imaging
July 29, 2013 - August 09, 2013
Organizers: Gunther Uhlmann (University of Washington)

SGS 6: Mathematical General Relativity in Cortona, Italy
July 29, 2013 - August 09, 2013
Organizers: Justin Corvino (Lafayette College), Pengzi Miao (University of Miami), Giorgio Patrizio (Istituto Nazionale di Alta Matematica "Francesco Severi" (INdAM))

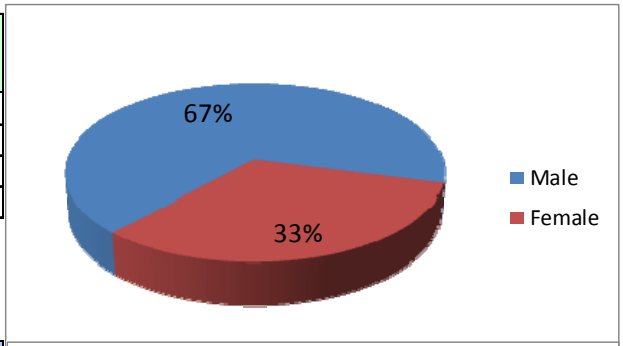
4.2 Summer Graduate School Data

Summer Graduate Schools	# of Participants	# of Citizens & Perm. Res.	%	# of Female	%	# of Minorities[1]	%	US Home Institution	%
Algebraic Topology	30	19	*63.3%*	13	*43.3%*	2	*10.5%*	25	83.3%
IAS/PCMI Summer 2013: Geometric Analysis	15	8	*53.3%*	3	*20.0%*	0	*0.0%*	15	100.0%
Introduction to the Mathematics of Seismic Imaging	39	11	*28.2%*	16	*41.0%*	1	*11.1%*	33	84.6%
Mathematical General Relativity in Cortona, Italy	8	7	*87.5%*	2	*25.0%*	0	*0.0%*	8	100.0%
New Geometric Techniques in Number Theory	50	22	*44.0%*	13	*26.0%*	2	*9.1%*	43	86.0%
Seminaire de Mathematiques Superieures 2013: Physics and Mathematics of	21	11	*52.4%*	5	*23.8%*	0	*0.0%*	20	95.2%
Total # of Distinct Participants	**163**	**78**	***47.9%***	**52**	***31.9%***	**5**	***6.8%***	**144**	***88.3%***

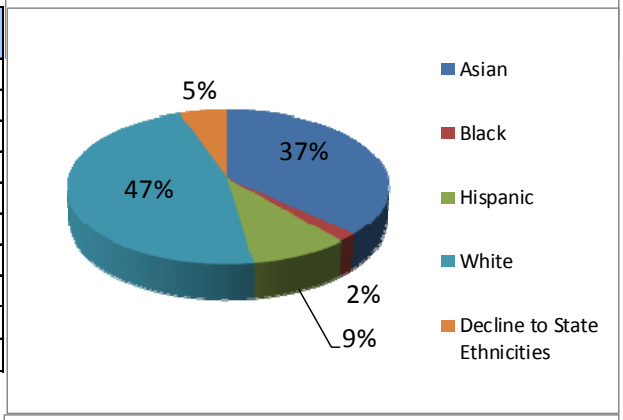
[1] *Minorities are US citizens who declare themselves American Indian, Black, Hispanic, or Pacific Islander. Minority percentage is calculated by dividing the number of Minorities by the total number of US citizens.*

2013–14 Summer Graduate Schools Demographic Summary

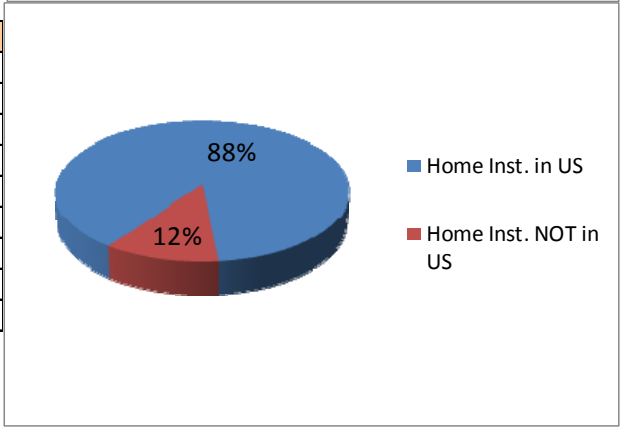
Gender	#	% (No Decl.)*	%
# of Distinct Participants	163		100.0%
Male	108	67.50%	66.3%
Female	52	32.50%	31.9%
Decline to State Gender	3		1.8%



Ethnicities	#	% (No Decl.)*	%
Native American	0	0.00%	0.0%
Asian	62	38.99%	36.9%
Black	3	1.89%	1.8%
Hispanic	15	9.43%	8.9%
Pacific	0	0.00%	0.0%
White	79	49.69%	47.0%
Decline to State Ethnicities	9		5.4%
Unavailable Information	0		0.0%
Minorities	5		6.8%



Citizenships	#		%
US Citizens & Perm. Residents	78		47.9%
Foreign	85		52.1%
Unavailable information	0		0.0%
# of Distinct Participants	163		100.0%
US Citizens	74		94.9%
Perm Residents	4		100.0%
Home Inst. in US	144		88.34%



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

Summer Graduate Schools

Algebraic Topology

IAS/PCMI Summer 2013: Geometric Analysis

Introduction to the Mathematics of Seismic Imaging

Mathematical General Relativity in Cortona, Italy

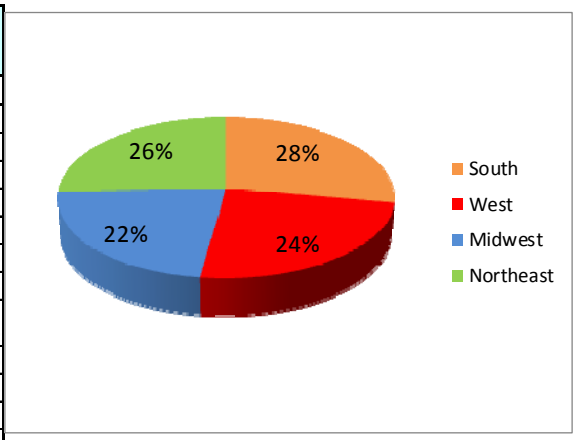
New Geometric Techniques in Number Theory

Seminaire de Mathematiques Superieures 2013: Physics and Mathematics of Link Homology

2013–14 Summer Graduate Schools Home Institution Classified by States

**Regions based on US Census classification*

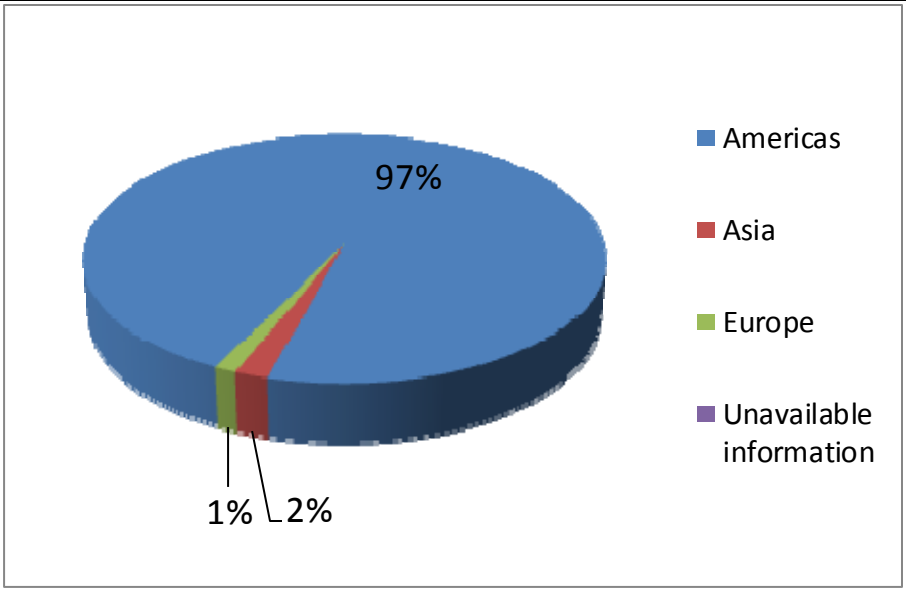
State	#	%	2007 Census Population
South	**40**	**27.8%**	**36.6%**
AL	-	0.0%	1.5%
AR	-	0.0%	0.9%
DE	2	1.4%	0.3%
DC	-	0.0%	0.2%
FL	-	0.0%	6.1%
GA	3	2.1%	3.2%
KY	1	0.7%	1.4%
LA	3	2.1%	1.4%
MD	5	3.5%	1.9%
MS	-	0.0%	1.0%
NC	5	3.5%	3.0%
OK	3	2.1%	1.2%
SC	-	0.0%	1.5%
TN	3	2.1%	2.0%
TX	11	7.6%	7.9%
VA	4	2.8%	2.6%
WV	-	0.0%	0.6%
West	**35**	**24.3%**	**23.2%**
AK	-	0.0%	0.2%
AZ	3	2.1%	2.1%
HI	-	0.0%	0.4%
ID	-	0.0%	0.5%
MT	-	0.0%	0.3%
CA	23	16.0%	12.1%
CO	2	1.4%	1.6%
NV	-	0.0%	0.9%
NM	-	0.0%	0.7%
OR	2	1.4%	1.2%
UT	2	1.4%	0.9%
WA	3	2.1%	2.1%
WY	-	0.0%	0.2%
Midwest	**32**	**22.2%**	**22.0%**
IL	9	6.3%	4.3%
IN	4	2.8%	2.1%
IA	3	2.1%	1.0%
KS	2	1.4%	0.9%
MI	6	4.2%	3.3%
MN	1	0.7%	1.7%
MO	1	0.7%	1.9%
ND	-	0.0%	0.2%
NE	2	1.4%	0.6%
OH	2	1.4%	3.8%
SD	-	0.0%	0.3%
WI	2	1.4%	1.9%
Northeast	**37**	**25.7%**	**18.1%**
CT	2	1.4%	1.2%
ME	-	0.0%	0.4%
MA	14	9.7%	2.1%
NH	2	1.4%	0.4%
NJ	6	4.2%	2.9%
NY	7	4.9%	6.4%
PA	5	3.5%	4.1%
RI	1	0.7%	0.4%
VT	-	0.0%	0.2%
Other	**-**	**0.0%**	**0%**
PR	-	0.0%	0%
Other	-	0.0%	0%
Total	**144**	**100%**	**100%**



2013–14 Summer Graduate Schools Home Institution Classified by Countries

**Regions based on United Nations classification*

Americas			**158**
	Central America	Mexico	3
	North America	Canada	9
		United States	144
	South America	Colombia	2
Asia			**3**
	East Asia	Korea, Republic of	3
Europe			**2**
	Northern Europe	Great Britain	1
	Western Europe	France	1
Unavailable information			0
Grand Total			**163**



4.3 Program Associates

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 54 graduate students who resided at MSRI for an extended period of time during the academic year 2013–14. See the table in section 4.4 for a detailed description of the demographic data.

4.4 Program Associates Data

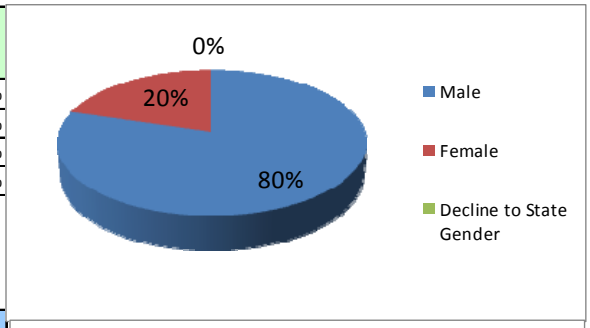
Programs	# of Members	# of Citizens & Perm. Res.	%	# of Female	%	# of Minorities [1]	%	US Home Institution	%
Mathematical General Relativity	12	2	*16.7%*	3	*25.0%*	0	*0.0%*	4	33.3%
Optimal Transport: Geometry and Dynamics	9	1	*11.1%*	2	*22.2%*	0	*0.0%*	1	11.1%
Model Theory, Arithmetic Geometry and Number Theory	16	3	*18.8%*	5	*31.3%*	1	*33.3%*	4	25.0%
Algebraic Topology	17	5	*29.4%*	1	*5.9%*	0	*0.0%*	9	52.9%
Complementary Program 2013-14	0	0	*0.0%*	0	*0.0%*	0	*0.0%*	0	0.0%
Total # of Distinct Program Associates	**54**	**11**	***20.4%***	**11**	***20.4%***	**1**	***9.1%***	**18**	***33.3%***

[1] *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 citizer*

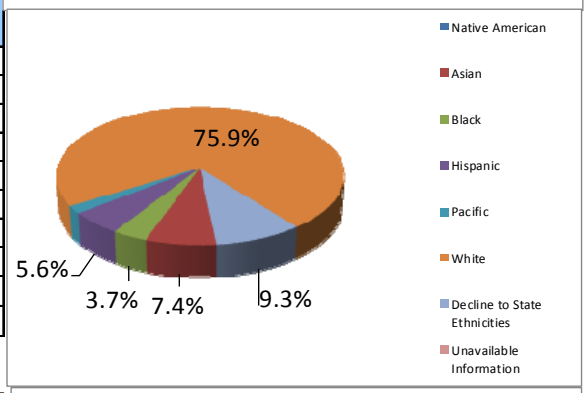
2013–14 Program Associates Demographic Summary

Gender	#	% (No Decl.)*	%
# of Program Associates	54		100.0%
Male	43	79.63%	79.6%
Female	11	20.37%	20.4%
Decline to State Gender	0		0.0%

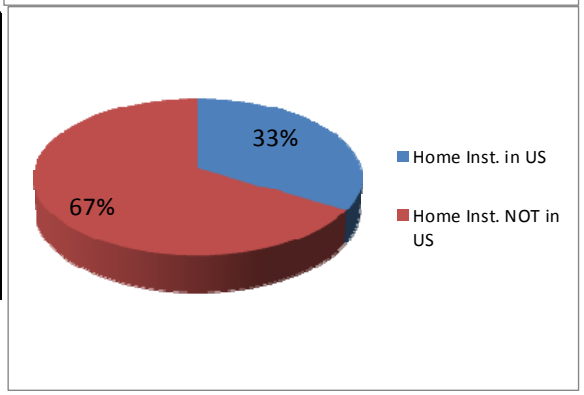
Program Associates are distinct within each academic year.



Ethnicities	#	% (No Decl.)*	%
Native American	0	0.00%	0.0%
Asian	4	7.84%	7.4%
Black	2	3.92%	3.7%
Hispanic	3	5.88%	5.6%
Pacific	1	1.96%	1.9%
White	41	80.39%	75.9%
Decline to State Ethnicities	5		9.3%
Unavailable Information	0		0.0%
Minorities	1		9.1%



Citizenships	#		%
US Citizens & Perm. Residents	11		20.4%
Foreign	43		79.6%
Unavailable information	0		0.0%
# of Program Associates	54		100.0%
US Citizens	11		20.4%
Perm Residents	0		0.0%
Home Inst. in US	18		33.33%

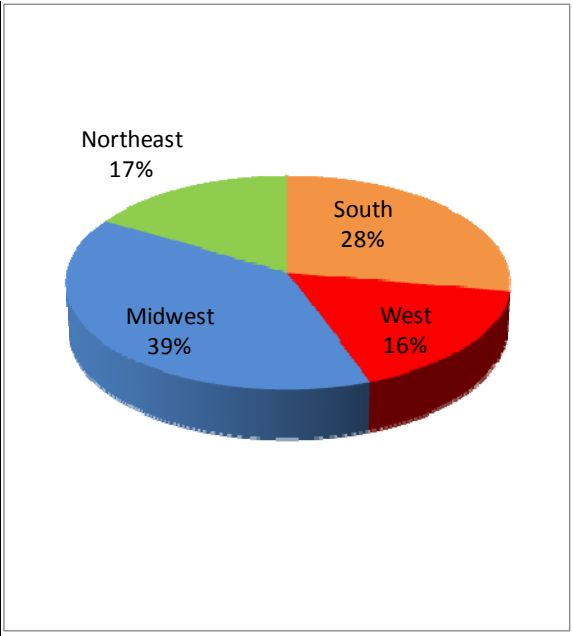


Programs:
Model Theory, Arithmetic Geometry and Number Theory
Mathematical General Relativity
Optimal Transport: Geometry and Dynamics
Algebraic Topology
Complementary Program 2013-14

2013–14 Program Program Associates Home Institution Classified by States

**Regions based on US Census classification*

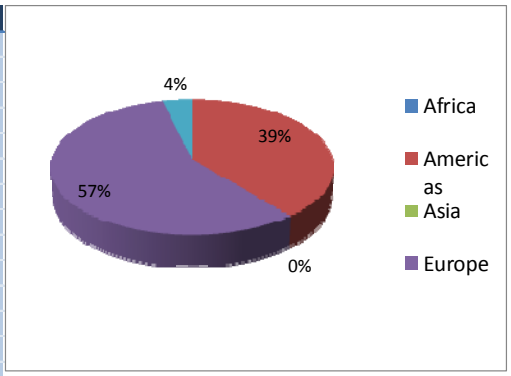
State	#	%	2007 Census Population
South	**5**	**27.8%**	**36.6%**
AL	-	0.0%	1.5%
AR	-	0.0%	0.9%
DE	-	0.0%	0.3%
DC	-	0.0%	0.2%
FL	-	0.0%	6.1%
GA	1	5.6%	3.2%
KY	-	0.0%	1.4%
LA	-	0.0%	1.4%
MD	-	0.0%	1.9%
MS	-	0.0%	1.0%
NC	-	0.0%	3.0%
OK	-	0.0%	1.2%
SC	-	0.0%	1.5%
TN	-	0.0%	2.0%
TX	3	16.7%	7.9%
VA	1	5.6%	2.6%
WV	-	0.0%	0.6%
West	**3**	**16.7%**	**23.2%**
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	1	5.6%	12.1%
CO	-	0.0%	1.6%
NV	-	0.0%	0.9%
NM	-	0.0%	0.7%
OR	2	11.1%	1.2%
UT	-	0.0%	0.9%
WA	-	0.0%	2.1%
WY	-	0.0%	0.2%
Midwest	**7**	**38.9%**	**22.0%**
IL	4	22.2%	4.3%
IN	3	16.7%	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	-	0.0%	1.9%
Northeast	**3**	**16.7%**	**18.1%**
CT	-	0.0%	1.2%
ME	-	0.0%	0.4%
MA	2	11.1%	2.1%
NH	-	0.0%	0.4%
NJ	-	0.0%	2.9%
NY	1	5.6%	6.4%
PA	-	0.0%	4.1%
RI	-	0.0%	0.4%
VT	-	0.0%	0.2%
Other	**-**	**0.0%**	**0%**
PR	-	0.0%	0%
Other	-	0.0%	0%
Total	**18**	**100%**	**100%**



2013–14 Program Associates Home Institution Classified by Countries

**Regions based on United Nations classification*

Region	Area	Country	Total
Americas	**North America**	Canada	3
		United States	18
	North America Total		21
Americas Total			**21**
Europe	**Northern Europe**	Denmark	2
		England	5
		Norway	1
		Sweden	1
	Northern Europe Total		9
	Southern Europe	Italy	2
	Southern Europe Total		2
	Western Europe	Austria	1
		Belgium	1
		France	10
		Germany	6
		Switzerland	2
	Western Europe Total		20
Europe Total			**31**
Oceania	**Australia and New Zealand**	Australia	2
	Australia and New Zealand Total		2
Oceania Total			**2**
Grand Total			**54**



4.5 Graduate Student List

(Participants who attended 2013–14 workshops, excluding Summer Graduate Schools)
(See e-mail attached file)

4.6 Graduate Student Data

(Participants who attended 2013–14 workshops, excluding Summer Graduate Schools)

Workshops	# of Participants	# of Citizens & Perm. Res.	%	# of Female	%	# of Minorities[1]	%	US Home Institution	%
13 Scientific Workshops									
Connections for Women on Optimal Transport: Geometry and Dynamics	14	4	*28.6%*	8	*57.1%*	1	*33.3%*	8	57.1%
Connections for Women: Algebraic Topology	40	20	*50.0%*	27	*67.5%*	3	*15.0%*	29	72.5%
Connections for Women: Mathematical General Relativity	8	2	*25.0%*	4	*50.0%*	0	*0.0%*	5	62.5%
Connections for Women: Model Theory and Its Interactions with Number Theory and Arithmetic Geometry	26	7	*26.9%*	13	*50.0%*	1	*14.3%*	13	50.0%
Fluid Mechanics, Hamiltonian Dynamics, and Numerical Aspects of Optimal Transportation	15	5	*33.3%*	3	*20.0%*	0	*0.0%*	5	33.3%
Hot Topics: Perfectoid Spaces and their Applications	76	31	*40.8%*	12	*15.8%*	0	*0.0%*	57	75.0%
Initial Data and Evolution Problems in General Relativity	33	9	*27.3%*	4	*12.1%*	0	*0.0%*	15	45.5%
Introductory Workshop on Optimal Transport: Geometry and Dynamics	33	9	*27.3%*	9	*27.3%*	2	*25.0%*	22	66.7%
Introductory Workshop: Algebraic Topology	81	46	*56.8%*	20	*24.7%*	4	*8.7%*	62	76.5%
Introductory Workshop: Mathematical Relativity	21	8	*38.1%*	4	*19.0%*	0	*0.0%*	13	61.9%
Introductory Workshop: Model Theory, Arithmetic Geometry and Number Theory	59	17	*28.8%*	14	*23.7%*	3	*17.6%*	29	49.2%
Model Theory in Geometry and Arithmetic	37	15	*40.5%*	9	*24.3%*	3	*20.0%*	20	54.1%
Reimagining the Foundations of Algebraic Topology	50	24	*48.0%*	11	*22.0%*	2	*8.3%*	37	74.0%
All 13 Workshops Total	**493**	**197**	***40.0%***	**138**	***28.0%***	**19**	***10.1%***	**315**	***63.9%***
1 Education & Outreach Workshops									
Critical Issues in Mathematics Education 2014: The role of the mathematics department in the mathematica	12	10	*83.3%*	6	*50.0%*	1	*10.0%*	11	91.7%
All Education & Outreach Workshop Total	**12**	**10**	***83.3%***	**6**	***50.0%***	**1**	***10.0%***	**11**	***91.7%***
All 14 Workshops Total	**505**	**207**	***41.0%***	**144**	***28.5%***	**20**	***10.1%***	**326**	***64.6%***

[1] *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 (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, thus there is no report attached in Section 12-Appendix.

Research Topic: Algebraic Combinatorics
Date: June 15, 2013 - July 28, 2013
Organizers: 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)

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. 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.

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

- participate in the mathematics research program under the direction of Dr. Rosa Orellana, Dartmouth College, a post-doc and two graduate students
- 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

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.

Algebraic combinatorics is an area of mathematics that studies objects that have combinatorial and algebraic properties. An example of such object is the ring of symmetric functions. In algebraic combinatorics, we use algebraic methods to answer combinatorial questions, and conversely, apply combinatorial techniques to problems in algebra.

Let $x_1, \ldots, x_n$ be commuting variables, a polynomial $f(x_1, \ldots, x_n)$ is *symmetric* if $f(x_{\sigma_1}, \ldots, x_{\sigma_n}) = f(x_1, \ldots, x_n)$ for all permutations σ. The space of all symmetric polynomials forms a ring, $\Gamma(x_1, \ldots, x_n)$. This simply says that if we multiply two symmetric functions we get another symmetric function. $\Gamma(x_1, \ldots, x_n)$ has several distinguished bases that are indexed by partitions. One of the most important bases is Schur's basis: $\{s_\lambda \mid \lambda \text{ is a partition}\}$. The objective of the summer is to learn about and work on open problems involving symmetric polynomials.

The academic and research portion of the 2013 MSRI-UP will be led by Prof. Rosa Orellana from Dartmouth College.

Short Biographies of the 2013 MSRI-UP organizers:

Ivelisse M. Rubio was born and raised in Puerto Rico. She received her B.S. and M.S. in Mathematics from the University of Puerto Rico-Río Piedras and her Ph.D. in Applied Mathematics from Cornell University. In 1998, she co-founded the NSF-REU Summer Institute in Mathematics for Undergraduates (SIMU) at the UPR-Humacao. Ive is currently a Professor in the Computer Science Department at the UPR-Rio Piedras. Her research interests are finite fields and applications to error-correcting codes.

Duane Cooper was raised in Atlanta, Georgia, where he remained for college, receiving his BS in mathematics from Morehouse College and his MS in electrical engineering from Georgia Tech in 1983. He received the PhD in Applied Mathematics from the University of California, Berkeley, in 1993. He is an Associate Professor of Mathematics at Morehouse College. It was during his graduate years that he found his calling in education, the result of a variety of experiences teaching elementary, high school, and college students. Thus, he sought and received a postdoctoral appointment in both the Center for Mathematics Education and the Department of Mathematics at the University of Maryland, where he served for several years on the faculty before returning to Morehouse in 2002. His current research interests are in the mathematics of voting and representation, with particular interests in election procedures that allow for fair representation. In addition, he has experience and maintains interest in mathematics student and teacher development.

Ricardo Cortez is a Professor in the Mathematics Department and Director of the Center for Computational Science at Tulane University in New Orleans. He received BS degrees in mathematics (1986) and mechanical engineering (1988) from Arizona State University and his PhD degree in applied mathematics from the University of California, Berkeley in 1995. Ricardo's research is in computational fluid dynamics and numerical analysis.

Ricardo serves on the Editorial Board of the American Mathematical Monthly, was co-Chair of the SIAM annual meeting in 2006, and has co-organized several mathematics conferences in the USA and abroad. Since 1990, Ricardo has been active in efforts to increase the number of

underrepresented groups in mathematics. He is a member of the Society for Advancement of Chicanos and Native Americans in Science (SACNAS), where he organizes events for its annual conference and has organized several Diversity Workshops at the SIAM conferences. Ricardo has served since 2004 on MSRI's Human Resources Advisory Committee (HRAC) and became the HRAC Chair in 2007 and Co-Chair in 2009.

Herbert A. Medina is a Professor of Mathematics at Loyola Marymount University. He completed his undergraduate studies at UCLA and Ph.D. at UC Berkeley. He is an analyst and has done work in Hilbert space operators (of a certain type) and some theoretical aspects of wavelets. He has also dabbled in other elementary math topics. Professor Medina has been involved in many undergraduate summer programs, including five summers as co-director of an REU at the University of Puerto Rico-Humacao.

Suzanne Weekes is the Associate Professor and Associate Head of the Department of Mathematical Sciences at Worcester Polytechnic Institute (WPI) in Massachusetts. She received her PhD in Mathematics and Scientific Computing from the University of Michigan. At WPI, she is also the Director of the Center for Industrial Mathematics and Statistics CIMS. Prof. Weekes has been senior personnel, co-PI, or PI in the NSF-funded REU Program in Industrial Mathematics and Statistics at WPI for the last 11 years DMS 0097469, DMS 0353816, DMS 0649127, and DMS 1004795. In this program, mathematics undergraduates do research on problems that come straight from the various sectors of industry, and are of direct importance to the industrial partners and impact research and development at these companies. Her research interests are in numerical methods for PDES, spatio-temporal composites, fluid flow, and industrial mathematics and modeling.

5.2 MSRI-UP Data

Participants List

Family Name	First Name	Home Institution
Arrua	Alicia	California State Polytechnic University
Burnley	Alexandria	University of Illinois at Urbana-Champaign
Castro	Francis	Massachusetts Institute of Technology
Contreras	Ryan	Columbia University
Corona	Isabel	Metropolitan State University of Denver
Emidih	Jeremiah	University of California, Riverside
Gonzales	Damien	University of California, Berkeley
Green	Arman	Morehouse College
Jansen	Nadine	North Carolina Agricultural and Technical State University
Melendez	Gustavo	University of Puerto Rico, Rio Piedras
Meza	Jeremy	Carnegie Mellon University
Pastrana	Jose	University of Puerto Rico, Rio Piedras
Richburg	Aquia	Morehouse College
Sarmiento	Matt	Columbia University

Stanley Caprice		George Washington University
Taylor Lynesia		Spelman College
Thiry	Simone	University of Maine at Farmington
Zevallos Rita		Swarthmore College

11. Brief Report

OVERVIEW OF ACTIVITIES 2014–15

1.1 Major Programs and their Associated Workshops

Note: The description of each activity is provided to MSRI by the organizers prior to the beginning of each activity; therefore, the verbs are in future tense. In the list of organizers of each activity, 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)*

The branches of number theory most directly related to the arithmetic of automorphic forms have seen much recent progress, with the resolution of many longstanding conjectures. These breakthroughs have largely been achieved by the discovery of new geometric techniques and insights. The goal of this program is to highlight new geometric structures and new questions of a geometric nature which seem most crucial for further development. In particular, the program will emphasize geometric questions arising in the study of Shimura varieties, the p-adic Langlands program, and periods of automorphic forms.

Workshops associated with the New Geometric Methods in Number Theory and Automorphic Forms:

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)*

This 2-day workshop will showcase 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 will bring together women who are working in these areas in all stages of their careers, featuring lectures by both established leaders and emerging researchers. In addition, there will be a poster session open to all participants and an informal panel discussion on career issues.

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)*
The goal of this workshop is to give a practical introduction to some of the main topics and techniques related to the August-December 2014 MSRI program, "New geometric methods in number theory and automorphic forms." The workshop is aimed at graduate students and interested researchers in number theory or related fields.

There will be 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.

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)*

L-functions attached to Galois representations coming from algebraic geometry contain subtle arithmetic information (conjectures of Birch and Swinnerton-Dyer, Deligne, Beilinson, Bloch and Kato, Fontaine and Perrin-Riou). Langlands has predicted the existence of a correspondence relating these L-functions to L-functions of automorphic forms which are much better understood. The workshop will focus on recent developments related to 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.

It will be dedicated to Michael Harris as a tribute to his enormous influence on the themes of the workshop.

Organized in partnership with Clay Mathematics Institute. Additional funding provided by ArShiFo and the European Research Council under the European Community's Seventh Framework Programme (FP7/2007-2013) / ERC Grant agreement n¬° 290766 (AAMOT).

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)*

Representation theory is the study of the basic symmetries of mathematics and physics. Symmetry groups come in many different flavors: finite groups, Lie groups, p-adic groups, loop groups, adelic groups,.. A striking feature of representation theory is the persistence of fundamental structures and unifying themes throughout this great diversity of settings. One such theme is the Langlands philosophy, a vast nonabelian generalization of the Fourier transform of classical harmonic analysis, which serves as a visionary roadmap for the subject and places it at the heart of number theory.

The fundamental aims of geometric representation theory are to uncover the deeper geometric and categorical structures underlying the familiar objects of representation theory and harmonic analysis, and to apply the resulting insights to the resolution of classical problems. A groundbreaking example of its success is Beilinson-Bernstein's generalization of the Borel-Weil-Bott theorem, giving a uniform construction of all representations of Lie groups via the geometric study of differential equations on flag varieties.

The geometric study of representations often reveals deeper layers of structure in the form of categorification. Categorification typically replaces numbers (such as character values) by vector spaces (typically cohomology groups), and vector spaces (such as representation rings) by categories (typically of sheaves). It is a primary explanation for miraculous integrality and positivity properties in algebraic combinatorics. A recent triumph of geometric methods is Ngô's proof of the Fundamental Lemma, a key technical ingredient in the Langlands program. The proof relies on the cohomological interpretation of orbital integrals, which makes available the deep topological tools of algebraic geometry (such as Hodge theory and the Weil conjectures).

A primary goal of the MSRI program is to explore the potential impact of geometric methods and ideas in the Langlands program by bringing together researchers working in the diverse areas impacted by the Langlands philosophy, with a particular emphasis on representation theory over local fields. More generally, participants in the program will seek to explore new principles and paradigms within geometric representation theory. A major source of inspiration comes from theoretical physics, where new perspectives on the central objects of geometric representation theory arise in the study supersymmetric gauge theory, integrable systems and topological string theory. The impact of these ideas is only beginning to be absorbed and the program will provide a forum for their dissemination and development.

Workshops associated with the Geometric Representation Theory:

Workshop 1: Connections for Women: Geometric Representation Theory
August 28, 2014 - August 29, 2014
**Monica Vazirani (University of California, Davis), Eva Viehmann (TU München)*

Within the broad range of geometric representation theory the Connections Workshop will focus on three research topics in which we expect particularly striking new developments within the next few years:

* Categorical and geometric structures in representation theory and Lie superalgebras
* Geometric construction of representations via Shimura varieties and related moduli spaces
* Hall algebras and representations

The workshop will bring together researchers from these different topics within geometric representation theory and will thus facilitate a successful start of the semester program. It will give junior researchers from each of these parts of geometric representation theory a broader picture of possible applications and of new developments, and will establish a closer contact between junior and senior researchers.

This workshop is aimed at encouraging and increasing the active participation of women and members of under-represented groups in the MSRI program.

All are welcome to participate in the scientific portions of the workshop and the panel discussion, regardless of gender.

Workshop 2: Introductory Workshop: Geometric Representation Theory
September 02, 2014 - September 05, 2014
**David Ben-Zvi (University of Texas), Kevin McGerty (University of Oxford)*

Geometric Representation Theory is a very active field, at the center of recent advances in Number Theory and Theoretical Physics. The principal goal of the Introductory Workshop will be to provide a gateway for graduate students and new post-docs to the rich and exciting, but potentially daunting, world of geometric representation theory. The aim is to explore some of the fundamental tools and ideas needed to work in the subject, helping build a cohort of young researchers versed in the geometric and physical sides of the Langlands philosophy.

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)*

The workshop will focus on the role of categorical structures in number theory and harmonic analysis, with an emphasis on the setting of the Langlands program. Celebrated examples of this theme range from Lusztig's character sheaves to Ngo's proof of the Fundamental Lemma. The workshop will be a forum for researchers from a diverse collection of fields to compare problems and strategies for solutions.

Organized in partnership with Clay Mathematics Institute.

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)*

Our program will focus on the deformation theory of geometric structures on manifolds, and the resulting geometry and dynamics. 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.

Hyperbolic structures on surfaces provide the first nontrivial examples, and the classical Teichmuller 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.

Teichmuller space can be realized as subset of the space of representations of a surface group into PSL(2,R). What has recently been called "higher Teichmuller theory" by Fock and Goncharov concerns certain deformation spaces arising from subsets of the space of representations of a surface groups into Lie groups of higher rank, e.g.PSL(n,R), which share some of the properties of classical Teichmuller space.

Recent interest in this subject has also come from mathematical physics, through Witten's suggestion relating representations in the Hitchin components, which furnish examples of higher Teichmuller spaces, to W_n-algebras, and applications of Hitchin representations to the geometric Langlands program. These unexpected inter-relationships underscore this subject's richness, timeliness and diversity. A central goal of the program will be to bring together researchers who work in the more fully developed areas of Teichmuller geometry and deformation spaces of hyperbolic structures in low dimensions with researchers studying more general deformation spaces in order to explore these new connections.

Workshops associated with the Dynamics on Moduli Spaces of Geometric Structures Program:

Workshop 1: Connections for Women: Dy namics 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)*
This two-day workshop will consist of various talks given by prominent female mathematicians in the field. These will be appropriate for graduate students, post-docs, and researchers in areas related to the program. The workshop will also include a professional development session.

This workshop is open to all mathematicians.

Workshop 2: Introductory Workshop: Dyna mics 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)*

The deformation theory of geometric structures on manifolds is 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.

The introductory workshop will serve as an overview to the program. It aims to familiarize graduate students, post-docs, and other researchers to the major topics of the program. There will be a number of short courses.

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)*

The Research Workshop of the "Dynamics on moduli spaces of geometric structures" will concentrate on some of the following general interrelated themes:

(1) Geometric structures on the spaces of geometric structures which extend and generalize classical constructions on Teichmüller spaces, such as the Weil-Petersoon metric, the pressure metric, the Teichmüller metric and its geodesic flow, Fenchel-Nielsen coordinates, Fock-Goncharov Thurson-Penner coordinates, and the symplectic and Poisson geometries

(2) Relations with harmonic maps, Riemann surfaces, complex geometry: specifically Higgs bundles, holomorphic differentials (quadratic, cubic, etc.) as parameters for representations of the fundamental group, hyperkähler and complex symplectic geometry of moduli spaces, lifts of Teichmüller geodesic flows to flat bundles of character varieties

(3) Asymptotic properties of higher Teichmüller spaces, including generalized measured geodesic laminations, Culler-Morgan-Shalen asymptotics of character varieties, degenerations of geometric structures and discrete subgroups

(4) Actions of mapping class groups and outer automorphism groups, properness criteria for Anosov representations and their generalizations, properness criteria for non-discrete representations, chaotic actions of mapping class groups and the monodromy map from structures to representations

(5) Classification of exotic geometric structures, tameness criteria, generalizations of ending lamination-type invariants to higher rank structures, rigidity and flexibility for thin subgroups, arithmeticity conditions, and geometric transitions.

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)*

Homogeneous dynamics is the study of asymptotic properties of the action of subgroups of Lie groups on their homogeneous spaces. This includes many classical examples of dynamical systems, such as linear Anosov diffeomorphisms of tori and geodesic flows on negatively curved manifolds. This topic is related to many branches of mathematics, in particular, number theory and geometry. Some directions to be explored in this program include: measure rigidity of multidimensional diagonal groups; effectivization, sparse equidistribution and sieving; random walks, stationary measures and stiff actions; ergodic theory of thin groups; measure classification in positive characteristic. It is a companion program to "Dynamics on moduli spaces of geometric structures".

Workshop 1: Conne ctions for Women: Ge ometric a nd Arithmetic Aspects of Homogeneous Dynamics
January 29, 2015 - January 30, 2015
*Elon Lindenstrauss (Hebrew University), *Hee Oh (Yale University)*

This workshop will consist of several mini-courses given by prominent female mathematicians in the field, intended for graduate students, post-docs, and researchers in areas related to the program. The workshop will also include an informal panel discussion session among female researchers on career issues. This workshop is open to all mathematicians.

Workshop 2: Introd uctory Workshop: Geometric a nd 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))*

This Introductory Workshop will consist of several introductory lectures and series of lectures on the recent trends in the field, given by experts in the domain. In addition, there will be several shorter talks by young researchers.

Please note that immediately preceding this workshop there is a Connections for Women workshop which will also be introductory in nature.

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)

The Advances in Homogeneous Dynamics workshop will feature the speakers whose work is at the forefront of the field. There will be a panel discussion accompanied by an open problem session to lay out possible directions for the research in homogeneous dynamics. Talks will be in a broad range of topics and this will help to build more connections between researchers interested in dynamical systems, number theory and geometry. For example we hope that the involvement of the participants of the other program held at MSRI during the same academic year (Dynamics on Moduli Spaces of Geometric Structures, Spring 2015) would create new connections between the topics. There will be shorter talks presented by early-career researchers.

Program 5: Complementary Program (2014–15)
August 11, 2014 to May 29, 2015

MSRI had a small Complementary Program comprised of twelve researchers, David Ben-Zvi (University of Texas), Valerio Capraro (University of Southampton), Indira Chatterji (Universite d'Orleans), Hailong Dao (University of Kansas), 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 Sarrlandes), Volkmar Welker (Universitaet Marburg and Gufang Zhao (Northeastern University).

1.2 Scientific Activities Directed at Underrepresented Groups in Mathematics

Undergraduate Program: MSRI-UP 2014: Ar ithmetic 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)*

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. 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.

The academic and research portion of the 2014 MSRI-UP will be led by Prof. Victor Moll from Tulane University.

The question of evaluation of finite sums with entries in a reasonable largeclass (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 n2+1 and n2+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,±1} satisfying an ordering condition and many other coming from Combinatorics. Recent symbolic experiments include sequences such as the harmonic numbers Hn=1+12+⋯+1n 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.

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

- participate in the mathematics research program under the direction of Dr. Victor Moll, Tulane University, a post-doc and two graduate students
- 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

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)

As part of the Mathematical Sciences Collaborative Diversity Initiatives, nine mathematics institutes (including ICERM) are pleased to host their annual pre-conference event, the 2013 Modern Math Workshop. This event precedes the SACNAS National Conference. If you are also attending the SACNAS National Conference then you must also register separately with SACNAS online.

The Modern Math Workshop is intended to re-invigorate the focus of mathematics students and faculty at minority-serving institutions and the research careers of minority mathematicians.

A report of this event will be submitted to the NSF by 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

IPAM is honored to host the 2014 Blackwell-Tapia Conference and Awards Ceremony. The conference and prize honors David Blackwell and Richard Tapia (who won the National Medal of Science in 2010), two seminal figures who inspired a generation of African-American, Native American and Latino/Latina students to pursue careers in mathematics. This will be the eighth conference since 2000, held every other year.

The conference will offer a mix of activities including scientific talks, poster presentations, panel discussions, ample opportunities for discussion and interaction, and the awarding of the Blackwell-Tapia Prize. Participants will come from all career stages and will represent institutions of all sizes across the country, including Puerto Rico.

The goals of the conference are:

Recognize and showcase mathematical excellence by minority researchers
Recognize and disseminate successful efforts to address under-representation
Inform students and mathematicians about career opportunities in mathematics, especially outside academia
Provide networking opportunities for mathematical researchers at all points in the higher education/career trajectory

The Blackwell-Tapia Prize recognizes a mathematician who has contributed significantly to research in his or her area of expertise, and who has served as a role model for mathematical scientists and students from underrepresented minority groups, or has contributed in other significant ways to addressing the program of underrepresentation of minorities in math.

The National Blackwell-Tapia Committee has selected Jacqueline M. Hughes-Oliver to receive the 2014 Blackwell-Tapia Prize. Hughes-Oliver has been a professor of statistics at North Carolina State University since 1992. She is visiting George Mason University until May 2014. She has made important contributions in a number of statistical research areas including methodological research on prediction and classification, variable and model selection with dimension reduction, design of experiments, and spatial modeling. She has worked passionately on the cause of increasing diversity of individuals working of the statistical and mathematical sciences. Read the press release.

Organizing Committee
Ricardo Cortez (Tulane University)
Monica Jackson (American University, Mathematics and Statistics)
Trachette Jackson (University of Michigan, Dept of Mathematics)
Herbert Medina (Loyola Marymount University, Mathematics)

A report of this event will be submitted to the NSF 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

The Infinite Possibilities Conference 2015 (IPC) will be held at Oregon State University (OSU) on March 2-3, 2015. IPC is a national conference designed to promote, educate, encourage and support minority women interested in mathematics and statistics. IPC 2015 is co-hosted by Building Diversity in Science and OSU.
IPC 2015 and the NSF-sponsored Mathematical Biological Institute will also offer a Short Course on Biostatistics for IPC participants on Sunday March 1, 2015.

The Dr. Etta Z. Falconer Awards Banquet will be held on Tuesday evening, March 3, 2014.

A report of this event will be submitted to the NSF by MBI.

1.3 Summer Graduate Schools 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)

The purpose of the workshop is to introduce graduate students to the recent developments in the area of dispersive partial differential equations (PDE).

Dispersive equations have received a great deal of attention from mathematicians because of their applications to nonlinear optics, water wave theory and plasma physics. We will outline the basic tools of the theory that were developed with the help of multi-linear Harmonic Analysis techniques. The exposition will be as self-contained as possible.

SGS 2: Seminaire de Mathematiques Superieures 20 14: 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)

In the past decade tremendous progress has been achieved on certain key problems involving counting objects of arithmetic interest, such as number fields (or étale algebras) of given degree, naturally ordered by the size of their discriminants, as well as 2 or 3-torsion elements in Selmer groups of elliptic curves. This progress, which blends elegant algebraic techniques with brilliant and powerful analytic ideas, has led, most recently, to striking upper bounds on the size of Selmer groups (and therefore ranks) of elliptic curves and even Jacobians of hyperelliptic curves of higher genus. The goal of this summer school will be to take stock of the recent breakthroughs and bring young researchers to the forefront of research in this exciting and fast-evolving area.

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)

The program in 2014 will bring together a diverse group of mathematicians and scientists with interests in fundamental questions in mathematics and the behavior of materials. The meeting addresses several themes including computational investigations of material properties, the emergence of long- range order in materials and self-assembly, the geometry of soft condensed matter and the calculus of variations, phase transitions and

statistical mechanics. The program will cover several topics in discrete and differential geometry that are motivated by questions in materials science. Many central topics, such as the geometry of packings, problems in the calculus of variations and phase transitions, will be discussed from the complementary points of view of mathematicians and physicists.

SGS 4: Algebraic Topology
June 30, 2014 - July 11, 2014
*Organizers: *Jose Cantarero-Lopez (Centro de Investigación en Matemáticas), Michael Hill (University of Virginia)*

Modern algebraic topology is a broad and vibrant field which has seen recent progress on classical problems as well as exciting new interactions with applied mathematics. This summer school will consist of a series of lecture by experts on major research directions, including several lectures on applied algebraic topology. Participants will also have the opportunity to have guided interaction with the seminal texts in the field, reading and speaking about the foundational papers.

SGS 5: Stochastic Partial Differential Equations
July 07, 2014 - July 18, 2014
Organizers: Yuri Bakhtin (New York University, Courant Institute), LEAD 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 is to educate graduate students on the state-of-the-art methods and results in SPDEs. The three courses which will be run simultaneously will highlight different (though related) aspects of this area including (1) Fluctuation theory of PDEs with random coefficients (2) Ergodic theory of SPDEs and (3) Exact solvability of SPDEs.

SGS 6: Geometry and Analysis
July 28, 2014 - August 08, 2014
Organizers: Hans-Joachim Hein (Imperial College, London), LEAD Aaron Naber (Massachusetts Institute of Technology)

Geometric and complex analysis is the application of tools from analysis to study questions from geometry and topology. This two week summer course will provide graduate students with the necessary background to begin studies in the area. The first week will consist of introductory courses on geometric analysis, complex analysis, and Riemann surfaces. The second week will consist of more advanced courses on the

regularity theory of Einstein manifolds, Kahler-Einstein manifolds, and the analysis of Riemann surfaces.

1.4 Other Scientific Workshops

Workshop 1: Breaking the Neutral Code
October 29, 2014 - November 01, 2014
*Larry Abbott (Columbia University), Ingrid Daubechies (Duke University), Michael Jordan (University of California), *Liam Paninski (Columbia University)*

For decades, neuroscientists have dreamed about the possibility of recording from all the neurons in a brain, or of having access to a complete large brain wiring diagram, or ideally to obtain both of these datasets simultaneously, in the same brain. Recent technical advances have brought this dream close to reality in some cases. Now the challenge will be to understand these massive datasets. A few domains will be particularly relevant:

Inferring network structure from noisy and incomplete data
Inferring computational input-output function from structure
Optimal experimental design (incl. compressive sensing methods) for observation of networks
Modeling structured stochastic network dynamics
Optimal control of network dynamics
Inferring low-dimensional dynamics from high-dimensional observations

There's a strong need in neuroscience for deep new ideas from mathematics and statistics, and our hope is that this small, focused workshop without many formal talks will spark collaborations that will lead to breakthroughs in the areas described above.

This workshop is by invitation only.

This workshop is supported by a generous donation from Sanford Grossman. No report will be included in this annual report.

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)*

The Bay Area Differential Geometry Seminar is a 1-day seminar on recent developments in differential geometry and geometric analysis, broadly interpreted. Typically, it runs from mid-morning until late afternoon, with 3-4 speakers. Lunch will be available and the final talk will be followed by dinner.

Workshop 3: Pacific Northw est and Bay Area Differentia l 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)*
The Bay Area Differential Geometry Seminar meets 3 times each year and is a 1-day seminar on recent developments in differential geometry and geometric analysis, broadly interpreted. Typically, it runs from mid-morning until late afternoon, with 3-4 speakers. Lunch will be available and the final talk will be followed by dinner.

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)*

In a recent paper, Marcus, Spielman and Srivastava solve 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 have also proved that there are infinite families of Ramanujan graphs of every degree, and they have developed a very simple proof of Bourgain and Tzafriri's Restricted Invertibility Theorem. The goal of this workshop is 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.

1.5 Education & Outreach Workshops

Critical Issues in Mathematics E ducation 2015: Developmental Mathematics: For whom? Toward what ends?
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)*

This workshop will address the critical issue of developmental mathematics at two- and four-year colleges and universities and the broader dynamic of mathematics remediation that occurs at all levels. It will engage mathematicians, K-12 teachers, mathematics educators, and administrators in a conversation about the goals of developmental mathematics and the contributions that our different professional communities make to this work. Key questions that will be addressed are:

1. How do we teach content in ways that acknowledge and leverage each student's prior learning experiences? In particular, how do we take advantage of a student's maturity while refining his or her learning habits where necessary?

2. How can developmental mathematics instruction move students through mathematics which must be relearned while simultaneously gaining momentum on more advanced mathematics (including the development of mathematical practices needed for meaningful mathematical work)?

3. What are strategies for supporting the needs of the wide range of students in developmental mathematics programs--those developing mathematical skills for life in general as well as those developing the foundation necessary to proceed towards a STEM major? How can we successfully address equity issues raised for students from groups underrepresented in STEM fields? How can developmental mathematics instruction blend synchronous and asynchronous instruction to achieve maximal efficiency and impact?

4. What is the proper balance between addressing the needs of the wide range of students mentioned in the preceding point and keeping instruction and course offerings concise?

5. What are the characteristics, training, and practices of a successful developmental mathematics teacher?

6. What support services enhance the success of a developmental mathematics program?

2. 2014-15 PROGRAM AND WORKSHOP PARTICIPANT SUMMARY

Time	*Activity Type*	*Activity Title*	*No. of participants*	*MSRI Postdocs*	*PD/RMs*
Fall 2014	Scientific Program	New Geometric Methods in Number Theory and Automorphic Forms	66	Zavosh Amir-Khosravi Hansheng Diao Daniel Disegni Christian Johansson Arno Kret Bao Le Hung Luis Lomeli Jasmin Matz	none
August 14, 2014 - August 15, 2014	Programmatic Workshop	Connections for Women: New Geometric Methods in Number Theory and Automorphic Forms	36		
August 18, 2014 - August 22, 2014	Programmatic Workshop	Introductory Workshop: New Geometric Methods in Number Theory and Automorphic Forms	100		
December 01, 2014 - December 05, 2014	Programmatic Workshop	Automorphic forms, Shimura varieties, Galois representations and L-functions	191		

Fall 2014	Scientific Program	Geometric Representation Theory	62	Alexis Bouthier Zsuzsanna Dansco Christopher Dodd Dragos Fratila Sam Gunningham Paul Hamacher Sean Rostami Nikita Rozenblyum Yaping Yang	Ian Le
August 28, 2014 - August 29, 2014	Programmatic Workshop	Connections for Women: Geometric Representation Theory	50		
September 02, 2014 - September 05, 2014	Programmatic Workshop	Introductory Workshop: Geometric Representation Theory	120		
November 17, 2014 - November 21, 2014	Programmatic Workshop	Categorical Structures in Harmonic Analysis	110		

Time	*Activity Type*	*Activity Title*	*No. of participants*	*MSRI Postdocs*	*PD/RMs*
Spring 2015	Scientific Program	Dynamics on Moduli Spaces of Geometric Structures	59	Caleb Ashley Shinpei Baba Guillaume Dreyer Qiongling Li Sara Maloni Kathryn Mann Maria Beatrice Pozzetti	Jeffrey Danciger Gye-Seon Lee
January 15, 2015 - January 16, 2015	Programmatic Workshop	Connections for Women: Dynamics on Moduli Spaces of Geometric Structures	62		
January 20, 2015 - January 23, 2015	Programmatic Workshop	Introductory Workshop: Dynamics on Moduli Spaces of Geometric Structures	132		
April 13, 2015 - April 17, 2015	Programmatic Workshop	Dynamics on Moduli Spaces	134		

Spring 2015	Scientific Program	Geometric and Arithmetic Aspects of Homogeneous Dynamics	64	Nicolas de Saxce Etienne Le Masson Han Li Ronggang Shi Alexander Wright Lei Yang	Ilya Vinogradov
January 29, 2015 - January 30, 2015	Programmatic Workshop	Connections for Women: Geometric and Arithmetic Aspects of Homogeneous Dynamics	63		
February 02, 2015 - February 06, 2015	Programmatic Workshop	Introductory Workshop: Geometric and Arithmetic Aspects of Homogeneous Dynamics	118		
May 11, 2015 - May 15, 2015	Programmatic Workshop	Advances in Homogeneous Dynamics	107		

Whole Year 2014-15	Scientific Program	Complementary Program 2014-15	13		

June 21, 2014 - August 03, 2014	Scientific Activities Directed at Underrepresented Groups in Mathematics	MSRI-UP 2014: Arithmetic Aspects of Elementary Functions	18		
October 15, 2014 - October 16, 2014	Scientific Activities Directed at Underrepresented Groups in Mathematics	Modern Math Workshop (SAMSI)	off site		
November 14, 2014 - November 15, 2014	Scientific Activities Directed at Underrepresented Groups in Mathematics	Blackwell-Tapia Conference and Awards Ceremony (IPAM)	off site		
March 2, 2015 - March 3, 2015	Scientific Activities Directed at Underrepresented Groups in Mathematics	Infinite Possibilities Conference 2015 Celebrating and Promoting Diversity in the Mathematical Sciences (MBI)	off site		

June 16, 2014 - June 27, 2014	Summer Graduate School (2014)	Dispersive Partial Differential Equations	50		
June 23, 2014 - July 04, 2014	Summer Graduate School (2014)	Seminaire de Mathematiques Superieures 2014: Counting Arithmetic Objects	26		
June 29, 2014 - July 19, 2014	Summer Graduate School (2014)	IAS/PCMI 2014: Mathematics and Materials	15		
June 30, 2014 - July 11, 2014	Summer Graduate School (2014)	Algebraic Topology (Guanajuato, Mexico)	16		
July 07, 2014 - July 18, 2014	Summer Graduate School (2014)	Stochastic Partial Differential Equations	58		
July 28, 2014 - August 08, 2014	Summer Graduate School (2014)	Geometry and Analysis	53		

12. Appendix – Final Reports

MSRI
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17 Gauss Way Berkeley, CA 94720-5070 p: 510.642.0143 f: 510.642.8609 www.msri.org

Model Theory, Arithmetic Geometry and Number Theory

January 20, 2014 to May 23, 2014
MSRI, Berkeley, CA
USA

Organizers:

Ehud Hrushovski (Hebrew University)
François Loeser (Université de Paris VI (Pierre et Marie Curie))
David Marker (University of Illinois)
Thomas Scanlon (University of California, Berkeley)
Sergei Starchenko (University of Notre Dame)
LEAD Carol Wood (Wesleyan University)

MODEL THEORY, ARITHMETIC GEOMETRY AND NUMBER THEORY, SPRING 2014

1. Introduction.

At a 2009 London Math Society workshop in Durham, several from the 1998 program at MSRI decided that, from our perspective, model theory was ripe for another such program, one tied to recent developments in applications to number theory and arithmetic geometry. Seven themes were mentioned in our proposal, including recent work not yet in print, on topics including motivic integration, model theory of valued fields, o-minimality and the Pila-Wilkie theorem, Pink-Zilber conjectures, definability in $\mathbb{Q}$, Keisler measures, and algebraic dynamics. Our proposal informed our selection of participants from a large pool of applicants, even though we regretted that we cculd not offer membership to strong mathematicians whose work lay outside our chosen topics.
The research of Spring 2014 confirmed these choices, alongside other topics not on our radar in 2009-e.g., applications to arithmetic combinatorics and developments in abstract stability theory (e.g. NIP theories).
As one indication of the impact of the work in this area, the 2013 Karp prize of the Association for Symbolic Logic, for outstanding research in logic, was awarded jointly to five mathematicians: one set theorist Gitik and four model theorists in our program: Peterzil, Pila, Starchenko, and Wilkie.

2. Research developments.

The results described in this section should be read in conjunction with the many results mentioned in the postdoctoral section below. Given the importance of postdoctoral participants to any program at MSRI, we feel that a detailed description of their work is of particular value in this report.

The research developments of the semester fall roughly into two bins: Bin A contains collaboration which benefited from the program and the proximity of colleagues either to start new projects or to to push existing projects along– in some cases to completion. Bin A is quite full, enough to support the claim that it was a productive semester. Bin B consists of work begun at MSRI, with collaborations among mathematicians who had never worked together, in some cases had never met. Our program aimed for results which would fall into Bin B, and this too occurred. Notable in Bin A was the major push made by Aschenbrenner, van den Dries, and van der Hoeven on the model theory of transseries. This multiyear project, begun at the conjectural stage twenty years ago, has occupied the three collaborators for some time. The first two authors were at MSRI for extended periods as Research Professors, and modulo certain verifications, the project was completed there. This tour de force was announced at the final workshop.
Scanlon finished work on algebraic differential equations arising from covering maps

(see arXiv:1408.5177) and together with Freitag (see below) gave details on the model theory of the j-function. DiVizio and Hardouin completed their paper on the Galois theory of q-difference equations, and Ducros, Hrushovski and Loeser pushed along their project on the structure of Berkovich spaces. Several projects involved various subsets of Bertrand, Masser, Pillay, and Zannier, resulting in papers in which methods from model theory and from number theory were employed to good effect. Peterzil and Starchenko continued their long-standing collaboration on o-minimality. Starchenko also worked on a combinatorial problem with postdoc Chernikov (see below).

As for Bin B, one notes the collaboration begun by Comte and Miller on "a non o-minimal expansion of $\mathbb{R}$ with few points of bounded height," in which they explore the extent to which Pila-Wilkie results require o-minimality. Without the MSRI program this collaboration would almost surely not have occurred. New collaborations were begun by researchers in related areas but coming from different continents, such as Hils and Kamensky on separably closed valued fields and Hils-Bays-Moosa on compact complex manifold with an automorphism, plus the many collaborations involving postdocs and student described below. Not all the cross-disciplinary activity is reflected as yet in publications, although it was a source of considerable discussion throughout the semester. Several members from outside model theory contributed to the liveliness of the program, and none more than Mazur, who was learning model theory, raising questions- e.g., for Scanlon and Freitag about strongly minimal sets, and holding conversations with many of us including Malliaris, Larsen, and especially Loeser, with whom the outline of a project was begun.

3. Organizational structure

Our program ran two weekly research seminars of 90 minutes duration. In addition, we organized several informal sessions. including "Model theory for dummies", at the request of someone very definitely not a dummy. In this session, a handful of model theory experts were chosen to field questions from the non-model theorists, an exercise enlightening to all. Most of our program participants attended the Wednesday model theory seminar at UCB run by one of our postdocs, James Freitag, and a substantial number were regulars in Ken Ribet's number theory seminar that same afternoon. Two postdocs in our program, Cameron Hill and Margaret Thomas, organized the Postdoctoral Seminar held jointly with the other program. The research seminars were organized by Zoé Chatzidakis, a Research Professor, with Tom Scanlon in second chair. Talks were focussed on the areas of applications. When the schedule allowed, the two research seminars met on the same day, with time for lunch conversations between talks The organizers were fortunate to have persuaded Chatzidakis to run these seminars; she was the ideal person to select topics and speakers for our program, with her breadth of knowledge and her experience in co-organizing the monthly Paris GTM seminar for several years with Francois Loeser. Chatzidakis selected speakers whose work was most relevant to our program's goals, coordinating these with talks in the seminars at UCB. A good measure of the value of a seminar talk is the number of comments and questions that arise during and after the talk; by that standard alone, these well-presented

seminars were huge successes!

4. Workshops and conferences.

The program held three workshops: Introductory, Connections for Women, and Research, all with supplemental funding from NSA. The semester began late, due to the late date of the Joint Math Meetings, so we chose to schedule the Introductory Workshop immediately after the introductory workshop in Algebraic Topology, hence prior to the Connections for Women, which in turn was followed quickly by the "Hot Topics" Perfectoid Workshop.
The introductory workshop played a significant role in getting the program off to a good start, by addressing the presence of mathematicians in our program with varied backgrounds. The organizing committee Moosa(Chair), Bouscaren, and Chambert-Loir was chosen with this goal in mind, and did not disappoint. Their speakers combined expository skill with expertise, and the lectures were well coordinated. Pierre Simon, one of our postdocs, presented the basics of model theory in three succinct lectures. The remainder of the workshop was organized around three themes (Diophantine Geometry, Berkovich Spaces and Combinatorics). In each, the lecturers carried the topics from elementary to advanced with remarkable efficiency. There was also a good deal of repetition of important topics from differing perspectives. This cross-referencing among the talks was notably helpful both in setting the stage for the program and for aiding understanding by the participants in the workshop.
These themes were followed in the Connections for Women workshop organized by Eisentrager, Gordon, and Haskell(Chair), with definability in number theory and algebraic dynamics added to the mix. There were ten speakers in the Connections workshop, nine women and one man...just like the old days, only flipped! The panel discussion touched on a range of topics, including the struggle of young mathematicians to feel comfortable in the world of mathematical research. One early career participant –someone who has been very successful and shows no hint of self-doubt— described her strategy as "fake it 'til you make it"!

The final workshop, Model Theory in Geometry and Arithmetic, was held one week before the end of the semester, organized by Cluckers, Pila (Chair), and Scanlon. It gave a spectacular account of the state of the art. Although the talks involved difficult material and correspondingly serious background, the speakers were able to talk across disciplines and to explain deep work to the non-experts; one would like to think that this gain in communication was enhanced by the semester long interactions. The final workshop was an exciting way to end the semester. The late timing worked well for participants, several of whom continued during the final week to the annual Association for Symbolic Logic meeting in Boulder, Colorado or to the IPAM workshop in Combinatorics.

At the suggestion of MSRI postdoc Dupuy, a follow-up AMS special session has been organized by Marker, Starchenko and Wood at the annual meetings in San Antonio. Of the 11 speakers, 6 are postdocs and a seventh is a graduate student.

5. Postdoctoral Fellows

The program in Model Theory, Arithmetic Geometry and Number Theory (MTNT) attracted a very strong group of postdoctoral fellows. Uri Andrews, Martin Bays, Artem Chernikov, Taylor Dupuy, Cameron Hill, Pierre Simon and Margaret Thomas were supported as MSRI postdocs. James Freitag, Holly Krieger and Adam Topaz are NSF postdocs who were MSRI members throughout the program. Maryanthe Malliaris would have been eligible for an MSRI postdoc, but was on the job market just before the program and opted to come as a Research Member. (She accepted a tenure track position at U.Chicago which supported her for the MSRI semester.) Vince Guingona was supported by an NSF RTG grant at Notre Dame. We were unable to offer him official status, but he too was an active participant in the program, working out of a desk in the library.

Each program postdoc was assigned one or more senior member to serve as a mentor. Postdocs and mentors were encouraged to meet frequently to discuss both research and career development. Some of the postdocs also organized a forum for other postdocs and graduate students to discuss strategies in applying for jobs.

Each of the postdocs spoke in the MSRI Postdoc seminar. This was a seminar held jointly with the Algebraic Topology program where speakers were encouraged to give colloquium style talks. In addition, each postdoc gave at least one lecture on their research, either in the MSRI Model Theory Seminar, the UC Berkeley Model Theory Seminar or one of the program workshops.

Three of the postdocs, Dupuy (differential algebra), Krieger (arithmetic dynamics) and Topaz (anabelian geometry), came from outside of model theory. Efforts were made to insure all three were integrated with the program.

The postdoctoral fellows were an extremely important part of the MTNT program. As described below, they were active participants in many of the collaborations developed during the semester.

Uri Andrews

Mentor: David Marker (University of Illinois at Chicago)
Employment: Assistant Professor, University of Wisconsin[1]

Andrews completed work on several projects while at MSRI. A local characterization of VC minimality was done in collaboration with Vince Guingona. He also finished and submitted a four author paper on VC-minimal structures, where two of the coauthors, James Freitag and Alice Medvedev were MSRI members.

Martin Bays

Mentor: Anand Pillay (University of Notre Dame)
Employment: Postdoctoral Fellow, McMaster University

Bays collaborated extensively with a number of members in the MTNT program. He started a new collaboration with Pierre Simon on profinite structures in algebraic geometry. He continued an ongoing collaboration with Research Professor Anand Pillay on universal covers of commutative groups of finite Morley rank. He continued long term projects around Zilber's exponentiation with member Jonathan Kirby. He also began a project with members Martin Hils and Rahim Moosa on holomorphic dynamics and the model theory of compact complex manifolds.

[1]Unless otherwise specified, postdoctoral fellows returned to the position they had in the fall.

Artem Chernikov

Mentor: François Loeser (Université Pierre and Marie Curie–Paris VI)
Employment: Postdoctoral Fellow, Université Paris Diderot–Paris VII)

Chernikov worked with Research Professor Sergei Starchenko on applications of model theory to extremal combinatorics. He completed an ongoing project with Pierre Simon on definably amenable groups in NIP theories and worked on another ongoing collaboration with member Martin Hils on the model theory of algebraically closed valued fields with an automorphism. He also collaborated with UC Berkeley Ph.D. student Nick Ramsey on a result about Shelah's tree properties.

During the semester Chernikov was awarded the 2013 Association for Symbolic Logic Sacks Prize for outstanding Ph.D. thesis.

Taylor Dupuy

Mentor: Thomas Tucker (Rochester University) and Carol Wood (Wesleyan University)
Employment: Prior to the semester, Dupuy was an Adjunct Assistant Professor at UCLA. In the fall, he will be a postdoc at Hebrew University.

During the program Dupuy completed and submitted two papers, one in combinatorial number theory, the other on deformations of curves using arithmetic jet spaces and based on his thesis. Dupuy collaborated on two projects with James Freitag–one on a arithmetic version of Kolchin's Irreducibility Theorem, the second on a method for finding large families of disintegrated strongly minimal sets living on curves not defined over the constants in differentially closed fields. The first project is joint with Lance Miller, the second with Aaron Royer, both participants in the algebraic topology program.

James Freitag

Mentor: Thomas Scanlon (UC Berkeley)
Employment: National Science Foundation Postdoctoral Fellow, UC Berkeley

In addition to projects mentioned above, Freitag was involved in a number of other collaborations at MSRI. The most notable among these was in collaboration with organizer Thomas Scanlon. Freitag and Scanlon addressed the strong minimality of those sets defined in a differentially closed field by the differential equations satisfied by the j-function. After lengthy discussions with Research Professor Barry Mazur, they were able to answer a number of his questions on bounds on Hecke orbits. Freitag began a number of other projects on the model theory of differential fields with visitors Omar León Sanchez and Ronnie Nagloo, member Michael Singer and organizer David Marker.

Freitag also played an important role helping integrate the postdocs from outside model theory. He was also an important contributor to the 2012 Graduate Student Workshop held as preparation for this semester.

Cameron Hill

Mentor: Lou van den Dries (University of Illinois at Urbana-Champaign)
Employment: Assistant Professor, Wesleyan University

Hill continued ongoing work on generalized indiscernibles, part of which was joint with RTG Postdoc Vincent Guingona. He began a far reaching project on model theoretic interpretations of polynomial invariants on graphs. Part of this was

motivated by discussions with organizer Thomas Scanlon and Research Professor Lou van den Dries.

Hill and Vince Guingona co-organized a joint MSRI–Berkeley seminar on model theory and finite structures.

Holly Krieger

Mentor: Thomas Tucker (Rochester University) and Carol Wood (Wesleyan University)

Employment: National Science Foundation Postdoctoral Fellow, MIT

Krieger's work at MSRI focused on unlikely intersections in complex dynamics. She discussed these topics with Research Professors Thomas Tucker and Barry Mazur as well as postdocs James Freitag andTaylor Dupuy. During the semester she completed a paper on the dynamical André-Oort conjecture with member Dragos Ghioca and UC Berkeley Ph.D. student Khoa Nguyen.

Krieger was the postdoc from the MTNT program asked to speak on Sponsor's Day. She also completed two numberphile videos.

Maryanthe Malliaris

Mentor: Matthias Aschenbrenner (UCLA)

Employment: Assistant Professor, University of Chicago

During the semester Malliaris completed the paper *Existence of optimal ultrafilters and the fundamental complexity of simple theories*, a milestone in her long standing collaboration with Saharon Shelah. Devoting most of her time to a project that in a different direction than the main lines of the program she may not have begun new collaborations at MSRI, nevertheless she says "I'm not sure it makes sense for me to name just a few "MSRI collaborator" per se; rather it was very stimulating to talk to a variety of people at MSRI on an informal basis.

Pierre Simon

Mentor: François Loeser (Université Pierre and Marie Curie–Paris VI)

Employment: CNRS Researcher, Université Claude Bernard, Lyon

In addition to the collaborations with Bays and Chernikov mentioned above, Simon worked with program associate Sylvain Rideau on valued differential fields and had extensive conversations with organizer and Clay Scholar Ehud Hrushovski, which he believes will lead to collaboration on several projects.

Simon was also called on the Introductory Workshop to give a three lecture tutorial on the basic concepts of model theory. His handling of this daunting task was an exemplar of clarity and efficiency.. He was designated by MSRI as its Strauch Postdoctoral Fellow.

Margaret Thomas

Mentor: Sergei Starchenko (University of Notre Dame)

Employment: Zukunftskolleg Research Fellow, Universität Konstanz

Thomas completed and submitted the paper *Rational values of Weierstrass zeta functions* with Gareth Jones. While at MSRI she discussed approaches to Wilkie's conjecture on mild parameterizations with Research Professors Sergei Starchenko

and Lou van den Dries. Thomas was involved in an extensive number of conversations on possible extensions of her work around the Pila–Wilkie Theorem and their possible applications with program participants James Freitag, David Masser, Barry Mazur, Jonathan Pila, Thomas Scanlon, Sergei Starchenko, Alex Wilkie and Umberto Zannier. She also began a collaboration with members George Comte and Chris Miller on notions of tameness around the Pila–Wilkie Theorem and another with Martin Bays and member Alf Onshuus on hypergeometric and Liouville functions.

Describing her semester at MSRI, Thomas says: "The opportunity to be surrounded by experts in my field of research, in particular those working on questions around the application of o-minimality to diophantine geometry and related topics, led to a swifter progress on identifying and refining suitable research questions to pursue than would have been possible elsewhere. The opportunity to interact with so many scholars in the discipline, to hear frequent seminars on the latest developments, to get to know other researchers and identify common interests, all helps to accelerate progress in the research field in general and in my own work in particular."

Thomas, like James Freitag, was also an important contributor to the MSRI graduate student workshop held in 2012 in anticipation of this program.

Adam Topaz

Mentor: Thomas Scanlon (UC Berkeley)

Employment: National Science Foundation Postdoctoral Research Fellow, UC Berkeley

Topaz started, and essentially finished his paper *Recovering function fields from rational quotients of mod-l Galois groups.* He spent much of the semester learning model theoretic techniques that are likely to be useful in his work in field arithmetic.

Topaz is one of the few members of the program who benefited greatly from the companion program in algebraic topology. He frequently attended the topology seminars and had many conversations with postdocs in that program.

6. Graduate students.

We were allotted seven Program Associates, which is to say 7 desk spaces in the offices for students. However, our program had at least 16 additional students from 7 countries in residence at some stage, all supported by their home institutions, all with their advisors in residence as well. In addition, there were ten UCBerkeley students participating. Some of these students were quite advanced–one was an invited speaker at the final workshop. Several spoke in seminars about their work, while others were just beginning to attack problems. Khoa Ngyuen, a student at UCBerkeley, was involved in several collaborations with program members and with Research Professor Tucker. Darío García (a student of member Onshuus and organizer Scanlon) worked with members MacPherson and Steinhorn; the time at MSRI allowed these three to bring their disparate ideas about dimension and asymptotic classes into focus. Aschenbrenner's student Walberg (UCLA) worked with Hrushovski on "bounded imaginaries in convex expansions."

We were grateful that MSRI was willing to welcome all these students, e.g., by providing bus passes for the visiting students. Students without offices found places to work in the library. In addition, James Freitag, an NSF supported postdoctoral

fellow, was in charge of the UCB Model Theory seminar. Speakers in that seminar were chosen largely from among the graduate students. This seminar played to a packed house each week. The benefit to this new generation of mathematicians was palpable, and the exit interviews convey the excitement they felt to be part of the program and to interact with members of several research communities.
In addition to the seminars mentioned above, a much smaller contingent of students and postdocs ran a small seminar regularly at UCB on finite model theory.

7. Diversity.

Fortunately for our program, several research areas, e.g., model theory, differential algebra and dynamics, have fostered diversity for many years, due in part to the leadership of certain key individuals. As a result, we had a strong pool of women applicants to the program, at all levels, and many more than we could accommodate. From the early career set we had two Postdocs Holly Krieger (NSF@MIT)and Margaret Thomas (Konstanz), members Maryanthe Malliaris (UChicago) and Alice Medvedev (CCNY), and graduate students Derya Ciray (Konstanz), Samaria Montenegro (Paris VII), Victoria Norquez (UIC), Caroline Terry (UIC), Samayeh Vojdani (Notre Dame) and Gwyneth Harrison-Shermoen (UCB). Our program also included many established women mathematicians: Research Professors Zoé Chatzidakis and Mei-Chu Chang, organizer Carol Wood, and members Paola D'Aquino, Françoise Delon, Lucia DiVizio, Kirstin Eisentrager, Charlotte Hardoiun, Deirdre Haskell and Françoise Point. The workshops were likewise populated by women at all stages of their careers. But diversity is not just about women, and for under-represented minorities our numbers, while smaller, were nonzero and concentrated in the early career contingent. One postdoctoral fellow, Cameron Hill, is an African-American, and several of the early career participants in our seminars and workshops come from Latino/a and African backgrounds, including Joel (Ronnie) Nagloo and Omar Sanchez. Nagloo received his doctorate in the UK, hence did not meet US government criterion for Af-Am at the time of application, but would now, having accepted a postdoctoral position in CUNY-Graduate Center.

8. Synergistic activities.

The synergy of our program is partly attributable to the breadth of the program itself, a result of our deliberate inclusion of mathematicians from areas with overlapping interests but coming from quite distinct research communities within model theory, number theory, algebraic geometry and combinatorics. This is reflected in the research interactions reported elsewhere, but also in the participation of members of our program in seminars down the hill; Ken Ribet reported that he relied on our program both for speakers and attendance at the UCB number theory seminar. Indeed, visits from our program to seminars at UCB often resulted in overcrowding. Likewise students and faculty from UCB made frequent trips up the hill for seminars and workshops. Many members of our program attended the perfectoid workshop, despite the workshop overload of our first month at MSRI; the overall setting employed by Scholze et al has a definite model theoretical flavor although the framework is different, since related model theoretical work is couched in the context of Berkovich spaces.

As mentioned earlier, the interaction between the two programs in residence in Spring 2014 was less than would be the usual expectation when MSRI is able to arrange parallel programs in highly related subjects. There are programs before and after ours which would have met this criterion better than that of Spring 2014. Nonetheless, there was some interaction, especially on the part of a few individuals.. Two of our postdocs (Dupuy and Freitag) are preparing papers with two AT program members.

The postdocs in our program organized a meeting intended for graduate students, to describe their experiences in searching for a job. Holly Krieger took part in the numberphile project, with two videos to her credit. Her first video, about 63 and -7/4, has over 395,000 views on youtube at this writing.

A long-term benefit of our program is that several mathematical communities have a much better feel for what the questions and approaches of the others are, and how these are relevant to one's home discipline. They have also acquired new colleagues with whom to collaborate now and in the future. Two of the organizers held parties to which all participants were invited, and in retrospect regret not having done so earlier; there was a clear benefit in giving our program participants many ways in which to interact and to learn others' perspectives.

9. Nuggets and breakthroughs.

The completion by Aschenbrenner, van den Dries, and Van der Hoeven, of the description of the first order theory of transseries, qualifies as a breakthrough, and a difficult one.
Transseries provide a rich domain in which to do several kinds of mathematics. In his survey paper posted on ArXiv, Edgar states:

"From the simplest point of view, transseries are a new kind of expansion for real-valued functions. But transseries constitute much more than that–they have a very rich (algebraic, combinatorial, analytic) structure. The set of transseries is a large ordered field, extending the real number field, and endowed with additional operations such as exponential, logarithm, derivative, integral, composition. Over the course of the last 20 years or so, transseries have emerged in several areas of mathematics: asymptotic analysis, model theory, computer algebra, surreal numbers. "

To know that a first order description exists, and moreover to have nailed down the axioms, informs future research in a deep way.

Another breakthrough occurred with the completion by Freitag and Scanlon of their project mentioned earlier, on the model theoretic properties of the analytic j-function. This work ties together ideas from differential algebra, the theory of automorphic functions, and diophantine geometry on moduli spaces of abelian varieties. Their theorem, that the third-order nonlinear ordinary differential equation satisfied by the j-function defines a strongly minimal set, answered negatively a long-standing open question about the structure of such sets in differentially closed fields. Answering questions raised by Mazur during the program, they used the

model theoretic classification and an effective finiteness theorem of Hrushovski and Pillay to prove explicit upper bounds on the number of points in an isogeny class satisfying an algebraic relation.

In addition, using two ideas from model theory, specifically elimination of Imaginaries in differentially closed fields and a strong GAGA theorem of Peterzil and Starchenko to the effect that an o-minimally definable complex analytic subset of a"quasi"-projective variety must be algebraic, Scanlon showed that under a local definability hypothesis, certain classical analytic differential operators associated to analytic covering maps must always be algebraic.

The "Model Theory for Dummies" seminar was, for us, a potential nugget. When mathematicians find themselves needing techniques or ideas from a somewhat alien discipline, this can be hard.

David Kazhdan, in his model theory lecture notes, states:

" I don't know any mathematician who did not start as a logician and for whom it was "easy and natural" to learn model theory. Often the experience of learning model theory is similar to one of learning physics: for a [short] while everything is so simple and so easily reformulated in familiar terms that "there is nothing to learn" but suddenly one finds himself in a place where model theoreticians "jump from a tussock to a hummock" while we mathematicians don't see where to "put a foot" and are at a complete loss."

The starting point for the "Model Theory for Dummies" session was a list of questions generated by the non-model theorists in our program, ones that arose during the "tussock to hummock" stage of understanding. The lively discussion allowed the model theorists to understand the sources of confusion, making it possible to say where indeed to plant one's feet. This was an excellent exercise, both efficient and effective.

This approach that might be useful in other contexts. However, our session benefited from the interest in the subject already taken by Mazur, Larsen, and Chang, whose questions drove the session. The presence of model theorists of broad background, such as Loeser and Scanlon, smoothed the way for translating answers from the strange to the familiar. We tried to replicate this in a second session, with different players, but the dynamics were not nearly as good, making it clear that such sessions require careful orchestration.

The organizing committee: Ehud Hrushovski, Franćois Loeser, Devid Marker,Thomas Scanlon, Sergei Starchenko, and Carol Wood (Chair)

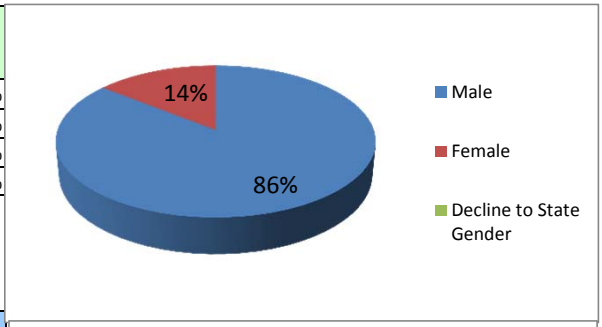
Postdoc Pre/Post-MSRI Institution Group

Family Name	First Name	Pre-MSRI Institution Group	Post-MSRI Institution Group	Pre-MSRI Institution Name	Placement Institution Name
Andrews	Uri	Group I Public	Group I Public	University of Wisconsin - Madison	University of Wisconsin - Madison
Bays	Martin	Foreign	Foreign	McMaster University	McMaster University
Chernikov	Artem	Foreign	Foreign	Université Paris Diderot - Paris 7	Université Paris Diderot - Paris 7
Dupuy	Taylor	Group I Public	Foreign	UCLA	Hebrew University
Hill	Cameron	Group II	Group II	Wesleyan University	Wesleyan University
Simon	Pierre	Foreign	Foreign	Hebrew University	Université Claude Bernard, Lyon, France
Thomas	Margaret	Foreign	Foreign	University of Konstanz, Germany	University of Konstanz, Germany

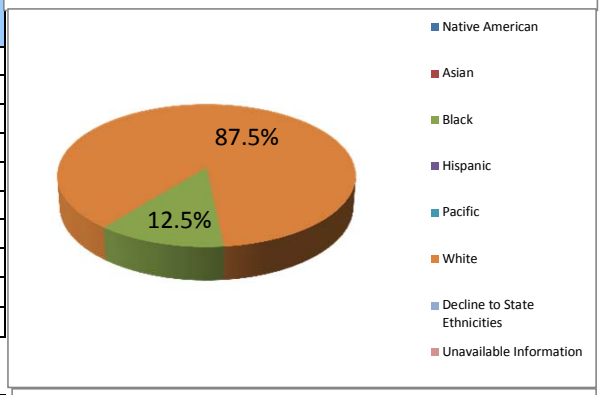
2013–14 Postdoctoral Fellows Demographic Summary

Gender	#	% (No Decl.)*	%
# of Members	7		100.0%
Male	6	85.71%	85.7%
Female	1	14.29%	14.3%
Decline to State Gender	0		0.0%

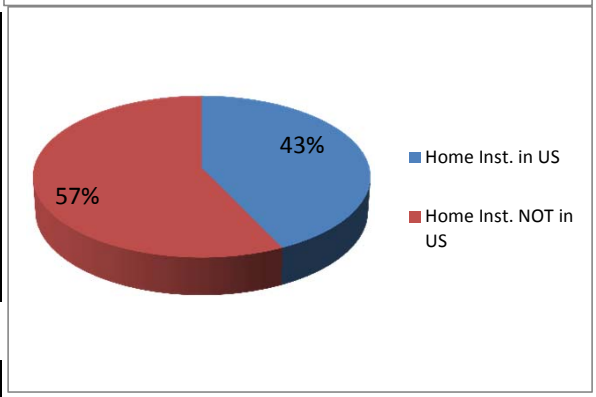
Members are distinct within each academic year.



Ethnicities	#	% (No Decl.)*	%
Native American	0	0.00%	0.0%
Asian	0	0.00%	0.0%
Black	1	12.50%	12.5%
Hispanic	0	0.00%	0.0%
Pacific	0	0.00%	0.0%
White	7	87.50%	87.5%
Decline to State Ethnicities	0		0.0%
Unavailable Information	0		0.0%
Minorities	1		33.3%

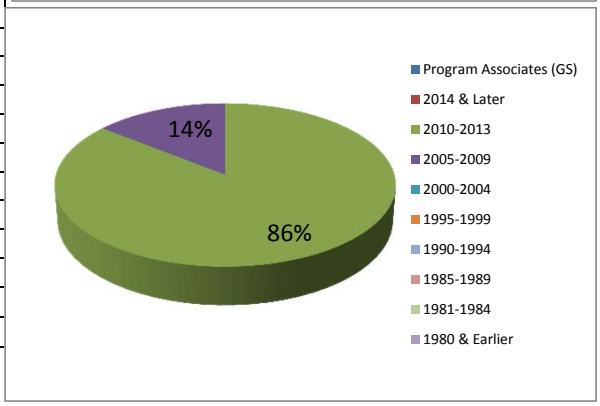


Citizenships	#		%
US Citizens & Perm. Residents	3		42.9%
Foreign	4		57.1%
Unavailable information	0		0.0%
# of Members	7		100.0%
US Citizens	3		42.9%
Perm Residents	0		0.0%
Home Inst. in US	3		42.86%



Year of Ph.D	#		%
Program Associates (GS)	0		0.0%
2014 & Later	0		0.0%
2010-2013	6		85.7%
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 Members	7		100.0%

**Statistic Calculation based on all members who did not decline to state.*



Model Theory, Arithmetic Geometry and Number Theory

Program Summary

Role	# of Distinct Members	%	# of Citizens & Perm. Res.	%	US Citizens	# of Female	%	# of Minorities[1]	%
Organizers	6	8.2%	5	83.3%	5	1	16.7%	0	0.0%
Research Professors	11	15.1%	7	63.6%	6	2	18.2%	0	0.0%
Postdoctoral Fellows	7	9.6%	3	42.9%	3	1	14.3%	1	33.3%
PD/RM	4	5.5%	4	100.0%	4	2	50.0%	0	0.0%
Research Members	29	39.7%	8	27.6%	7	8	27.6%	0	0.0%
Program Associates	16	21.9%	3	18.8%	3	5	31.3%	1	33.3%
Total # of Distinct Members	***73***	***100%***	***30***	***41%***	***28***	***19***	***26%***	***2***	***7.1%***

[1] *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.*

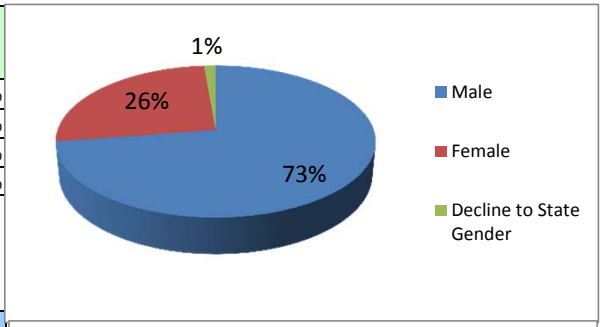
Home Institute Grouping

	US								
Role	**Group I Private**	**Group I Public**	**Group II**	**Group III**	**Group IV**	**Group M**	**Non-Group**	**Foreign**	**Total**
Organizers	1	1	1	0	1	0	0	2	6
Research Professors	2	3	2	0	0	0	0	4	11
Postdoctoral Fellows	0	2	1	0	0	0	0	4	7
PD/RM	1	3	0	0	0	0	0	0	4
Research Members	0	2	2	0	0	1	1	23	29
Program Associates	1	1	0	0	2	0	0	12	16
Total	**5**	**12**	**6**	**-**	**3**	**1**	**1**	**45**	**73**
%	***6.8%***	***16.4%***	***8.2%***	***0.0%***	***4.1%***	***1.4%***	***1.4%***	***61.6%***	***100.0%***

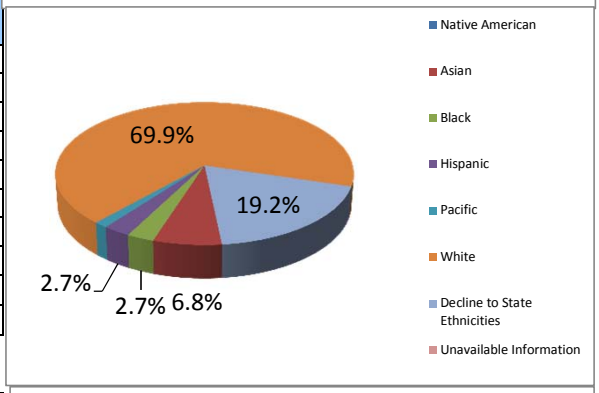
2013–14 Program Members Demographic Summary

Gender	#	% (No Decl.)*	%
# of Members	73		100.0%
Male	53	73.61%	72.6%
Female	19	26.39%	26.0%
Decline to State Gender	1		1.4%

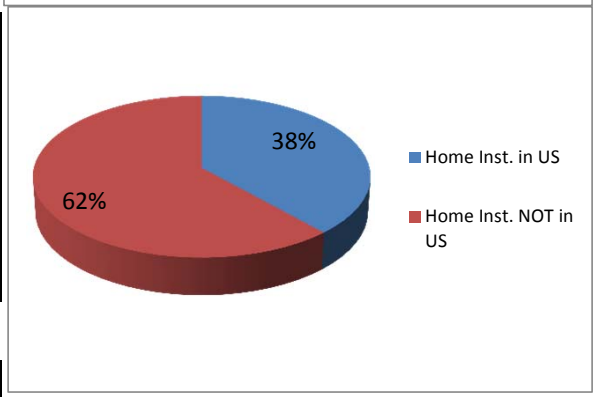
Members are distinct within each academic year.



Ethnicities	#	% (No Decl.)*	%
Native American	0	0.00%	0.0%
Asian	5	8.20%	6.8%
Black	2	3.28%	2.7%
Hispanic	2	3.28%	2.7%
Pacific	1	1.64%	1.4%
White	51	83.61%	69.9%
Decline to State Ethnicities	14		19.2%
Unavailable Information	0		0.0%
Minorities	2		7.1%

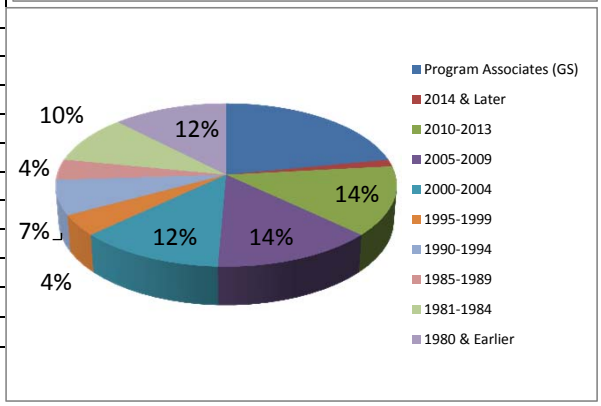


Citizenships	#		%
US Citizens & Perm. Residents	30		41.1%
Foreign	43		58.9%
Unavailable information	0		0.0%
# of Members	73		100.0%
US Citizens	28		38.4%
Perm Residents	2		2.7%
Home Inst. in US	28		38.36%



Year of Ph.D	#		%
Program Associates (GS)	16		21.9%
2014 & Later	1		1.4%
2010-2013	10		13.7%
2005-2009	10		13.7%
2000-2004	9		12.3%
1995-1999	3		4.1%
1990-1994	5		6.8%
1985-1989	3		4.1%
1981-1984	7		9.6%
1980 & Earlier	9		12.3%
Unavailable Info.	0		0.0%
Total # of Members	73		100.0%

**Statistic Calculation based on all members who did not decline to state.*



RESPONSIBLE CONDUCT OF RESEARCH (RCR) TRAINING CERTIFICATION FORM

Effective January 4, 2010, when submitting new research proposals to the National Science Foundation (NSF), UC Berkeley will be required to certify that the campus has a plan in place for providing education and training in the Responsible Conduct of Research (RCR) to all students (undergraduate and graduate) and postdoctoral scholars who will be supported by those grants to conduct research. This RCR training is required under the America COMPETES Act. While training plans are not required to be included in proposals submitted to NSF, institutions are advised that they are subject to review upon request. See http://rac.berkeley.edu/rcr.html for more information.

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As Principal Investigator/Project Director, I certify that I have read and understand the National Science Foundation's requirement on Responsible Conduct of Research (RCR) training, and I certify the following:

Project Title: Mathematical Sciences Research Institute (MSRI)

~~Fall 2013~~ Programs-Postdoctoral Fellowships Spring 2014

NSF Award Number: 0932078

☒ All students (undergraduate and graduate) and postdoctoral scholars who are supported by the grant to conduct research have been trained in the Responsible Conduct of Research within 60 days of beginning work on this project. (Please complete the next two sections; continue on additional page if necessary.)

- Provide name(s) of students and postdoctoral scholars and title(s) of RCR education program(s) completed, and check the correct box for UCB status (undergraduate, graduate, or postdoc):

Name(s) of students and postdoctoral scholars:	UCB Status: UG | G | PD	Education program(s) completed:
Sean Tilson	☐ | ☐ | ☒	Collaborative Institutional Training Initiative (CITI)
Hiroaki Tanka	☐ | ☐ | ☒	Collaborative Institutional Training Initiative (CITI)
Anna Marie Bohmann	☐ | ☐ | ☒	Collaborative Institutional Training Initiative (CITI)
Angelica Osorno	☐ | ☐ | ☒	Collaborative Institutional Training Initiative (CITI)
David Ayala	☐ | ☐ | ☒	Collaborative Institutional Training Initiative (CITI)
Cameron Hill	☐ | ☐ | ☒	Collaborative Institutional Training Initiative (CITI)
Margaret Thomas	☐ | ☐ | ☒	Collaborative Institutional Training Initiative (CITI)

- If any RCR education program(s) or activities were used other than the UC System Handout for Undergrads or the UCB CITI Program for graduate students and posdocs, then provide brief, one-sentence description(s) of the RCR education program(s) or activities:

☐ No additional students or postdocs are or have been supported since previous certification for this project.

Principal Investigator Name: David Eisenbud
(Please type or print.)

D Eisenbud
PI Signature

4/1/14
Date

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Name(s) of students and postdoctoral scholars:	UCB Status: UG | G | PD	Education program(s) completed:
Artem Chernikov	☐ | ☐ | ■	Collaborative Institutional Training Initiative (CITI)
Uri Andrews	☐ | ☐ | ■	Collaborative Institutional Training Initiative (CITI)
Vesna Stojanoska	☐ | ☐ | ■	Collaborative Institutional Training Initiative (CITI)
Pierre Simmon	☐ | ☐ | ■	Collaborative Institutional Training Initiative (CITI)
Martin Bays	☐ | ☐ | ■	Collaborative Institutional Training Initiative (CITI)
Joseph Hirsh	☐ | ☐ | ■	Collaborative Institutional Training Initiative (CITI)
Ilya Grigoriev	☐ | ☐ | ■	Collaborative Institutional Training Initiative (CITI)

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Name(s) of students and postdoctoral scholars:	UCB Status: UG | G | PD	Education program(s) completed:
Taylor Dupuy	☐ | ☐ | ☒	Collaborative Institutional Training Imitative (CITI)
	☐ | ☐ | ☐	
	☐ | ☐ | ☐	
	☐ | ☐ | ☐	
	☐ | ☐ | ☐	
	☐ | ☐ | ☐	
	☐ | ☐ | ☐	

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Principal Investigator Name: David Eisenbud
(Please type or print.)

D Eisenbud
PI Signature

4/1/14
Date

MSRI
Mathematical Sciences Research Institute

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Mathematical General Relativity

August 19, 2013 to December 20, 2013
MSRI, Berkeley, CA
USA

Organizers:

Piotr Chrusciel (Universität Wien)
Greg Galloway (University of Miami)
Gerhard Huisken (Math. Forschungsinstitut Oberwolfach)
LEAD James Isenberg (University of Oregon)
Sergiu Klainerman (Princeton University)
Igor Rodnianski (Massachusetts Institute of Technology)
Richard Schoen (Stanford University)

Program Report
Mathematical General Relativity

Piotr T. Chruściel (Vienna), Greg Galloway (Miami),
Jim Isenberg (Oregon), Richard Schoen (Stanford)

1 Introduction

The Mathematical General Relativity (MGR) program was held during the Fall Semester of 2013, at the Mathematical Sciences Research Institute in Berkeley. It brought together a diverse group of researchers, all working on various mathematical aspects of Einstein's theory of gravitation. Because of the nature of this enterprise, there were researchers participating in the program working on linear and nonlinear elliptic PDEs, linear and nonlinear hyperbolic PDEs, differential geometry, dynamical systems, geometric measure theory, numerical simulations, along with a number of other mathematical disciplines.

Einstein first formulated general relativity almost a hundred years ago, but the serious mathematical study of Einstein's theory really started about sixty years ago, with Yvonne Choquet-Bruhat's proof that Einstein's theory has a well-posed Cauchy problem. Following her work, mathematicians began to work in the field, but the influx was slow until the early 1980's when the positive mass theorem was proven, and the early 1990's when the stability of Minkowski spacetime was established.

Now mathematical general relativity has matured as a mathematical discipline, and it is an especially interesting one as a consequence of its overlap with many mathematical areas.

This was the first semester-long program at MSRI in mathematical relativity, following previous such programs in 2005 at the Newton Institute in the UK, and in 2008 at the Mittag-Leffler Institute in Sweden. The program was vibrant, reflecting the rapid growth and surging interest in mathematical relativity.

2 Research Developments

One of the main topics of study in general relativity is the analysis of initial data sets. The construction of a striking family of such data which are exactly Euclidean outside a cone of arbitrarily small angle has been carried out by A. Carlotto and R. Schoen and was announced, and described in detail, in the program workshops. The method provides a way to flatten a

general initial data set to make it Euclidean on as large a set as possible given a specific decay rate. One thus obtains examples of nontrivial initial data sets which contain asymptotically planar stable MOTS or minimal hypersurfaces. The method can be used to construct new n-body solutions of the Einstein equations. From the physical point of view, the result is more than surprising, as we witness *gravity screening*: the construction leads to initial data sets which model physical systems containing many bodies which do not feel any mutual gravitational interactions for periods of time which can be made as large as desired.

The "conformal method" provides another tool for constructing and analyzing initial data sets which satisfy the Einstein constraint equations. While the method is known to work very well for constant mean curvature (CMC) and near-CMC initial data sets, not much is known about its ability to handle data sets with general (non-CMC) mean curvature. A number of people working on this issue–James Dilts, Romain Gicquaud, Michael Holst, Jim Isenberg, David Maxwell, Caleb Meier, Rafe Mazzeo, Jeremy Leach and Ana Sakovich–were participants in this program, and significant progress was made as a result of their collaborations at MSRI. They were able to show that Holst's "far-CMC" results (with Nagy and Tsogtgerel), as well as the "limit equation" criterion for determining if the conformal method works for given sets of conformal data, extend to asymptotically Euclidean data sets, to asymptotically cylindrical data sets, and to data sets on manifolds with boundary. As well, a number of families of non-CMC conformal data for which there are multiple solutions or no solutions to the conformal constraint equations were explored. Finally, Maxwell proved the very useful result that the conformal thin sandwich method and conformal method coincide, and consequently are both conformally covariant.

During the program participants Lars Andersson, Greg Galloway and Dan Pollack made significant progress in extending to higher dimensions recent results concerning the topology of asymptotically flat initial data sets with horizon boundary and the occurence of marginally outer trapped surfaces in the initial data.

Amongst the deepest achievements of mathematical general relativity are proofs of positivity of gravitational energy. The previously known proofs were indirect, involving the analysis of apparently unrelated equations, and requiring sophisticated PDE techniques. During their stay at MSRI, Piotr Chruściel and Tim Paetz undertook to revisit the question of positivity of total energy of light-cones within a framework they recently developed for the study of the characteristic Cauchy problem. This resulted, a week after the end of the programme, in a completely elementary proof of positivity in

asymptotically Minkowskian space-times containing complete light-cones.

In addition to research devoted to studying initial data sets and the Einstein constraints equations, the program included work on the dynamical aspects of Einstein's equations. Hans Ringström discovered striking instability results for expanding spatially homogeneous solutions; these results match formal results of Beverly Berger and James Isenberg. Hans Lindblad explored a class of weak-field solutions of the Einstein equations, and showed that one has detailed control of their asymptotic behavior.

3 Organizational structure

The mathematical relativity program featured three intensive 2-5 day workshops, plus a number of activities held throughout the program. The workshops included the Connections for Women, the Introductory Workshop, and the Workshop on Initial Data and Evolution Problems in General Relativity (these are all discussed further in Section 4 below). The program-long activities included a twice weekly research seminar series, the weekly Geroch lunch seminar, the weekly Converging Spaces Reading seminar, the weekly postdoc seminar, and the MSRI-Evans Lecture series.

The twice-weekly seminar of MGR research talks was organized by Piotr Chruściel. One of the aims was to give an opportunity to the junior participants to present their results: nine speakers out of twenty-five were postdocs. Among the breakthrough results that have been presented, Friedrich described his astounding discovery that massive fields with a specific value of the mass, determined by the cosmological constant, propagate innocuously across conformal boundaries at infinity, while Lindblad explained how to obtain delicate control of the asymptotic behaviour of the gravitational field in the radiation regime.

Every week on Wednesday, a number of participants in the MGR program met for an informal lunchtime seminar. There was no set topic, nor a set speaker. The idea was that anyone attending could ask questions related to mathematical relativity, and anyone present could address the questions. The discussions were very lively, and covered a large variety of topics, including field averaging in cosmology, initial data for black hole collisions, and the relevance of classical studies of singularities for exploring a quantum theory of gravity. These informal meetings were labeled the "Geroch Seminar", recalling Bob Geroch's weekly seminar of this nature at the University of Chicago. Our Geroch seminar meetings were always well attended, and we recommend the idea to future MSRI programs.

Also meeting weekly on Wednesdays for 2 hours, the "Converging Spaces Reading Seminar" brought together people from both the MGR program and our sister program on Optimal Transport. The focus of this seminar was ideas related to convergence of Riemannian geometries, but the range of topics discussed was very wide, including the positive mass theorem in general relativity, Brakke flow, the Bray-Brendle-Neves splitting theorem, and Allard's theory of varifold regularity. This seminar is discussed further in Section 8 below.

The postdoc seminar, which met every Friday down in Evans Hall (home of the UC Berkeley Math Department), featured talks by postdoctoral members of the MGR program, as well as by some of the graduate students participating in the program. Included in this series were talks on the mass-angular momentum inequality for asymptotically Euclidean initial data sets, on the construction of far-from-CMC solutions of the Einstein constraint equations, on Type II singularities in Ricci flow, and on the first law of black hole mechanics for Einstein-Yang-Mills black holes.

In addition to these series of talks, there were talks given by MGR members as part of the MSRI-Evans series of lectures. These were presented in Evans Hall, and were generally very well attended by members of the UC Berkeley Math Department. These are discussed further in Section 8 below.

4 Workshops and conferences

The "Connections for Women: Mathematical General Relativity" workshop was the kickoff meeting for the MGR program. The two-day workshop, which took place on September 3rd and 4th, featured eleven speakers. There were a number of talks covering a wide range of topics in mathematical relativity, including the mass of asymptotically hyperbolic initial data sets, the study of marginally outer trapped surfaces via null mean curvature flow, and a vector field approach to the analysis of sharp well-posedness for quasiliner wave equations (such as the Einstein system). In addition, the Connections for Women workshop included speakers discussing recent developments in numerical relativity and astrophysics. The mixing of mathematical relativists, numerical relativists, and astrophysicists led to interesting interchanges. Consequently, the two hour discussion session at the end of the workshop was devoted to ideas on how the research of these different groups can most effectively enhance each other, and lead to a much better understanding of general relativity, cosmology, astrophysics, and the mathematics used to model these phenomena.

The workshop "Introductory Workshop: Mathematical Relativity" took place the week of September 9, 2013. The purpose of this workshop was to introduce some of the leading areas of current interest associated with problems in cosmology, the theory of black holes, and the geometry and physics of the Cauchy problem (initial data constraints and evolution) for the Einstein equations. By design, the intended audience of the introductory workshop included graduate students, postdocs, and non-experts. To enhance accessibility, several speakers were invited to give two lectures, thereby permitting a slower, more detailed, pace. Dan Pollack opened the workshop with two introductory lectures on spacetime geometry and the Einstein equations. Following that were lectures on constructing Cauchy data by the conformal method (David Maxwell) and by gluing methods (Rick Schoen), the decay of fields on black hole backgrounds, in connection with the stability of the Kerr solution (Pieter Blue), quasi-local mass (Mu-Tao Wang), cosmic censorship (Mihalis Dafermos), and the Penrose inequality (Marc Mars), in addition to others. The lecturers did an excellent job of starting off with introductory material and then leading up to topics of current research interest. Rick Schoen's preliminary presentation of his already mentioned new initial data gluing result, obtained with his student Alessandro Carlotto, generated considerable interest.

The workshop "Initial Data and Evolution Problems in General Relativity" took place in the week starting on November 18. The aim of the workshop was to review recent developments in the study of both the properties of initial data for Einstein's equations and the Einstein evolution problem, and to inspire new directions of research. Cosmic censorship, the formation and stability of black holes, and the construction of solutions of the Einstein constraint equations were some of the main topics. Eighteen lectures were held by leading researchers in the field. One of the highlights was the lecture by Gustav Holzegel, who outlined his recent proof with Mihalis Dafermos and Igor Rodnianski of the dynamical linearization stability of the Schwarzschild metric. See the workshop report for more details.

5 Postdoctoral mentoring and results

It was a pleasure to discuss mathematics with the outstanding young people who participated in our program. They worked hard, interacted intensely with each other and with the senior participants, wrote excellent papers and developed new collaborations. All were mentored by senior participants in the program.

1. Semyon Dyatlov graduated at UC Berkeley and is currently holding a five-years Clay Research Fellowship at MIT. Mutual benefit was drawn from many discussions with several members of the program. He is likely to play a major role in studies of wave equations on black hole spacetimes in the future.

2. Nick Haber graduated from Stanford, and is currently holding a seven-months Research Fellowship at McGill. He initiated two new collaborations, as well as a few other projects, and worked on preparing his thesis for publication.

3. Davi Maximo graduated from the University of Texas at Austin, and is currently holding a three years position as Szego Assistant Professor at Stanford. His research interests overlapped with both programs. While at MSRI, he finished writing a paper and initiated two new collaborations.

4. Kristen Moore graduated from Free University Berlin under the direction of Gerhard Huisken. She had a one-year postdoctoral position in Potsdam before coming to MSRI and is currently holding a 6 months lecturership at Stanford. She was an active participant of both programs, giving in particular an excellent Evans Hall lecture on her thesis. Her research is focused on geometric aspects of the Einstein equations; specifically spacelike surface flows in four dimensional Lorentz manifolds.

5. Anna Sakovich graduated from the Royal Institute of Technology in Stockholm. She has been a Visiting Teacher at Linköping University before joining the programme, and holds currently a two-years postdoctoral position in Golm, Germany. At MSRI she worked on three papers, two of which are based on collaborations initiated at MSRI.

6. Volker Schlue graduated from the University of Cambridge. He came to MSRI after having held a postdoctoral position in Toronto, and is now on a seven-month postdoctoral fellowship in Princeton. He finished a manuscript and worked on several further projects, including a collaboration which arose out of discussions with his MSRI mentor, Hans Lindblad.

7. Carlos Vega graduated from the University of Miami. As a result of his interactions with C. Sormani during the program, pertaining to convergence of manifolds in the Lorentzian setting, he has been

invited to visit CUNY on a postdoctoral position for the Spring of 2014. During the program he was able to extend his thesis work in important new directions, and initiate new collaborations.

8. Haotian Wu graduated from the University of Texas at Austin. He is currently holding a three-years Visiting Assistant Professorship at University of Oregon in Eugene. He finished writing a paper and initiated two new collaborations. In addition to discussing his work on neckpinch singularities in Ricci flow with others at the program, he renewed his interest in mathematical relativity, which he worked on as an undergraduate at Lafayette College.

9. Xin Zhou graduated from Stanford University and is currently a Moore Instructor at MIT, for the coming two and half years. He has been finishing previous projects, and developed ideas for new directions of research in discussions with other members of the program. During the program he prepared (in consultation with his advisor and MSRI mentee) and submitted an NSF research proposal.

6 Graduate students

The graduate students were actively involved in the program, including attendance of the seminar and workshop lectures as well as direct interaction with the members including senior participants. Several (including Stephen McCormick, Shiwu Yang, and Daniel Jackson) gave lectures in the Postdoc Seminar. The program provided a unique opportunity for the students to meet and interact with active researchers in the field. This will certainly help them launch their research careers successfully.

Alessandro Carlotto gave a lecture on Positive Mass Theorems in the Sormani seminar which was very well received. He is a joint author with R. Schoen on the work described above concerning new constructions of vacuum initial data sets. This work was conceived before the program began, but was substantially expanded and improved during the program.

James Dilts was a very active graduate student participant who interacted with many of the members, particularly in the area of solving the constraint equations. During the program, he worked on generalizing both the far-from-CMC approach and the limit equation criterion to asymptotically Euclidean, asymptotically cylindrical, and manifold with boundary initial data sets. As a result of these collaborations, Dilts was offered a future post doc position in Holst's group at UC San Diego.

Tim Paetz, a graduate student from Vienna, worked on preparing for publication two papers based on the results of his thesis. Following inspiring discussions at MSRI with Semyon Dyatlov and Robert Wald, a study with Piotr Chruściel of the energy associated with null hypersurfaces was initiated. One of the fall-outs of this is the already-mentioned simple proof of positivity of mass.

7 Diversity

We were pleased to host for a month Roger Tagne Wafé from University of Douala, Cameroon, who collaborated with Piotr Chruściel on the question of existence of solutions of the characteristic Cauchy problem for a wide class of nonlinear evolution equations. A paper containing the results of this work will be available shortly. Further enhancing the interaction of the MGR program with researchers from Africa, Calvin Cadmon from South Africa and Jean Baptiste Patenou from Cameroon presented posters at the workshops.

Carlos Vega, a Cuban-American from Miami, was a very active participant in the MGR program. Through connections established at the program, Carlos will begin a post-doctoral position in New York. There are very few Cuban-American researchers in mathematical relativity; he provides a tie to this community.

Women played an important and influential role in the MGR program. Yvonne Choquet-Bruhat, whose work on the well-posedness of the initial value problem for general relativity was essentially the starting point for mathematical relativity over 60 years, was an organizer of the program. While age (she has just turned 90) prevented her from attending, her influence was strong throughout the program.

The Connections for Women workshop brought a number of the leading researchers in general relativity to MSRI, including numerical relativists and astrophysicists as well as researchers working in mathematical relativity. A number of potential collaborations were established involving women doing numerical relativity and mathematical relativists were established.

Lydia Bieri, a leading researcher working on both the mathematics and the physics of general relativity, has taken the leadership role in establishing the Website for Women in Mathematical Relativity. It is hoped that this website will be helpful in sustaining the network of women working in mathematical relativity.

8 Synergistic aspects

The two programs, Mathematical General Relativity (MGR) and Optimal Transport (OT), had much in common in terms of mathematical methods including nonlinear partial differential equations and geometric methods. Both programs had a strong emphasis on the mathematics of physical problems. As a result there were many lectures that were of interest to both groups, and both the seminar and workshop lectures were well attended by a diverse audience.

Christina Sormani, a member jointly with the Optimal Transport Program, organized a very successful reading seminar on Converging Spaces, which involved participants from both programs. The seminar covered key papers related to the weak convergence of manifolds, such as Gromov-Hausdorff and Intrinsic Flat convergence of Riemannian manifolds and varifold and current convergence of submanifolds. The seminar also covered papers which applied these notions, in particular the Schoen-Yau proof of the Positive Mass Theorem in dimension three and recent work of Eichmair concerning Jang's equation.

From MGR there were four members who gave MSRI-Evans Hall Lectures. The first was Greg Galloway, whose title was 'On the topology of black holes and beyond'. His lecture described what black holes are in General Relativity and in higher dimensional gravity. He went on to describe the way in which the Einstein equations impose topological restrictions both on the black holes and on the region in their exterior.

Hans Ringström gave an MSRI-Evans Hall Lecture entitled 'On the topology and future stability of the universe'. He spoke about the current cosmological models and their explanation in terms of the Einstein-Vlasov equations. He then discussed recent results on the stability of such models.

Kristen Moore gave an MSRI-Evans Hall Lecture entitled 'Inverse mean curvature flow, black holes and quasi-local mass'. In it she gave a description of the inverse mean curvature flow and the important role it has played in MGR including the proof of the Riemannian Penrose Inequality and its use in gaining information about quasi-local mass notions. She then described a spacetime version of the inverse mean curvature flow which has the potential to significantly extend these applications.

Vincent Moncrief gave an MSRI-Evans Hall lecture entitled 'Could the universe have an exotic topology?' In this talk he suggested that the commonly observed aspects of homogeneity and isotropy for the universe can only be observed locally, and are consistent with a much larger class of topologies than the Friedman, Robertson-Walker models. He then described

a dynamical mechanism under which an expanding solution will be dominated by homogeneous and isotropic regions.

There were two postdocs common to both programs, Davi Maximo and Kristen Moore. Davi actively participated in both programs and interacted with senior people from both of them. He worked on a new construction of free boundary minimal surfaces in convex domains in R^3, and wrote an interesting paper constructing such a surface of annular topology in any convex domain. Kristen Moore was also an active participant in both programs. Her research focused mainly on geometric aspects of the Einstein equations, specifically spacelike surface flows in four dimensional Lorentz manifolds.

9 Nuggets and breakthroughs

One of the most fascinating results, conceived before the meeting but developed, discussed, and first presented at MSRI, was the proof by Carlotto and Schoen that *gravity can be screened away*: it has been shown for the first time that it is possible to construct space-times where bodies do not feel mutual gravitational interactions for periods of time which can be made as large as desired. This should be contrasted with Newton's theory of gravitation, where the presence of any massive object is immediately felt by all other massive objects via the gravitational field.

Amongst the deepest achievements of mathematical general relativity are proofs of positivity of gravitational energy. The previously known proofs were extremely indirect, requiring sophisticated techniques of the theory of partial differential equations. As a direct result of studies started and MSRI, Chruściel and Paetz were able to give a completely elementary proof of positivity of total energy of gravitating systems in asymptotically Minkowskian space-times in which the light rays emanating from space-time points do not intersect at caustics.

One of the key directions of research in general relativity is the study of the global dynamical behaviour of space-times. The main concern here is the formation of singularities, which are regions of space-times where every observer is crushed by infinite forces resulting from distortion of space-time fabric. While at MSRI, Ringström discovered and described in detail striking instabilities in the dynamical behavior of space-times: the stripping of each successive layer of symmetry of the space-times considered leads to completely new dynamical behaviour.

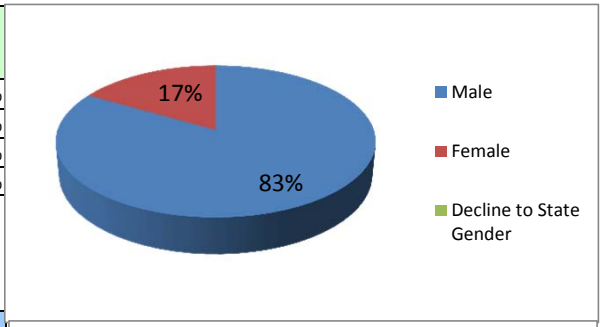
Postdoc Pre/Post-MSRI Institution Group

Family Name	First Name	Pre-MSRI Institution Group	Post-MSRI Institution Group	Pre-MSRI Institution Name	Placement Institution Name
Haber	Nick	Group I Private	Foreign	Stanford University	McGill University
Sakovich	Anna	Foreign	Foreign	Linkoping, Sweden	Max Planck, Germany
Schlue	Volker	Foreign	Group I Private	University of Toronto	Princeton University
Vega	Carlos	Group II	Group I Public	University of Miami	CUNY
Wu	Haotian	Group I Public	Group I Public	University of Texas, Austin	University of Oregon
Zhou	Xin	Group I Private	Group I Private	Massachusetts Institute of Technology	Massachusetts Institute of Technology

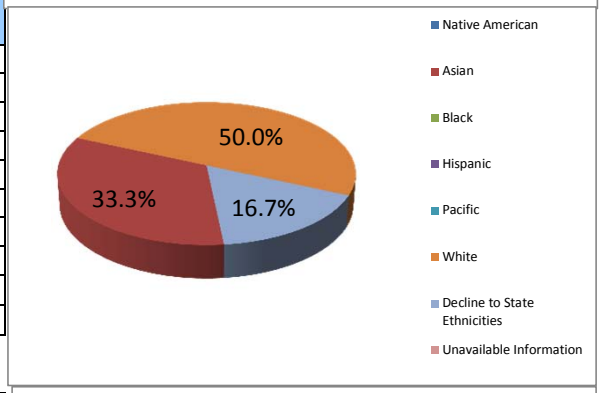
2013–14 Postdoctoral Fellows Demographic Summary

Gender	#	% (No Decl.)*	%
# of Members	6		100.0%
Male	5	83.33%	83.3%
Female	1	16.67%	16.7%
Decline to State Gender	0		0.0%

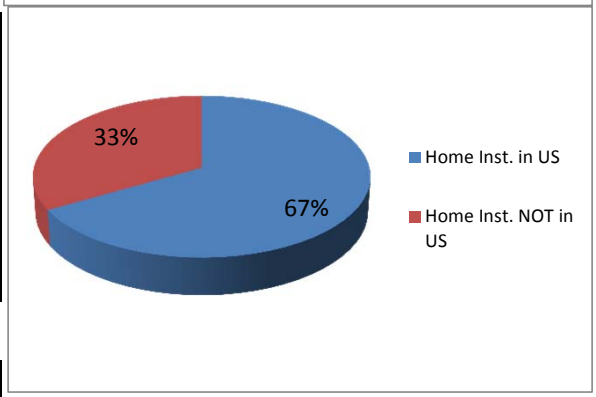
Members are distinct within each academic year.



Ethnicities	#	% (No Decl.)*	%
Native American	0	0.00%	0.0%
Asian	2	40.00%	33.3%
Black	0	0.00%	0.0%
Hispanic	0	0.00%	0.0%
Pacific	0	0.00%	0.0%
White	3	60.00%	50.0%
Decline to State Ethnicities	1		16.7%
Unavailable Information	0		0.0%
Minorities	0		0.0%

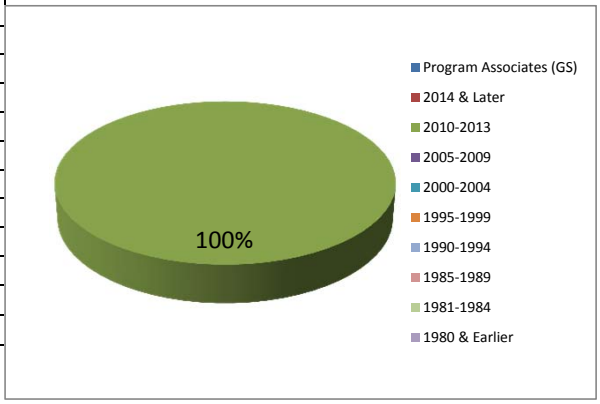


Citizenships	#		%
US Citizens & Perm. Residents	2		33.3%
Foreign	4		66.7%
Unavailable information	0		0.0%
# of Members	6		100.0%
US Citizens	2		33.3%
Perm Residents	0		0.0%
Home Inst. in US	4		66.67%



Year of Ph.D	#		%
Program Associates (GS)	0		0.0%
2014 & Later	0		0.0%
2010-2013	6		100.0%
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 Members	6		100.0%

**Statistic Calculation based on all members who did not decline to state.*



Mathematical General Relativity

Program Summary

Role	# of Distinct Members	%	# of Citizens & Perm. Res.	%	US Citizens	# of Female	%	# of Minorities[1]	%
Organizers	6	9.0%	4	66.7%	4	0	0.0%	0	0.0%
Research Professors	12	17.9%	7	58.3%	5	1	8.3%	0	0.0%
Postdoctoral Fellows	6	9.0%	2	33.3%	2	1	16.7%	0	0.0%
PD/RM	6	9.0%	2	33.3%	2	2	33.3%	0	0.0%
Research Members	25	37.3%	12	48.0%	10	4	16.0%	0	0.0%
Program Associates	12	17.9%	2	16.7%	2	3	25.0%	0	0.0%
Total # of Distinct Members	***67***	***100%***	***29***	***43%***	***25***	***11***	***16%***	***-***	***0.0%***

[1] *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.*

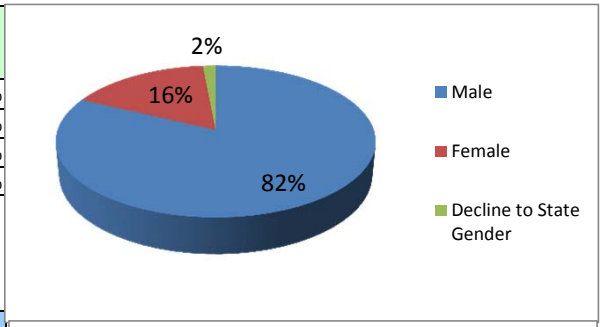
Home Institute Grouping

	US								
Role	**Group I Private**	**Group I Public**	**Group II**	**Group III**	**Group IV**	**Group M**	**Non-Group**	**Foreign**	**Total**
Organizers	2	1	1	0	0	0	0	2	6
Research Professors	3	2	0	0	0	0	1	6	12
Postdoctoral Fellows	2	1	1	0	0	0	0	2	6
PD/RM	2	2	0	0	0	0	0	2	6
Research Members	1	3	2	2	0	1	2	14	25
Program Associates	1	3	0	0	0	0	0	8	12
Total	**11**	**12**	**4**	**2**	**-**	**1**	**3**	**34**	**67**
%	***16.4%***	***17.9%***	***6.0%***	***3.0%***	***0.0%***	***1.5%***	***4.5%***	***50.7%***	***100.0%***

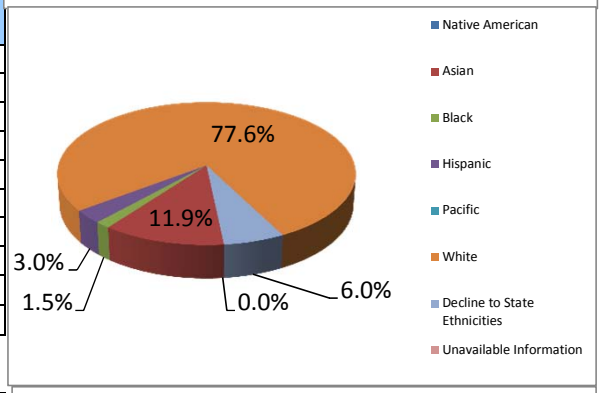
2013–14 Program Members Demographic Summary

Gender	#	% (No Decl.)*	%
# of Members	67		100.0%
Male	55	83.33%	82.1%
Female	11	16.67%	16.4%
Decline to State Gender	1		1.5%

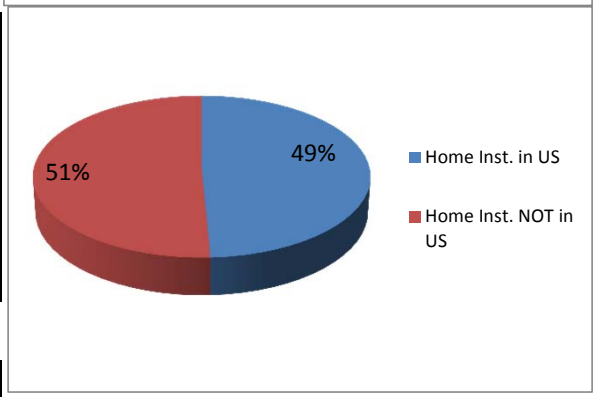
Members are distinct within each academic year.



Ethnicities	#	% (No Decl.)*	%
Native American	0	0.00%	0.0%
Asian	8	12.70%	11.9%
Black	1	1.59%	1.5%
Hispanic	2	3.17%	3.0%
Pacific	0	0.00%	0.0%
White	52	82.54%	77.6%
Decline to State Ethnicities	4		6.0%
Unavailable Information	0		0.0%
Minorities	0		0.0%

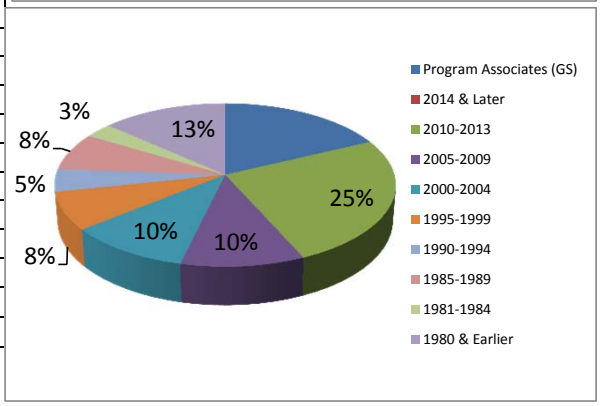


Citizenships	#		%
US Citizens & Perm. Residents	29		43.3%
Foreign	38		56.7%
Unavailable information	0		0.0%
# of Members	67		100.0%
US Citizens	25		37.3%
Perm Residents	4		6.0%
Home Inst. in US	33		49.25%



Year of Ph.D	#		%
Program Associates (GS)	12		17.9%
2014 & Later	0		0.0%
2010-2013	17		25.4%
2005-2009	7		10.4%
2000-2004	7		10.4%
1995-1999	5		7.5%
1990-1994	3		4.5%
1985-1989	5		7.5%
1981-1984	2		3.0%
1980 & Earlier	9		13.4%
Unavailable Info.	0		0.0%
Total # of Members	67		100.0%

**Statistic Calculation based on all members who did not decline to state.*



RESPONSIBLE CONDUCT OF RESEARCH (RCR) TRAINING CERTIFICATION FORM

Effective January 4, 2010, when submitting new research proposals to the National Science Foundation (NSF), UC Berkeley will be required to certify that the campus has a plan in place for providing education and training in the Responsible Conduct of Research (RCR) to all students (undergraduate and graduate) and postdoctoral scholars who will be supported by those grants to conduct research. This RCR training is required under the America COMPETES Act. While training plans are not required to be included in proposals submitted to NSF, institutions are advised that they are subject to review upon request. See http://rac.berkeley.edu/rcr.html for more information.

Instructions: Principal Investigators (PIs) must certify on a per award basis, that all students and postdoctoral scholars supported by his or her NSF award have completed RCR training **within 60 days of the individual's becoming supported by NSF funding**. This certification document must be submitted to the Research Administration and Compliance Office, c/o Rebecca Armstrong - RCR Coordinator, **initially within 90 days of the award being made; and annually thereafter on the anniversary date of the award for the duration of the project, updating any additions of students and postdocs since the last report and certifying the training has occurred as required**.

As Principal Investigator/Project Director, I certify that I have read and understand the National Science Foundation's requirement on Responsible Conduct of Research (RCR) training, and I certify the following:

Project Title: Mathematical Sciences Research Institute (MSRI)
Fall 2013 Programs - Postdoctoral Fellowships

NSF Award Number: 0932078

☒ All students (undergraduate and graduate) and postdoctoral scholars who are supported by the grant to conduct research have been trained in the Responsible Conduct of Research within 60 days of beginning work on this project. (Please complete the next two sections; continue on additional page if necessary.)

- Provide name(s) of students and postdoctoral scholars and title(s) of RCR education program(s) completed, and check the correct box for UCB status (undergraduate, graduate, or postdoc):

Name(s) of students and postdoctoral scholars:	UCB Status: UG | G | PD	Education program(s) completed:
Shibing Chen	☐ | ☐ | ☒	Collaborative Institutional Training Initiative (CITI)
Matthias Erbar	☐ | ☐ | ☒	Collaborative Institutional Training Initiative (CITI)
Nick Haber	☐ | ☐ | ☒	Collaborative Institutional Training Initiative (CITI)
Emanuel Indrei	☐ | ☐ | ☒	Collaborative Institutional Training Initiative (CITI)
Jun Kitagawa	☐ | ☐ | ☒	Collaborative Institutional Training Initiative (CITI)
Davi Maximo	☐ | ☐ | ☒	Collaborative Institutional Training Initiative (CITI)
Kristen Moore	☐ | ☐ | ☒	Collaborative Institutional Training Initiative (CITI)

- If any RCR education program(s) or activities were used other than the UC System Handout for Undergrads or the UCB CITI Program for graduate students and posdocs, then provide brief, one-sentence description(s) of the RCR education program(s) or activities:

☐ No additional students or postdocs are or have been supported since previous certification for this project.

Principal Investigator Name: David Eisenbud
(Please type or print.)

PI Signature

Date: 9/30/13

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Name(s) of students and postdoctoral scholars:	UCB Status: UG | G | PD	Education program(s) completed:
Anna Sakovich	☐ | ☐ | ☒	Collaborative Institutional Training Initiative (CITI)
Volker Schlue	☐ | ☐ | ☒	Collaborative Institutional Training Initiative (CITI)
Carlos Vega	☐ | ☐ | ☒	Collaborative Institutional Training Initiative (CITI)
Haotian Wu	☐ | ☐ | ☒	Collaborative Institutional Training Initiative (CITI)
Ling Xiao	☐ | ☐ | ☒	Collaborative Institutional Training Initiative (CITI)
Jinxin Xue	☐ | ☐ | ☒	Collaborative Institutional Training Initiative (CITI)
Xin Zhou	☐ | ☐ | ☒	Collaborative Institutional Training Initiative (CITI)

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Principal Investigator Name: David Eisenbud
(Please type or print.)

D Eisenbud
PI Signature

9/30/13
Date

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- Provide name(s) of students and postdoctoral scholars and title(s) of RCR education program(s) completed, and check the correct box for UCB status (undergraduate, graduate, or postdoc):

Name(s) of students and postdoctoral scholars:	UCB Status: UG | G | PD	Education program(s) completed:
Zahra Sinaei	☐ | ☐ | ☒	Collaborative Institutional Training Initiative (CITI)
	☐ | ☐ | ☐	
	☐ | ☐ | ☐	
	☐ | ☐ | ☐	
	☐ | ☐ | ☐	
	☐ | ☐ | ☐	
	☐ | ☐ | ☐	

- If any RCR education program(s) or activities were used other than the UC System Handout for Undergrads or the UCB CITI Program for graduate students and posdocs, then provide brief, one-sentence description(s) of the RCR education program(s) or activities:

☐ No additional students or postdocs are or have been supported since previous certification for this project.

Principal Investigator Name: David Eisenbud (Please type or print.)

D Eisenbud
PI Signature

9/30/13
Date

MSRI
Mathematical Sciences Research Institute

17 Gauss Way Berkeley, CA 94720-5070 p: 510.642.0143 f: 510.642.8609 www.msri.org

Optimal Transport: Geometry and Dynamics

August 19, 2013 to December 20, 2013
MSRI, Berkeley, CA
USA

Organizers:

Luigi Ambrosio (Scuola Normale Superiore)
Yann Brenier (École Polytechnique)
Panagiota Daskalopoulos (Columbia University)
Lawrence Evans (University of California, Berkeley)
Alessio Figalli (University of Texas)
Wilfrid Gangbo (Georgia Institute of Technology)
LEAD Robert McCann (University of Toronto)
Felix Otto (Max-Planck-Institut für Mathematik)
Neil Trudinger (Australian National University)

MSRI FINAL REPORT ON FALL 2013 PROGRAM:

OPTIMAL TRANSPORT: GEOMETRY AND DYNAMICS

ORGANIZING COMMITTEE:

Luigi Ambrosio (Pisa), Yann Brenier (Paris),
Panagiota Daskalopoulos (New York), Lawrence C. Evans (Berkeley),
Alessio Figalli (Austin), Wilfrid Gangbo (Atlanta),
Robert McCann (Toronto), Felix Otto (Leipzig),
Neil Trudinger (Canberra).

1. Introduction

In the past two decades, the theory of optimal transportation emerged as a fertile field of inquiry, and a diverse tool for exploring applications within and beyond mathematics. This transformation occurred partly because long-standing issues could finally be resolved, but also because unexpected connections emerged which linked these questions to classical problems in geometry, partial differential equations, nonlinear dynamics, natural sciences, design problems and economics. The Fall 2013 MSRI program **Optimal Transport: Geometry and Dynamics** gathered many leading experts in optimal transport and areas of potential application together with an emerging generation of young researchers to disseminate progress, catalyze new investigations and collaborations, and invigorate ongoing exploration.

2. Research Developments

2.1. **Optimal transport.** The Monge-Kantorovich optimal transportation problem can be caricatured as the problem of pairing two given distributions of factories and mines, so as to minimize total transportation costs. In spite of much progress, a number of fundamental questions concerning this problem remain open. For example, when the mines and factories are distributed continuously over compact manifolds on which the cost function is smooth, is there is a unique way to solve this problem? Except when one of the domains is a sphere (or contractible), no such criterion is known. This topic was the focus of investigations at MSRI by Ludovic Rifford and Robert McCann, two of the Simons and Eisenbud Professors for the program. Although a general criterion remains elusive, they were successful in construction examples of costs on manifolds of arbitrary topology for which the desired uniqueness is true. They were also able to adapt an argument of Mañe and Bernard to show uniqueness is true for any fixed pair of measures and a generic smooth cost. The more general problem has intriguing connections

to dynamical systems which they continue to pursue, but simplifies surprisingly when one of domains is a 2-dimensional torus.

2.2. **Numerics.** On the algorithmic side, there is a need for efficient numerical approaches to optimal transportation problems. Research Professor Gerard Awanou spent his time at MSRI focusing on the convergence analysis of standard discretizations for the Dirichlet problem for the Monge-Ampère equation, with the goal of clarifying how standard tools, such as finite-element methods, can be brought to bear on the numerical resolution of the transportation with quadratic costs.

2.3. **Multi-marginal partial transport.** Recent interest in multi-marginal transportation (matching N distributions of mass instead of just two) has been stimulated in part by emergent connections to semi-classical limits of the quantum many-body problem. Brendan Pass and Jun Kitagawa tackled the partial transport variant of this, in which one tries to match up an optimally chosen fraction of the N distributions. The also explored a barycenter version, in which one wants to design an $(N+1)$st distribution which interpolates between parts of the N given distributions in an optimal way. Their problem can be interpreted in terms of a company building a particular type of good, whose production requires the consumption of N different types of resources (say iron, aluminum, and nickel). Knowing the distributions of availability of these various resources in Euclidean space, the company wishes to optimal place a distribution of factories to engage in production. Assuming shipping costs are quadratic in the distance shipped, they were able to establish uniqueness of the optimal plan, while demonstrating that a number of its properties known to hold in case $N = 2$ (such as monotonicity with respect to production level) can fail for $N \geq 3$.

2.4. **Applications to quantum and statistical physics.** Density functional theory (DFT) was explored by several MSRI researchers, including Program Associate Maria Colombo, and Research Members Codina Cotar and Brendan Pass. DFT is a quantum mechanical theory of electrons which constitutes a large and very active research area in physics and chemistry. It has been recently shown that in a natural scaling limit, the celebrated Hohenberg-Kohn density functional from DFT reduces to an optimal transport problem in which the Coulomb cost models the self-repulsion of the electron cloud. In joint work with Gero Friesecke, Cotar and Pass, worked on a paper which combines methods from optimal transport and probability theory to provide new and improved conditions on N-representability. This is one of the main outstanding issues arising in DFT: it seeks to characterize

those two-particle density matrices which can arise as projections from anti-symmetric N-particle wave functions.

Cotar also focused her efforts on introducing optimal transport methods to a number of important models in statistical mechanics, such as gradient interface models and the Ising model. These appear in the study of phase transitions of lattice gases, elasticity, the Cauchy-Born rule etc. Tools such as the Brascamp-Lieb, log-Sobolev, and concentration inequalities play an important role in the analysis of many such models, but new ideas are also required.

2.5. **Geometry.** Optimal transportation is now known to enjoy intimate connections with various notions of curvature — sectional, Ricci and mean. Along with John Lott and Karl-Theodor Sturm, Clay Senior Scholar Cédric Villani was one of the originators of an optimal transport based theory of Ricci curvature / dimension lower bounds in metric-measure spaces which possess geodesics. Exposing this theory is one of the raison d'etres of his encyclopedic tome *Optimal Transport: Old and New* (2009). During the MSRI semester, Villani undertook to prepare a second edition of the book, incorporating a new chapter on Riemannian CD(K,N) spaces which culminates in Nicola Gigli's extension of the Cheeger-Gromoll splitting theorem. To facilitate the preparation of this second edition, Villani organized a reading course for graduate students and postdoctoral participants based related materials which was undoubtedly one of the high points of the semester. It is described in some detail in the section on Graduate Students, below.

2.6. **Isoperimetric inequalities on Cartan-Hadamard manifolds.** Optimal transport methods provide the simplest known proof of the Euclidean isoperimetric inequality. Inspired by this, a working group of researchers at MSRI led by Ludovic Rifford, Alessio Figalli and Young-Heon Kim decided to tackle the celebrated Weil conjecture, which asserts that in any simply connected manifold of non-negative sectional curvature the isoperimetric inequality should hold with the same constant as in Euclidean space. The conjecture has been settled affirmatively in dimensions 2, 3 and 4 by Weil, Kleiner and Croke respectively. The working group, which included postdoctoral researchers Jinxin Xue and Yi Wang, reviewed previous approaches to the question including Croke's result in dimension 4, Kleiner's result in dimension 3, and other methods proposed by Gromov, Cabre, Trudinger and Spruck, using conformal geometry and curvature flows. Their study of a linear programming approach pioneered by Kloeckner and Kuperberg, led to the discovery of new and relevant constraints.

2.7. **Notions of convergence and compactness.** Professor Christina Sormani led a working group which studied notions of convergence, compactness and lower Ricci-curvature bounds in metric-measure spaces. She completed a preprint applying results of Ambrosio and Kirchheim to establish a stronger relationship between intrinsic flat and Gromov-Hausdorff convergence. In it, she proves that sequences of uniformly bounded Lipschitz functions with uniformly bounded Lipschitz constants whose domains converge in the intrinsic flat sense have a limit function. These results have interest in connection with the development of a Lorentzian intrinsic flat convergence which Prof. Sormani has been working on with Prof. Andersson and Dr. Vega of MSRI's Mathematical General Relativity program.

A number of other research projects emerged from this working group. Professors Wei and Sormani began the exploration of a notion of intrinsic varifold convergence, based on Professor Sturm's Wasserstein distance between metric measure spaces. Sormani guided postdocs M Erbar and S Lakzian to begin working together on the adaption of Wenger's Intrinsic Flat Compactness Theorem to prove a new compactness theorem for Sturm's Wasserstein distance. And she suggested that postdocs J Xin and Z Sinaei study the convergence of minimal surfaces and harmonic maps respectively. All four of these postdocs as well as other young mathematicians affiliated with the General Relativity program were active participants in the working group.

2.8. **Ricci bounds in discrete settings.** The Lott-Villani-Sturm theory of Ricci curvature / dimension bounds referred to above is set it geodesic spaces. It does not adapt well to discrete settings, because the Renyi-entropy upon which it is based does not have the desired convexity along discrete geodesics. It has remained an outstanding open problem to formulate a satisfactory curvature-dimension criterion for discrete spaces. Curvature-dimension bounds have a number of important consequences, such as log-Sobolev, spectral gap, and concentration inequalities.

In joint work initiated at MSRI, Jan Maas and Matthias Erbar succeeded to define a curvature-dimension criterion for discrete spaces. This notion relies on a dimensional refinement of the so-called *evolution variational inequality*. Among their results are sharp functional inequalities for discrete systems as well as a tensorization result for their curvature-dimension condition.

In further work initiated at MSRI with Simons Institute visitor Prasad Tetali, the same two postdoctoral visitors investigated Ricci curvature bounds for various discrete models where interactions are

present. Among their results are bounds (of the optimal order) for the Bernoulli-Laplace model and for the random transposition walk on the permutation group. They are optimistic that their techniques can also be applied to models like e.g. Kac's random walk on the sphere.

Finally, postdoctoral visitor Martin Huesmann teamed up with Erbar to establish and compare different notions of (Riemannian) curvature bounds for configuration spaces Y. These consist of locally finite counting measures over a base space X, which can have globally infinite mass unless X is compact. If X is a Riemannian manifold, different aspects of its Riemannian structure were lifted to Y in 1998 constructions of Albeverio, Kondratiev, Röckner and Schied. The Poisson measure, Dirichlet energy and 2-Wasserstein distance from optimal transportation all play a role. Motivated by a desire to understand how curvature properties are inherited by the configuration space from the base space, Erbar and Huesmann managed to establish several different manifestations of curvature bounds, such as gradient estimates and Wasserstein contraction estimates and the K-convexity of the entropy. Moreover, they were able to prove the evolution variational inequality for the configuration space.

This progress towards a theory of curvature-dimension conditions in discrete settings represents one of the most fundamental advances made during the program.

2.9. **Hamilton-Jacobi dynamics in infinite-dimensional spaces.** Turning from geometry to dynamical systems, an active topic of research by several program visitors was the theory Hamilton-Jacobi equations (HJE) set in the space of measures. These are infinite-dimensional, differential equations such as

$$\partial_t \mathcal{U} + \frac{1}{2}||\nabla_\mu \mathcal{U}||^2_{L^2(\mu)} + \mathcal{V}(\mu) = 0, \quad (\mu, t) \in \mathcal{P}_2(\mathbb{R}^d) \times (0, \infty). \tag{1}$$

Here $\mathcal{V} : \mathcal{P}_2(\mathbb{R}^d) \to \mathbb{R}$ is given and the unknown is a function $\mathcal{U} : \mathcal{P}_2(\mathbb{R}^d) \times [0, \infty) \to \mathbb{R}$. These equations arise in a variety of contexts including the Euler-Poisson model for a gravitating fluid.

Building on recent work by researchers such as Luigi Ambrosio, Jin Feng, Wilfrid Gangbo, and Adrian Tudorascu, Ryan Hynd was able to provide a relatively simple uniqueness theorem for (strict) viscosity solutions. Specifically, with the aid of Ekeland's variational principle and the positive curvature property of the space $\mathcal{P}_2(\mathbb{R}^d)$, he verified that a variant of the classical Crandall-Lions "variable doubling" argument applies in this abstract setting. He hopes that these ideas can be extended to develop a full theory of HJE in the space of measures.

2.10. **Mean Field Games.** A more complicated variant of (1) plays a central role in the theory of Mean Field Games (MFG) theory pioneered by Lasry and Lions. Called the *master equation*, it is a non-local equation set on the torus rather than $\mathbb{R}^d$, and $\mathcal{U}$ depends on $q \in \mathbb{T}^d$ as well as on $\mu \in \mathcal{P}(\mathbb{T}^d)$. It has attracted an increasing level of attention from the PDE community, and retained a fascination in part because its non–local character defies any suitable definition of viscosity solution, therefore begging the question of whether and in what sense the initial value problem can be solved. Lasry and Lions do not specify in which sense the master equation is supposed to be satisfied, nor have they disclosed any proof of existence of a solution. In work in progress with A. Swiech on the special case in which $\mathcal{V}(q, \mu) = V(q) + W * \mu$, Wilfrid Gangbo (and independently Ambrosio–Feng) have introduced a concept of metric viscosity solution on an arbitrary metric space, and proved existence and uniqueness of solution in that context, assuming $V, W \in C^2(\mathbb{T}^d)$. They were also able to completely characterize the solution of a related equation. This makes a remarkable unexpected connection between two fields of research, which over the past several years, have been developed independently by two different communities pursuing unrelated goals using completely different methods.

2.11. **Fluid mechanics and weather forecasting.** Problems in fluid mechanics absorbed the attention of several MSRI Visiting Research Members, such as Boris Khesin and Mike Cullen. With a postdoctoral collaborator, Khesin focused on the classification of coadjoint orbits of the group of area-preserving diffeomorphisms for any closed two-dimensional surface. This classification problem is related to Arnold's stability criterion for 2D fluid flows and well-known to specialists. He also collaborated with S. Kuksin and D. Peralta-Salas on the development of a KAM-type theory for near-steady Euler solutions. They showed that the dynamical system defined by the hydrodynamical Euler equation on any closed Riemannian 3-manifold is not mixing in the C^k topology ($k > 4$) for any prescribed value of helicity and a sufficiently large value of energy.

Mike Cullen (of the UK's Royal Meteorological Office) worked on several projects at MSRI related to weather forecasting, concerning both theoretical and practical aspects. On the theoretical side, with Beatrice Pelloni he extended his previous work with Yann Brenier to a proof that solutions of the Navier-Stokes equations converge to those of the semi-geostrophic equations for rotating stratified 3d flow in an appropriate asymptotic limit. Although the result is subject to some (presumably artificial) restrictions, it is still a significant step forward.

With Wilfrid Gangbo and Marc Sedjro he submitted a paper using optimal transport methods to solve an axisymmetric flow problem relevant to both tropical cyclones and tropical variability. On the more practical side he studied methods of generating forecast ensembles in support of data assimilation. The ensembles need to represent the errors in the forecasts, so that the correct blend of observed and forecast data can be made. A particular issue is the need to allow for model error. He significantly advanced his understanding of the relation between stochastic and variational data assimilation, theories which appear to give contradictory messages. He shows in particular that it is not possible to use observations to estimate model error from observations at the same time as doing data assimilation.

2.12. **Hyperbolic balance laws and tumor growth.** During her stay at MSRI, Research Professor Konstantina Trivisa completed and submitted two long term projects.

The first of these concerned relaxation approximations to systems of hyperbolic balance laws. Such approximations are essential for investigating models arising in continuum mechanics and the kinetic theory of gases, and can serve as a basis for the design of numerical schemes for such models. By introducing a new class of relaxation schemes, Professor Trivisa was able and establish their stability, convergence, and rate of convergence to the solution of the hyperbolic balance laws before the formation of shocks. Her article is the first step towards the construction of fully discrete schemes and the development of numerical methods for the approximation of solutions to complex nonlinear multidimensional systems of hyperbolic balance laws arising in applications.

Her second project involved a nonlinear mixed model for tumor growth. The key characteristic of these type of tumor growth models is that the different populations of cells are continuously present everywhere in the tumor at all times. Her preprint focuses on the evolution of tumor growth in the presence of proliferating, quiescent and dead cells as well as a nutrient. The system is given by a multi-phase flow model governed by transport equations for the evolution of the cell population densities and the Brinkman equation for the evolution of the velocity field. The tumor is described as a growing continuum Ω with boundary $\partial\Omega$, both of which evolve in time. Global-in-time weak solutions are obtained using an approach based on penalization of the boundary behavior, diffusion and viscosity in the weak formulation. Her framework relies on biologically grounded principles which are motivated by experiments performed by Roda *et al*, and provides a

description of the dynamics of the population of cells within the tumor. The MSRI program also stimulated her to determine whether or not this tumor growth model can be formulated as a gradient flow in future work, and to explore the implications of this for structure and pattern formation.

2.13. **Works-in-progress.** In addition to the works sketched above, many visitors completed preprints while at MSRI or initiated new collaborations.

For example, R. McCann completed and submitted two projects including a new approach to linear programming duality through quadratic penalization (with Jonathan Korman and Christian Seis), and computing the spectrum of a fourth-order family of evolution equations spanning the thin-film and quantum drift-diffusion equations (with Christian Seis). He also made good progress writing up the discovery of a phase-transition which occurs in the wage profile of the most talented teachers in a certain model coupling the academic and labor markets, depending on model parameters which measure the overall effectiveness of education. L.C. Evans finished writing a paper explaining why optimal paths for a random turn game converge as the step size goes to zero to asymptotic curves (=curves whose geodesic curvature equals total curvature) on the graph of the solution to the infinity Laplacian PDE, and reworked and reformulated a famous paper on principal/agent problems by Sannikov. J. Lott finished the research for a paper on "Tangent cones and parallel transport in Wasserstein space". The motivation is to better understand the metric geometry of the space of probability measures with the W_2 Wasserstein metric from optimal transportation. G. Wolanksy completed a work (which developed from a discussion with F. Otto) on sharp Hölder estimates for path of probability measure-valued orbits whose tangent derivative is a measure. J.A. Carrillo finished a new short proof with Francois Bolley of the contractivity of transport distances for nonlinear diffusions and its connection to the displacement convexity of the functionals, discussing several aspects of the paper with McCann and with Sturm. Andrea Bertozzi and PhD student Katy Craig worked on a manuscript on blob methods for aggregation equations. They consider power law kernels with a range of singularity up to and including the Newtonian potential. The method is constructed by a particle approximation for the density, removing the singularity of the kernel by convolution with a mollifier or "blob function". Regularizing the kernel in this way allows them to compute numerical solutions beyond classical blowup time. They prove that for smooth, compactly supported classical solutions,

the approximate numerical solution converges to the exact solution as the spatial grid is refined, with appropriate controls on the width and accuracy of the blobs. They quantify the error of this approximation and demonstrate its agreement with numerical simulation. Katy Craig is a '14 PhD student from Rutgers who has since secured an NSF post-doctoral fellowship.

2.14. **New collaborations.** New collaborations fostered by the program at MSRI include those of Carrillo and Wolanski on projecting the 2-Wasserstein gradient flow of the Keller-Segal system onto the set of empirical measures representing particle systems. This was also the origin of part of the thesis project of a student of Carrillo's at Imperial College. Program associates Augusto Gerolin, Jean Louet, and Rosemonde Lareau-Dussault teamed up to work on free boundaries and partial transport, while Emanuel Indrei and Maria Colombo started and finished a paper together. Being officemates at MSRI, led W. Gangbo and K. Trivisa to initiate a project on possible blow-up of solutions to the semi-geostrophic equation for initial data with compact support. Gangbo and Ghoussoub have initiated a collaboration on variational problems in material science with polyconvex integrands. Brenier and Ghoussoub have initiated a collaboration on the connection between optimal transport with symmetry constraints and periodic dynamics in fluid mechanics and convection theory. Ghoussoub and Pass worked on aspects of density functional theory, where specific symmetries are imposed on subsets of the the interacting electrons. And Brendan Pass joined R. McCann in collaborating with Columbia economist Pierre-Andre Chiappori on economic matching problems which are uni-dimensional on one side of the market.

3. Organizational Structure

The program was organized by a committee consisting of Professors
Luigi Ambrosio (Scuola Normale Superiore),
Yann Brenier (Ecole Polytechnique),
Panagiota Daskalopoulos (Columbia University),
Lawrence C. Evans (University of California at Berkeley),
Alessio Figalli (University of Texas),
Wilfrid Gangbo (Georgia Institute of Technology),
Robert McCann (University of Toronto),
Felix Otto (Max-Planck-Institut for Mathematics in the Sciences), and
Neil Trudinger (Australian National University).

McCann was our program's lead organizer, while Gangbo was our program's representative on MSRI's diversity committee. McCann, Figalli and Gangbo chaired the respective organizing committees of our program's three workshops. Brenier, Evans, Gangbo and McCann were in residence at MSRI for the entire semester, as were several research professors such as Gerard Awanou, Young-Heon Kim, John Lott, Christina Sormani, Konstantina Trivisa and Special Professors Ludovic Rifford and Cedric Villani. Figalli and Trudinger stayed for several months each. The presence of so many senior researchers helped to anchor our program and provide ample mentoring capacity for a good number of postdoctoral researchers and graduate student program associates.

3.1. **Graduate courses.** As Chancellor's Professor, Yann Brenier taught a wonderful graduate course in the UC Berekely Mathematics Department on *Hidden convex structures in nonlinear partial differential equations*. The attendance was very good, with an audience of about 25 UCB graduate students, MSRI postdocs, and about 5 professors coming regularly.

3.2. **Seminars and reading groups.** Evans organized a 2-hour weekly seminar held at the UC Berkeley Math Department on Friday afternoons, where postdocs of both MSRI programs (OT and GR) presented their research. He was assisted by postdoctoral organizers from each program: Emanuel Indrei from OT and Haotian Wu from GR. This was followed by beer and pizza at a nearby restaurant. This format certainly helped foster interactions between the programs, and with the UCB mathematics department.

In addition, Gangbo and Kim ran a members seminar at MSRI most Tuesday and Thursday afternoons, which focused on presentations by more senior members of the OT program. Some junior members such as Program Associate Maria Colombo and non-MSRI visitors such as Greg Kuperberg (UC Davis) gave talks in this seminar as well.

There were two very successful additional weekly seminars organized spontaneously by other visitors. The first, organized by Cédric Villani, was devoted to a careful review on Villani's treatise on OT and attracted most of the postdocs and PhD students of the OT program. The second, run by Sormani, focused on the various connexions between OT and GR, through Romanian geometry (with topics such as Gromov-Hausdorff convergence and OT, positive mass theorems, etc...).

It was remarkable that so many activities could succesfully attract large audiences without negative interference.

3.3. **Postdoctoral Mentoring.** The presence of so many senior researchers for the entire program afforded us the luxury of assigning two senior mentors to each of our postdocs. This included not only the MSRI POSTDOCS (Primary mentor, secondary mentor)

1 Chen, S. (Figalli, Villani)
2 Erbar, M. (Brenier, Sormani)
3 Indrei, E. (Villani, YHKim)
4 Kitagawa, J. (Awanou, McCann)
5 Maximo, D. (YH Kim + Schoen from MGR)
6 Moore, K. (Trivisa + Schoen from MGR)
7 Sinaei, Z. (Sormani, Lott)
8 Xiao, L. (Evans, Trivisa)

but also all full semester Research Members within five years of PhD:
9 Lakzian, S. (Lott, Trivisa)
10 Pass, B. (Gangbo, Brenier)
11 Somersille, S. (Evans, Gangbo)
12 Wang, Y. (Rifford, Figalli)
13 Zhang, Y. (McCann, Figalli)
14 Xue, J. (Rifford, Awanou)

In addition, O. Kneuss (a postdoc of L.C. Evans at the UC Berkeley Math Department) was very actively involved in the MSRI OT program.

4. Workshops and Conferences

The "Optimal Transport" program included three workshops, briefly described below. More detailed reports on each of these workshops have been supplied separately to MSRI.

4.1. **Connections for Women on Optimal Transport: Geometry and Dynamics.** 22-23 August 2013. Organized by Sun-Yung Alice Chang (Princeton University), Panagiota Daskalopoulos (Columbia University), Maria Westdickenberg (RWTH Aachen), and Robert McCann (University of Toronto, lead organizer).

This 2-day workshop aimed to connect female graduate students and beginning researchers with established female researchers who use optimal transportation in their work and can serve as professional contacts

and potential role-models. It showcased a selection of four lectures a day by female scientists, including established leaders (such as Andrea Bertozzi, Alice Chang, Claudia Klueppelberg, and Christina Sormani), and up and coming researchers (such as Elanora Cinti, Julie Delon, Marina Chugunova, and Maria Westdickenberg). This schedule left plenty of time for informal interactions.

The younger participants were exposed to some of the diverse areas in which optimal transportation can be applied, the basic techniques of the field, and open challenges on the horizon. In addition, younger participants were actively encouraged (for instance via networking events such as a panel discussion, a workshop dinner for women only, and an informal lunchtime mixer) to ask questions of senior scientists and use the workshop in order to gather new perspective on career development.

Participants were encouraged to stay for the Introductory Workshop the following week.

4.2. **Introductory Workshop on Optimal Transport: Geometry and Dynamics.** 26-30 August 2013. Organized by Luigi Ambrosio (Scuola Normale Superiore), Lawrence C. Evans (University of California, Berkeley), and Alessio Figalli (University of Texas, lead organizer)

This workshop was intended to give an overview of the research landscape surrounding optimal transportation, including its connections to geometry, design applications, and fully nonlinear partial differential equations. It featured three minicourses of 3 hours each by distinguished visitors and organizers of the theme semester, amounting to a kind of summer school. These minicourses, given by Nicola Gigli (on lower Ricci curvature bounds), Filippo Santambrogio (on prescribed divergence problems), and Robert McCann (on optimal transport and economic applications), were complemented by a sampling of research lectures and short presentations from a spectrum of invited guests and other participants, including some who attended the previous week's "Connections for Women" workshop.

The introductory workshop aimed to familiarize graduate students, postdocs, and non-experts to major and new topics of the current program. Though the audience was expected to have a general mathematical background, knowledge of technical terminology and recent findings was not assumed. Highlights included Luis Caffarelli's lecture on non-local Monge-Ampère equations, and Xu-Jia Wang's lecture on the regularity of optimal mappings.

A notable features of the workshop was the interaction with the "Connection for Women" workshop, hosted by MSRI the week immediately before the "Introductory Workshop on Optimal Transport: Geometry and Dynamics". This highlighted the research accomplishment of young women working in optimal transportation. Our committee coordinated offers of financial support with the organizing committee of the "Connection for Women" workshop, hence many participants at the first meeting received funding and stayed on for the second. In addition, one of the main guidelines in making funding decisions was to offer support to participants in earlier stages of their careers, with little access to personal or institutional grants, while encouraging more senior participants to use such grants for their expenses whenever possible. As a result, women and young mathematicians were more heavily represented at our workshop than at a typical conference in the subject, thus contributing to an exciting diverse week.

We definitely regard this workshop as a success, with talks on several important research directions in the field. And we received lots of compliments from participants, especially for the format of three minicourses of 3 hours each complemented by research lectures.

4.3. **Fluid Mechanics, Hamiltonian Dynamics, and Numerical Aspects of Optimal Transportation.** 14-18 October 2013. Organized by Yann Brenier (Ecole Polytechnique), Michael Cullen (Met Office, UK), Allen Tannenbaum (SUNY) and Wilfrid Gangbo (Georgia Institute of Technology, lead organizer).

This workshop was devoted to emerging approaches to fluid mechanical, geophysical and kinetic theoretical flows based on optimal transportation. It also explored numerical approaches to optimal transportation problems.

The workshop lasted 5 days and attracted participants from all over the world, including Canada, Germany, France, United Kingdom, Italy. Several high profile mathematicians presented their work. Efforts were made to include speakers ranging from PhD students such as Maria Colombo to celebrated reseachers such as Cédric Villani. One of the highlights of the workshop was a survey of recent progress on demixing of binary viscous fluids by Felix Otto. Speakers from the USA represented a large variety of geographic areas.

5. Postdoctoral Fellows

We have been especially pleased by the very strong group of postdoctoral fellows who participated in our program. This group consisted of:

Shibing Chen, Matthias Erbar, Emanuel Indrei, Jun Kitagawa, Davi Maximo, Kristen Moore, Zahra Sinaei, and Ling Xiao.

They generated a tremendous amount of energy and contributed new ideas to the program. To each postdoctoral fellow were assigned two seniors members as mentors (a primary and a secondary one). We list each postdoc, their mentors (first the primary mentor and then the secondary mentor), their professional placement after the program at MSRI, and specific research accomplishments in the form of papers and preprints below.

Since two postdocs — Maximo and Moore — were joint with the Mathematical General Relativity (MGR) program, they had one mentor from each program. We comment on Maximo's participation in detail, leaving detailed comments on Moore's participation to the final report of the companion program on General Relativity. The mentors met regularly with their assigned postdoctoral fellows to discuss mathematics and offer career advice.

As it is evidenced by the description on the work performed by each postdoctoral member as well by their comments (see below), we truly believe that the postdoctoral program has been a real success, and the interactions at MSRI have been extremely fruitful both for the postdocs and for the senior members working with them.

The weekly postdoctoral research seminar gave these fellows the opportunity to give a focused one-hour research talk on their work, with the aim of familiarizing the senior members and their fellow postdocs with their research projects. These talks were joint with the weekly seminar organized at UC Berkeley by L.C. Evans with his students, so every Friday there were two talks. The seminars have all been of high level and the attendance has been impressive (also by members exterior to the program) all along the semester.

Placement, mentors, and publications. The professional placements of these postdoctoral fellows is listed below. We also list their postdoctoral mentors and their work performed during their stay at MSRI.

5.1. **Shibing Chen.** Mentors: Alessio Figalli (University of Texas at Austin), Cèdric Villani (IHP and Lyon 1).

Professional placement: Postdoctoral position at Australian National University and tenure-track position at Zhejiang University of Technology.

During his stay at MSRI, Chen worked with his mentor Prof. Alessio Figalli on the regularity of potential function in optimal transportation. In particular, they were interested in the case when the cost function does not satisfy the well known MTW condition. They started their project by establishing a boundary ϵ-regularity result which corresponds to the interior ϵ-regularity result of De Philippis and Figalli in their paper "Partial Regularity for optimal transport maps". The result obtained by Chen and Figalli says that the potential function is $C^{2,\alpha}$ around a boundary point x_0, provided the cost is C^2 close to the linear cost $-x \cdot y$, the densities are $C^{0,\alpha}$ and close to 1, and the boundary around x_0 is very flat. As an interesting corollary, they proved that when the cost is $|x-y|^p$ with p being very close to 2, both the source domain and target domain are C^2 and strongly convex, and the densities are $C^{0,\alpha}$, then the potential function is $C^{2,\alpha}$ up to the boundary. Note that the interior part of this corollary was proved by Caffarelli, Gonzales and Nguyen.

During his stay at MSRI, Chen has participated in workshops and seminars at MSRI. He says: "My experience at MSRI has been very helpful to my research."

5.2. **Matthias Erbar.** Mentors: Yann Brenier (Ecole Polytechnique of Paris), Christina Sormani (CUNY).

Professional placement. Postdoctoral position at the Scuola Normale Superiore of Pisa.

In a recent work with Jan Maas previous to his stay at MSRI, Erbar studied a notion of Ricci curvature for (Markov chains on) discrete spaces. This notion relies on convexity of the entropy along geodesics of a discrete transportation metric. Ricci curvature bounds have a number of important consequences, such as log-Sobolev, spectral gap, and concentration inequalities. Unfortunately, establishing Ricci bounds in concrete models proved to be very difficult and the only bounds available so far are for models in product form by means of a general tensorization result.

During his stay at MSRI, together with Jan Maas and Prasad Tetali, he has investigated Ricci curvature bounds for various discrete models where interactions are present. Among their results are bounds (of the optimal order) for the Bernoulli-Laplace model and for the random transposition walk on the permutation group. They are optimistic that their techniques can also be applied to models like e.g. Kac's random walk on the sphere.

Erbar has participated in workshops at MSRI as well as at the Simons Institute. At MSRI he has continued collaborations with other visitors (Jan Maas, Martin Huesmann) and established new collaborations (Sajjad Lakzian, Prasad Tetali).

He says: "My experience has been very positive and beneficial to my work."

5.3. **Emanuel Indrei.** Mentors: Cédric Villani (IHP and Lyon 1), Young-Heon Kim (UBC).

Professional placement. NSF PIRE Postdoctoral Associate at Carnegie Mellon University.

During his stay at MSRI, Indrei completed a total of four research papers, two of which have been submitted for publication during the fall 2013 semester.

The title of the first is "Obstructions to regularity in the classical Monge problem" and is co-authored with Maria Colombo, a research associate in the MSRI Optimal Transport program. In this work, Indrei and Colombo construct a family of examples which illustrate how classical optimal maps in the Monge problem may develop singularities which prevent them from being in certain well-known function spaces. The collaboration originated during the MSRI introductory workshop on optimal transport and the resulting research has been submitted for publication during the fall 2013 semester.

The second paper, entitled "Regularity of shadows and the geometry of the singular set associated to a Monge-Ampere equation," is co-authored with Levon Nurbekyan, a postdoctoral fellow at Instituto Superior Tecnico. In this work, Indrei and Nurbekyan prove optimal regularity results of certain natural constructions in classical convex geometry and apply these results to a free boundary problem arising in optimal transport theory. Moreover, this project makes novel connections between the fields of differential geometry and optimal transportation. The resulting paper has been submitted for publication during the fall 2013 semester.

The third paper, "Optimal regularity for fully nonlinear elliptic and parabolic free boundary problems," is co-authored with Andreas Minne, a PhD student at KTH Royal Institute of Technology, and is currently being prepared for submission. In this paper, Indrei and Minne prove optimal regularity for solutions to a general class of fully nonlinear obstacle-type free boundary problems.

The fourth paper, "A circulant matrix theory approach to quantitative polygonal isoperimetric inequalities," is based on joint work with Levon Nurbekyan. In this paper, Indrei and Nurbekyan develop a completely novel technique based on circulant matrix theory to study the stability problem for the classical polygonal isoperimetric inequality. A preprint is currently being prepared for submission.

During his stay at MSRI, Indrei has participated in various seminars, workshops, and outreach programs affiliated with MSRI. He has lectured in the Geometry seminar at Stanford, the MSRI Postdoc seminar, the Berkeley math circle, and the Berkeley Student Harmonic Analysis and PDE seminar. Moreover, he was co-organizer of the Optimal Transport Postdoc Seminar.

He says: "The research environment at MSRI generates creativity, fosters scientific curiosity, and paves the way to an intellectually stimulating and rewarding experience."

5.4. **Jun Kitagawa.** Mentor: Gerard Awanou (University of Illinois, Chicago), Robert McCann (University of Toronto).

Professional placement. Postdoctoral fellow at the University of Toronto.

During his stay at MSRI, he initiated a collaboration with Brendan Pass to investigate the multi-marginal optimal partial transport problem, a generalization combining the multi-marginal optimal transport problem and the two-marginal optimal partial transport problem. They have shown uniqueness of solutions to this generalization under conditions that are natural analogues of those given by Figalli in the two-marginal case. Additionally, they show some analytical properties of solutions, among which is possible non-monotonicity of active marginals (surprisingly in contrast with the two-marginal case). Initially, they give proofs with the Gangbo-Święch cost function, which is then extended to a more general class of cost functions.

He has also continued collaboration with both long and short term visitors (Nestor Guillen, Young-Heon Kim) and begun discussions with others (Gerard Awanou, Robert McCann).

5.5. **Davi Maximo.** Mentors: Young-Heon Kim (UBC) from OTGD and Richard Schoen from MGR.

Professional placement. Szego Assistant Professor at Stanford University.

During his stay at MSRI, Maximo finished a paper, jointly with Ivaldo Nunes and Graham Smith, on the existence of free boundary minimal surfaces of prescribed topology inside suitably convex subsets of three-dimensional Riemannian manifolds with nonnegative Ricci curvature — including strictly convex domains of the Euclidean space R^3.

Together with Haotian Wu, he started investigating whether the moduli space of metrics with non-negative Ricci curvature and convex boundary on a three-dimensional ball is path connected. This would allow for an extension of his result with Nunes and Smith. Maximo has also started investigating rigidity questions for minimal submanifolds with free boundary in the ball with Alessio Figalli.

Maximo has participated at workshops at MSRI, gave a talk at the Geometry Seminar at UC Berkeley, and wrote a NSF proposal. Overall, he appreciated a lot his time at Institute and his interactions with other visitors. His visit was very beneficial for his proposal, which should set the tone for his research in the next couple of years.

5.6. **Kristen Moore.** Mentors: Konstantina Trivisa (University of Maryland) from OTGD and Richard Schoen from MGR.

Professional placement. Lecturer at Stanford University.

For detailed comments on Moore's time at MSRI, see the final report of the companion program on Mathematical General Relativity.

5.7. **Zahra Sinaei.** Mentors: Christina Sormani (CUNY), John Lott (UC Berkeley).

Professional placement. Postdoc at Courant Institute of Mathematical Sciences.

During her stay at MSRI, she started working on two new projects and learning new techniques.

First, she studied Riemannian curvature dimension conditions in order to generalize some of her previous results on polyhedra with nonnegative Ricci curvature $CD(0, N)$ to general metric measure spaces with RCD bounds. These results are Liouville type theorems for harmonic maps and functions. The generalization of results for harmonic functions seems doable and she is planning to write it up soon. For harmonic maps it is much less clear.

She has also been studying convergence of manifolds under Ricci curvature bounds, and convergence of harmonic maps when their underling spaces converge and satisfy a Ricci bound. The general case of collapsing seems to be difficult and currently she is focused on the non-collapsing case. She also opened up the same type of question for energy minimizing maps instead of harmonic maps, and for convergence under sectional curvature bounds.

She says: "Being in contact with experts in Optimal Transport has been very helpful and beneficial for my research."

5.8. **Ling Xiao.** Mentors: Lawrence Craig Evans (UC Berkeley), Konstantina Trivisa (University of Maryland).

Professional placement. Postdoctoral position at Cornell University.

During Ling Xiao's stay at MSRI, she was especially interested in problems related to mean curvature flow. She wrote two papers in this direction while she was at MSRI.

The first one is *Gradient estimates and lower bound for the blow-up time of star-shaped mean curvature flow* (http://arxiv.org/pdf/1311.3721v1.pdf). In this paper, she investigates star-shaped hypersurfaces flowing by mean curvature. Without any assumption on the convexity, she gives a new proof of gradient estimate for a short time. She also gives a lower bound for the blowing up time.

The second paper *Minimal graphs and graphical mean curvature flow in* $M \times \mathbb{R}$ (http://arxiv.org/pdf/1311.3699.pdf) is written by Matthew McGonagle and Ling Xiao. In this paper, they use a variational approach to study the problem of finding minimal surfaces in $M \times \mathbb{R}$. They also show that, if the boundary data satisfies certain conditions, then under a very weak assumption on the boundary, the solutions obtain the boundary data. Finally, they study the convergence of corresponding flow problem, and show that every convergent subsequence $u(\cdot, t_i)$ converges to the general solution of the Dirichlet problem.

Ling Xiao has participated in workshops as well as seminars at MSRI. She says "At MSRI, I'm not only having lots of opportunities to learn new things [but] also being very productive."

6. Graduate Students

The Optimal Transport program hosted 9 graduate student Program Associates. There were three masters level students who participated in

the program and revealed themselves to be candidates of outstanding promise for PhD programs. We paid close attention to junior scientists, including the students, while allocating our financial resources, to ensure their participation all activities, especially the program workshops. While most Program Associates came to the program with their advisors, the few who did not were sponsored by Research Professors attending the program with whom they engaged in collaborative research.

At the beginning of the semester we organized a two–day event aiming to connect women graduate students and beginning researchers with more established female researchers in the field. This gave the opportunity to junior participants to be paired with more senior researchers.

The students were offered many opportunities to get involved in various small working groups to strengthen their knowledge and increase the interactions between one another and lead senior faculty members. C. Sormani and C. Villani independently organized two remarkable intensive working sessions during which the students presented new materials as they were learning them.

Cédric Villani ran a class which met 17 times, each meeting lasting 2 hours. The task of the students and postdocs participating in the class was to work on a research paper and then give an expository talk to the rest of the classroom. C. Villani himself contributed to the lectures but made a point to give less than a fifth of the 34 lecture hours, leaving the remainder of the lectures in the hand of the students and postdocs. For instance Alexi Hoeft, one of the masters students attending the program, volunteered to give a two-hour lecture on the Kantorovich duality theory. Based on the quality of her presentation, it appeared that she probably had spent over ten hours preparing her lectures to reach an impressive level of perfection. Rosemonde Lareau–Dussault, a PhD student from Toronto, gave a lecture on Displacement Interpolation, while Augusto Gerolin, a student from Italy presented a solution to the Monge Problem. Christopher Policastro, a PhD student from UC Berkeley gave a lecture on CD and $CD^*(K, N)$ spaces, covering a very challenging topic. The students were exposed to a lecture on the Nonsmooth Splitting Theorem, which has seen an important contribution from Nicola Gigli, one of the mini-course speakers from the August Workshop. The Nonsmooth Splitting Theorem theory considered here is a substantial improvement of a celebrated result by Cheeger and

Gromoll, factorizing limits of smooth varieties. The theory pioneered by N. Gigli shows that nonsmooth Riemannian spaces satisfying some Ricci curvature conditions (such as $RCD(0, N)$) which contain a line can be factorized. One of the postdocs of the program, endeavored to understand this recent innovation and presented it to an audience of students and postdocs.

Christina Sormani ran a Converging Spaces reading seminar more geared toward postdocs in both the OT and MGR programs, but which also welcomed students. She spoke to each postdoc, learned what they knew and wanted to learn and then devised a schedule so that each topic would lead to the next; see the webpage at https://
sites.google.com/site/professorsormani/teaching/msri-reading-seminar

Several Program Associates also volunteered to give talks in the Tuesday, Thursday and Friday seminar series. For instance, PhD students Jean Louet and Roméo Awi presented their respective works in the Friday postdoctoral seminar at UC Berkeley, while Maria Colombo, a PhD student from Italy, gave a talk in the Tuesday afternoon Member's Seminar at MSRI.

The MSRI program had a significant impact on our students. For instance Malcolm Bowles, one of the bright masters students — who was undecided about pursuing an enrollment into a PhD program – made up his mind by the end of the program to send applications to doctoral programs.

7. Diversity

Of the 58 members who participated in the program, 5 were underrepresented minorities (9%) and 15 were women (26%). These ranged across all levels of participants, from Eisenbud Professor Wilfrid Gangbo to program organizers Gangbo and Panagiota Daskalopoulos, to Research Professors Gerard Awanou, Andrea Bertozzi, Christina Sormani, Tatiana Toro and Konstantina Trivisa, to Research Members such as Codina Cotar, Ryan Hynd, Stephanie Somersille (a double minority), Yi Wang and Guofang Wei, to Postdoctoral Fellows such as Kristen Moore, Zahra Sinaie and Ling Xiao, to Program Associates Romeo Awi, Maria Colombo and Rosemonde Lareau-Dusseault. Here we do not count the numerous diverse participants who participated in our conferences and workshops, including the August 22-23 Connections for Women event which featured an all female slate of eight

speakers and attracted a large number of other women at various career stages.

8. Synergistic Activities

It was enjoyable and fruitful to have together at MSRI the OT and GR programs. Several members were part of both programs. Professor Sormani in particular was very successful in organizing a joint working group on topics of interest for both programs. The seminar organized at UC Berkeley by Professor Evans featured postdoctoral speakers from each program every Friday afternoon, and was another fruitful point of contact and exchange. Interactions between OT and GR are quite natural and can be expected to develop further in the future. Professor McCann gave a popular lecture to MSRI visitors and staff, introducing both subjects through the key concept of curvature and showing the many relationships between them. This lecture was reprised at the MSRI board of trustees meeting in New York. Of course, Perelman's solution to the Poincaré conjecture has been very influential in connecting these fields, through the introduction of several key concepts related to OT or GR (Ricci flow, Boltzmann entropy, Fisher information etc...). This has been now well established through papers and notes by Professors Lott, McCann, Tao, Topping, in particular.

Representatives of our program participated as speakers in various local events, such as the Berkeley High School Math Circle (Emanuel Indrei) and Bay Area Differential Geometry Seminar (Robert McCann). Several of our participants gave Evans lectures at the UC Berkeley mathematics department: Andrea Bertozzi, Christina Sormani, Wilfrid Gangbo, Kristen Moore, and Cédric Villani. Cédric Villani also gave a well-attended public lecture titled *Of triangles, gas, prices, and men* which was filmed at MSRI in the closing days of the program. As two of the documentary's featured subjects, he and J.P. Bourguignon participated in a discussion panel with the director following the Berkeley premier of Olivier Peyon's film *Comment j'ai détesté les Maths* (How I came to hate math), which was sponsored by MSRI and the French Consulate.

Finally, in addition to the three workshops organized by our program at MSRI, a weekend workshop on *Infinite-Dimensional Geometry* was organized 7-8 December 08, 2013 on the UC Berkeley campus by Lawrence C. Evans (University of California at Berkeley), Dmitry Jakobson (McGill University), Robert McCann (University of Toronto),

and Stephen Preston (University of Colorado, lead organizer). It attracted a distinguished schedule of speakers and a number of our program participants chose to attend.

9. Nuggets and Breakthroughs

Among the research breakthroughs initiated at our program, we would like to highlight the framework for formulating and studyding Ricci curvature / dimension conditions in discrete settings by Matthias Erbar and his collaborators: Jan Maas, Prasad Tetali, and Martin Huesmann. We also mention the progress on density functional theory achieved by Codina Cotar, Brendan Pass, and their collaborators, and the existence and uniqueness theory for solutions to the master equation of mean-field games proposed by Gangbo and Swiech.

Other high points of the program included the success of the various courses and reading seminars organized for graduate students and postdoctoral participants, which generated a high level of enthusiasm among their numerous participants: Yann Brenier's Chancellor lectures at UC Berkeley, Christina Sormani's reading seminar on *Converging Spaces*, and Cédric Villani's graduate student working group on *Optimal Transport: Old and New*.

Outreach activities such as the 17 December public lecture by Field's Medallist Cédric Villani, McCann's lectures to the MSRI staff and Board of Trustees linking optimal transport to general relativity, and Villani's participation in the Berkeley première of Olivier Peyon's film "Comment j'ai détesté les Maths" were particularly appreciated.

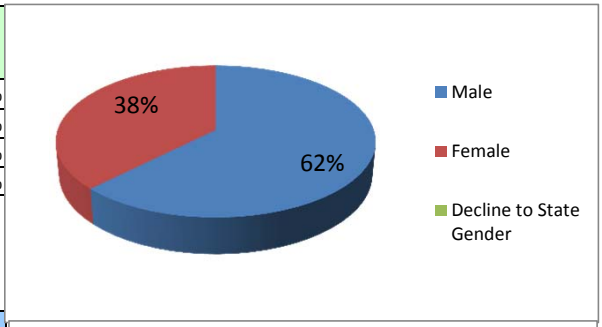
Postdoc Pre/Post-MSRI Institution Group

Family Name	First Name	Pre-MSRI Institution Group	Post-MSRI Institution Group	Pre-MSRI Institution Name	Placement Institution Name
Chen	Shibing	Foreign	Foreign	University of Toronto	Zhejiang University of Technology
Erbar	Matthias	Foreign	Foreign	University of Bonn	Scuola Normale Superiore, Pisa
Indrei	Emanuel	Group I Private	Group I Private	Carnegie Mellon University	Carnegie Mellon University
Kitagawa	Jun	Foreign	Foreign	University of British Columbia	University of Toronto
Maximo	Davi	Group I Public	Group I Private	University of Texas, Austin	Stanford University
Moore	Kristine	Group I Private	Group I Private	Stanford University	Stanford University
Sinaei	Zahra	Foreign	Group I private	Ecole Polytechnique	NYU
Xiao	Ling	Group I Private	Group I Private	Johns Hopkins University	Johns Hopkins University

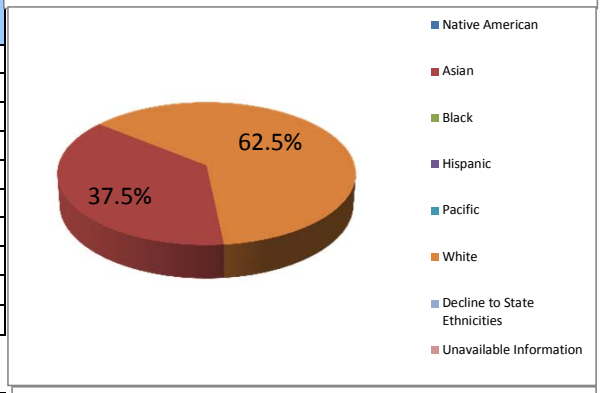
2013–14 Postdoctoral Fellows Demographic Summary

Gender	#	% (No Decl.)*	%
# of Members	8		100.0%
Male	5	62.50%	62.5%
Female	3	37.50%	37.5%
Decline to State Gender	0		0.0%

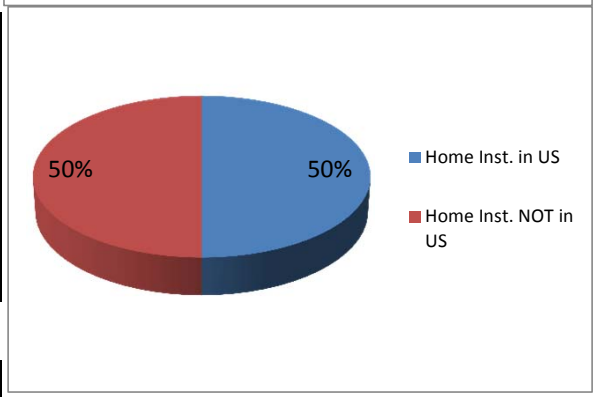
Members are distinct within each academic year.



Ethnicities	#	% (No Decl.)*	%
Native American	0	0.00%	0.0%
Asian	3	37.50%	37.5%
Black	0	0.00%	0.0%
Hispanic	0	0.00%	0.0%
Pacific	0	0.00%	0.0%
White	5	62.50%	62.5%
Decline to State Ethnicities	0		0.0%
Unavailable Information	0		0.0%
Minorities	0		0.0%

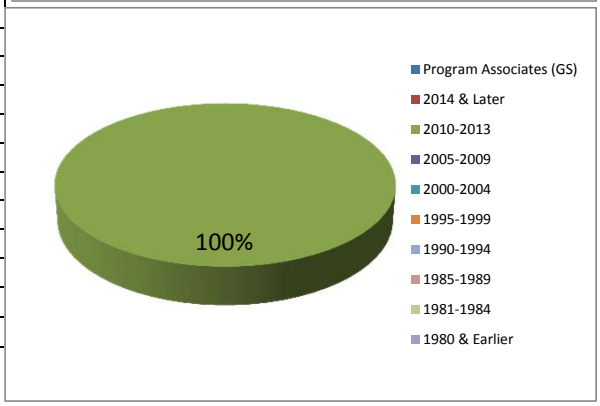


Citizenships	#		%
US Citizens & Perm. Residents	2		25.0%
Foreign	6		75.0%
Unavailable information	0		0.0%
# of Members	8		100.0%
US Citizens	2		25.0%
Perm Residents	0		0.0%
Home Inst. in US	4		50.00%



Year of Ph.D	#		%
Program Associates (GS)	0		0.0%
2014 & Later	0		0.0%
2010-2013	8		100.0%
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 Members	8		100.0%

**Statistic Calculation based on all members who did not decline to state.*



Optimal Transport: Geometry and Dynamics

Program Summary

Role	# of Distinct Members	%	# of Citizens & Perm. Res.	%	US Citizens	# of Female	%	# of Minorities[1]	%
Organizers	9	15.5%	4	44.4%	2	1	11.1%	1	50.0%
Research Professors	11	19.0%	5	45.5%	5	3	27.3%	1	20.0%
Postdoctoral Fellows	8	13.8%	2	25.0%	2	3	37.5%	0	0.0%
PD/RM	5	8.6%	1	20.0%	1	2	40.0%	1	100.0%
Research Members	16	27.6%	4	25.0%	4	4	25.0%	2	50.0%
Program Associates	9	15.5%	1	11.1%	1	2	22.2%	0	0.0%
Total # of Distinct Members	***58***	***100%***	***17***	***29%***	***15***	***15***	***26%***	***5***	***33.3%***

[1] *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.*

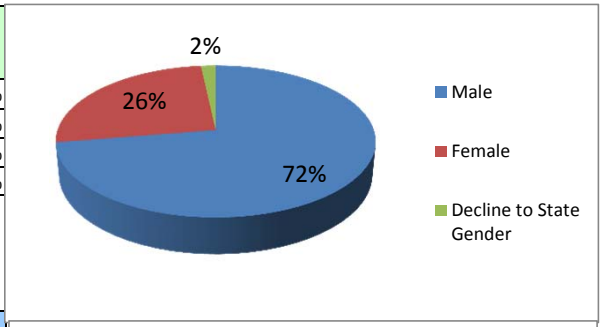
Home Institute Grouping

	US								
Role	**Group I Private**	**Group I Public**	**Group II**	**Group III**	**Group IV**	**Group M**	**Non-Group**	**Foreign**	**Total**
Organizers	1	3	0	0	0	0	0	5	9
Research Professors	0	3	0	0	1	1	0	6	11
Postdoctoral Fellows	4	0	0	0	0	0	0	4	8
PD/RM	2	0	1	0	0	0	0	2	5
Research Members	1	3	0	0	0	1	0	11	16
Program Associates	0	1	0	0	0	0	0	8	9
Total	**8**	**10**	**1**	**-**	**1**	**2**	**-**	**36**	**58**
%	***13.8%***	***17.2%***	***1.7%***	***0.0%***	***1.7%***	***3.4%***	***0.0%***	***62.1%***	***100.0%***

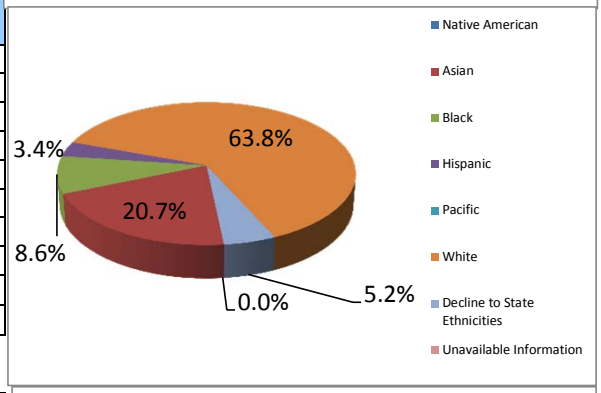
2013–14 Program Members Demographic Summary

Gender	#	% (No Decl.)*	%
# of Members	58		100.0%
Male	42	73.68%	72.4%
Female	15	26.32%	25.9%
Decline to State Gender	1		1.7%

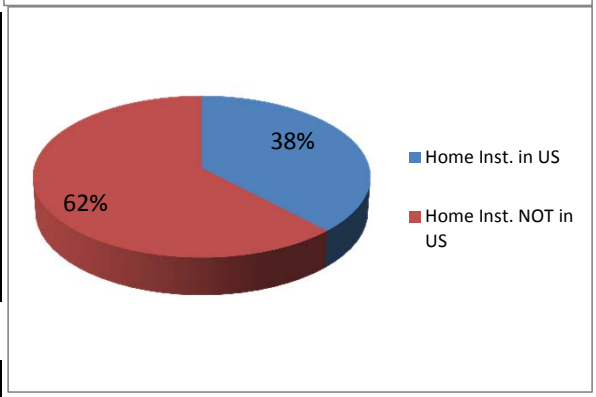
Members are distinct within each academic year.



Ethnicities	#	% (No Decl.)*	%
Native American	0	0.00%	0.0%
Asian	12	21.43%	20.7%
Black	5	8.93%	8.6%
Hispanic	2	3.57%	3.4%
Pacific	0	0.00%	0.0%
White	37	66.07%	63.8%
Decline to State Ethnicities	3		5.2%
Unavailable Information	0		0.0%
Minorities	5		33.3%

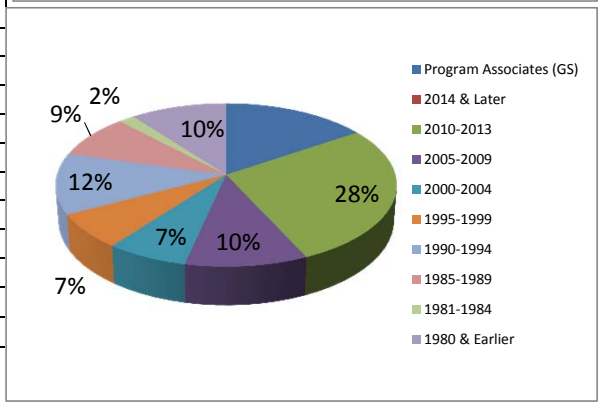


Citizenships	#		%
US Citizens & Perm. Residents	17		29.3%
Foreign	41		70.7%
Unavailable information	0		0.0%
# of Members	58		100.0%
US Citizens	15		25.9%
Perm Residents	2		3.4%
Home Inst. in US	22		37.93%



Year of Ph.D	#		%
Program Associates (GS)	9		15.5%
2014 & Later	0		0.0%
2010-2013	16		27.6%
2005-2009	6		10.3%
2000-2004	4		6.9%
1995-1999	4		6.9%
1990-1994	7		12.1%
1985-1989	5		8.6%
1981-1984	1		1.7%
1980 & Earlier	6		10.3%
Unavailable Info.	0		0.0%
Total # of Members	58		100.0%

**Statistic Calculation based on all members who did not decline to state.*



RESPONSIBLE CONDUCT OF RESEARCH (RCR) TRAINING CERTIFICATION FORM

Effective January 4, 2010, when submitting new research proposals to the National Science Foundation (NSF), UC Berkeley will be required to certify that the campus has a plan in place for providing education and training in the Responsible Conduct of Research (RCR) to all students (undergraduate and graduate) and postdoctoral scholars who will be supported by those grants to conduct research. This RCR training is required under the America COMPETES Act. While training plans are not required to be included in proposals submitted to NSF, institutions are advised that they are subject to review upon request. See http://rac.berkeley.edu/rcr.html for more information.

Instructions: Principal Investigators (PIs) must certify on a per award basis, that all students and postdoctoral scholars supported by his or her NSF award have completed RCR training **within 60 days of the individual's becoming supported by NSF funding**. This certification document must be submitted to the Research Administration and Compliance Office, c/o Rebecca Armstrong - RCR Coordinator, **initially within 90 days of the award being made; and annually thereafter on the anniversary date of the award for the duration of the project, updating any additions of students and postdocs since the last report and certifying the training has occurred as required**.

As Principal Investigator/Project Director, I certify that I have read and understand the National Science Foundation's requirement on Responsible Conduct of Research (RCR) training, and I certify the following:

Project Title: Mathematical Sciences Research Institute (MSRI)
Fall 2013 Programs - Postdoctoral Fellowships

NSF Award Number: 0932078

☒ All students (undergraduate and graduate) and postdoctoral scholars who are supported by the grant to conduct research have been trained in the Responsible Conduct of Research within 60 days of beginning work on this project. (Please complete the next two sections; continue on additional page if necessary.)

- Provide name(s) of students and postdoctoral scholars and title(s) of RCR education program(s) completed, and check the correct box for UCB status (undergraduate, graduate, or postdoc):

Name(s) of students and postdoctoral scholars:	UCB Status: UG | G | PD	Education program(s) completed:
Shibing Chen	☐ | ☐ | ☒	Collaborative Institutional Training Initiative (CITI)
Matthias Erbar	☐ | ☐ | ☒	Collaborative Institutional Training Initiative (CITI)
Nick Haber	☐ | ☐ | ☒	Collaborative Institutional Training Initiative (CITI)
Emanuel Indrei	☐ | ☐ | ☒	Collaborative Institutional Training Initiative (CITI)
Jun Kitagawa	☐ | ☐ | ☒	Collaborative Institutional Training Initiative (CITI)
Davi Maximo	☐ | ☐ | ☒	Collaborative Institutional Training Initiative (CITI)
Kristen Moore	☐ | ☐ | ☒	Collaborative Institutional Training Initiative (CITI)

- If any RCR education program(s) or activities were used other than the UC System Handout for Undergrads or the UCB CITI Program for graduate students and posdocs, then provide brief, one-sentence description(s) of the RCR education program(s) or activities:

☐ No additional students or postdocs are or have been supported since previous certification for this project.

Principal Investigator Name: David Eisenbud
(Please type or print.)

PI Signature

Date: 9/30/13

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Name(s) of students and postdoctoral scholars:	UCB Status: UG | G | PD	Education program(s) completed:
Anna Sakovich	☐ | ☐ | ☒	Collaborative Institutional Training Initiative (CITI)
Volker Schlue	☐ | ☐ | ☒	Collaborative Institutional Training Initiative (CITI)
Carlos Vega	☐ | ☐ | ☒	Collaborative Institutional Training Initiative (CITI)
Haotian Wu	☐ | ☐ | ☒	Collaborative Institutional Training Initiative (CITI)
Ling Xiao	☐ | ☐ | ☒	Collaborative Institutional Training Initiative (CITI)
Jinxin Xue	☐ | ☐ | ☒	Collaborative Institutional Training Initiative (CITI)
Xin Zhou	☐ | ☐ | ☒	Collaborative Institutional Training Initiative (CITI)

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Principal Investigator Name: David Eisenbud
(Please type or print.)

D Eisenbud
PI Signature

9/30/13
Date

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- Provide name(s) of students and postdoctoral scholars and title(s) of RCR education program(s) completed, and check the correct box for UCB status (undergraduate, graduate, or postdoc):

Name(s) of students and postdoctoral scholars:	UCB Status: UG | G | PD	Education program(s) completed:
Zahra Sinaei	☐ | ☐ | ☒	Collaborative Institutional Training Initiative (CITI)
	☐ | ☐ | ☐	
	☐ | ☐ | ☐	
	☐ | ☐ | ☐	
	☐ | ☐ | ☐	
	☐ | ☐ | ☐	
	☐ | ☐ | ☐	

- If any RCR education program(s) or activities were used other than the UC System Handout for Undergrads or the UCB CITI Program for graduate students and posdocs, then provide brief, one-sentence description(s) of the RCR education program(s) or activities:

☐ No additional students or postdocs are or have been supported since previous certification for this project.

Principal Investigator Name: David Eisenbud (Please type or print.)

D Eisenbud
PI Signature

9/30/13
Date

MSRI
Mathematical Sciences Research Institute

17 Gauss Way Berkeley, CA 94720-5070 p: 510.642.0143 f: 510.642.8609 www.msri.org

Algebraic Topology

January 20, 2014 to May 23, 2014
MSRI, Berkeley, CA
USA

Organizers:

Vigleik Angeltveit (Australian National University)
Andrew Blumberg (University of Texas)
Gunnar Carlsson (Stanford University)
Teena Gerhardt (Michigan State University)
LEAD Michael Hill (University of Virginia)
Jacob Lurie (Harvard University)

FINAL REPORT: ALGEBRAIC TOPOLOGY SEMESTER

1. Introduction

The semester-long research program in Algebraic Topology was held at MSRI January - May, 2014. The program was organized by

- Vigleik Angeltveit (Australia National University),
- Andrew Blumberg (University of Texas at Austin),
- Gunnar Carlsson (Stanford University),
- Teena Gerhardt (Michigan State University),
- Michael Hill (University of Virginia), and
- Jacob Lurie (Harvard University).

Blumberg, Gerhardt, and Hill were in residence the entire semester, coordinating the basic day-to-day organizing of the program. Angeltveit and Carlsson also spent several months at MSRI.

This was the first time in over 25 years that there was a semester-long program on algebraic topology at MSRI. The program was a wild success. Over 65 algebraic topologists at various stages in their careers spent time working at MSRI, and hundreds more came to the three large workshops. Many new collaborations were formed in different areas of the field, including

- foundational material in abstract homotopy and ∞-categories,
- structural and computational questions in equivariant homotopy theory,
- computational problems in algebraic K-theory,
- essential constructions in motivic homotopy theory, and
- fundamental questions on moduli spaces of manifolds.

Many other areas were also developed and significant progress was made. The three workshops generated a lot of interest in new research areas, introducing researchers to problems they had perhaps not seen and allowing them to connect with active workers in those areas. The established weekly seminars built on this momentum, describing open problems in the field and helping students and researchers explore new topics, guided by an expert.

The sections below spell out more of the specifics for the program.

2. Research developments

One of the most exciting and helpful aspects of the program was to have people from so many different areas of algebraic topology present and working in the same space. This led to several very exciting and fascinating collaborative projects. We highlight a few below.

In many parts of algebraic topology, significant and interesting progress was made. Spectacular computations were made in algebraic K-theory and in topological Hochschild homology. The trace method connections between algebraic K-theory and equivariant homotopy theory were made significantly more transparent,

Date: November 17, 2014.

and several unexpected computations and constructions in equivariant homotopy were carried out. Galois equivariance bridged between genuine equivariant homotopy theory and motivic stable homotopy theory, and several conjectures about motivic stable homotopy were refined or proved. Basic, foundational results were proven, from classification theorems for higher categories to ways to understand infinite loop space machines. On the more geometric front, a new understanding of Poincaré duality via factorization homology was developed, and a more general and systemic approach to the vibrant field of homological stability was proved.

We single out several projects for more detail.

(1) Blumberg and Mandell proved several deep results on the algebraic K-theory of the sphere spectrum. Algebraic K-theory records deep number theoretic properties of a ring or spectrum, and for fundamental examples like the integers or the sphere spectrum, we know frustratingly little. Blumberg and Mandell proved two main results: all of the elements in positive dimension for the algebraic K-theory of the sphere spectrum are nilpotent, and the homotopy groups algebraic K-theory of the sphere spectrum split into pieces coming from the sphere spectrum, a certain Thom spectrum related to the bordism category, and the K-theory of the integers.
(2) Heller and Ormsby explained the dictionary linking motivic stable homotopy over a non-algebraically closed field to G-equivariant stable homotopy for G the absolute Galois group of the field. This connection was known and heavily exploited for the case of motivic homotopy over the real numbers, but even there the connection between the algebraic geometry constructions like quadratic forms and the homotopical constructions like the transfer were not understood. Heller and Ormsby showed what happens generically, explaining exactly how to understand the connections and how to see when expected connections fail.
(3) Greenless showed that for a very wide range of examples of maps of ring spectra $R \to k$, the topological Hochschild homology $THH(R;k)$ is Gorenstein. This provides a clean explanation of duality phenomena observed in various computations of topological Hochschild homology and explains the various shifts to the topological gradings observed therein. Since topological Hochschild homology is the primary tool for computing algebraic K-theory via homotopy theoretic methods, this opens the door to many more computations in a very conceptual way.
(4) Bergner and Rezk produced a series of papers on models for (∞, n)-categories. Lurie's book *Higher topos theory* describes quasi-categories, a model for $(\infty, 1)$-categories. Homotopical higher categories arise extremely naturally in physics (for example, via topological field theories), but there is little understanding of how to model them or compare models. Bergner-Rezk's work links with several of the models for these homotopical higher categories and explains how to see that they are equivalent.
(5) In two papers, Heard-Stojanoska and Schlank-Stojanoska connect various kinds of duality observed in algebraic topology (specifically Andersen and Brown-Comenitz) with various kinds of duality from algebraic geometry. Their clear treatment explains exactly why we should expect the topological duality to match up with that from algebraic geometry while also deriving

significant and unexpected consequences about the existence of rational points for varieties to corresponding statements about spectra.

3. Organizational structure

During the semester, three workshops took place as part of the Algebraic Topology program: Connections for Women in Algebraic Topology, Introductory Workshop in Algebraic Topology, and Reimagining the Foundations of Algebraic Topology. Further details about these three workshops can be found in Section **??** below.

On weeks when the workshops were not occurring, there were several regularly scheduled meetings that provided structure to the program. These meetings are outlined below:

Research Seminar: In this seminar, which met once a week on Thursday afternoons, leaders in the field gave talks on their recent research. To make the afternoon talk more accessible to graduate students and early career researchers the speaker also gave a "pre-talk" in the morning. In the "pre-talk" the speaker gave an accessible introductory talk on some of the background that would be useful for the afternoon research talk. Both the pre-talks and the research talks were well attended.

Open Problems Seminar: In this seminar, which met once a week on Monday afternoons, leaders in the field gave talks about open problems in Algebraic Topology. The open problems discussed ranged from long-standing conjectures to very current questions. This seminar was a favorite amongst program participants, and it drew a large, enthusiastic crowd every week.

Post-Doc Seminar: On Fridays the post-docs from both programs (Algebraic Topology and Model Theory) would gather for a seminar featuring two talks: one from a post-doc in the Algebraic Topology program and one from a post-doc in the Model Theory program. These two talks were colloquium-style to give early career researchers practice giving job-talk style lectures. Participants were encouraged to give feedback to the speakers from both programs. Between the two talks a pizza lunch was served. The seminar was organized by two post-docs, one from each program.

Women in Topology Lunch: The female graduate students, post-docs, research members, research professors, and visitors affiliated with the Algebraic Topology program gathered each Monday for a brown bag lunch in the Baker Boardroom. This weekly opportunity to eat together, get to know one another, and provide informal mentoring led to many lively and substantial conversations about life as a professional mathematician. Several women suggested that future programs institute similar gatherings.

UC Berkeley Topology Seminar: Many members of the Algebraic Topology program went "down the hill" on Wednesday afternoons to attend the UC Berkeley Topology Seminar. The Berkeley Topology seminar featured a number of speakers

who were participants in the MSRI Algebraic Topology program, as well as some Algebraic Topologists not affiliated with the program at MSRI.

4. Workshops and conferences

Connections for Women: This two-day workshop included three short courses given by prominent female mathematicians in the field. These introductory courses were at a level appropriate for graduate students, post-docs, and researchers in related areas. The workshop also included a number of short contributed talks by participants. A panel discussion featuring women at various stages in their mathematical careers, and a conference dinner rounded out this successful workshop.

Introductory Workshop: The introductory workshop served as an overview to the overlying programmatic themes, featuring nineteen introductory talks by experts on a wide range of topics in algebraic topology. It aimed to familiarize graduate students, postdocs, and non-experts with major and new topics in algebraic topology. Though the audience was expected to have a general algebraic topology background, knowledge of technical terminology and recent findings was not assumed, as the goal of the talks was to provide this basis for future work in these areas.

Reimagining the foundations of algebraic topology This five-day workshop featured nearly twenty talks on the use of recent innovations in higher category theory to reimagine the basic tools and constructions in algebraic topology. Many of the talks described the interplay between these higher and ∞-categorical techniques and classical algebraic topology. The workshop was very well attended and covered a remarkably wide range of topics.

5. Postdoctoral fellows

Our program was fortunate to have an excellent group of postdoctoral fellows, consisting of **David Ayala, Anna Marie Bohmann, Ilya Grigoriev, Angelica Osorno, Vesna Stojanoska, Sean Tilson, Joseph Hirsch, and Emily Riehl**. The postdoctoral members contributed enormously to the success of the program, as their energy and enthusiasm was infectious. They were active participants in the weekly seminars and interacted with a wide array of Research Members and Professors. The postdocs were also the principal organizers for most of the informal reading groups during the program. These resulted in a number of new projects and collaborations, some of which included graduate students and more senior participants, in addition to post-docs.

Each postdoctoral fellow was assigned to a research mentor selected from among the senior participants. The pairs met weekly. Exit surveys of both postdocs and mentors suggest that these interactions were rich and beneficial to both parties; the postdocs report getting a lot of valuable guidance about research and the pragmatic aspects of the discipline (e.g., career advice), and the mentors describe invigorating discussions with exciting young mathematicians. We think that the mentoring program is one of the strongest organizational aspects of the postdoctoral fellows program.

The postdoctoral members were also required to participate in a weekly "postdoc seminar" in which they presented expository talks to their peers, including postdocs

from the complementary program. While we believe that the goals of this program are laudable, we felt there were some problems with the implementation; we discuss this below in a section on suggestions for improvements to the postdoctoral fellows program.

We now summarize some relevant data about each postdoctoral fellow and give a brief summary of their research accomplishments during the program.

Postdoctoral members:

- **David Ayala**
  - MSRI Mentor: Andre Henriques
  - PhD: Stanford University, 2009
  - Institutions before MSRI: USC and Harvard – NSF Postdoc
  - Institution after MSRI: Montana State University – Tenure-track

  Ayala worked on a number of projects relating to his ongoing work on factorization homology. Notably, he studied various possible constructions of topological cyclic homology in that context. He also continued to work on his project with John Francis on generalized Poincare duality.

- **Anna Marie Bohmann**
  - MSRI Mentor: John Greenlees
  - PhD: University of Chicago, 2011
  - Institutions before MSRI: Northwestern – Postdoc
  - Institution after MSRI: Northwestern – Postdoc

  Bohmann worked on a number of research projects. Notably, she finished a preprint with Osorno entitled "An equivariant infinite loop space machine via Mackey functors" and posted it on the arxiv. With Vigleik Angeltveit, she completed a project on graded Tambara functors; a preprint is in progress. She also explored a number of possible new projects in equivariant stable homotopy theory; interactions with a number of senior mathematicians (most notably Greenlees) were essential.

- **Ilya Grigoriev**
  - MSRI Mentor: Nathalie Wahl
  - PhD: Stanford University, 2013
  - Institutions before MSRI: University of Chicago – Postdoc
  - Institution after MSRI: University of Chicago – Postdoc

  Grigoriev extended his thesis (on relations between so-called "Miller-Mumford-Morita" classes) in collaboration with Galatius and Randal-Williams. He also embarked on a new collaboration with Wahl to study a different extension of his thesis work to dimension 3.

- **Angelica Osorno**
  - MSRI Mentor: Kathryn Hess
  - PhD: MIT, 2010
  - Institutions before MSRI: University of Chicago - Postdoc, Reed College - Tenure-track
  - Institution after MSRI: Reed College – Tenure-track

  In addition to the work with Bohmann (mentioned above), Osorno started two new projects, including one with Marc Stephan, a visiting graduate student at the program.

- **Vesna Stojanoska**
  - MSRI Mentor: Michael Hill
  - PhD: Northwestern University, 2011
  - Institutions before MSRI: MIT-Postdoc
  - Institution after MSRI: Max Planck Institute - Postdoc, University of Illinois at Urbana-Champaign - Tenure-track

  Stojanoska made progress on a number of different fronts. Her on-going projects with Bergner, Joachimi, Lesh, and Wickelgren advanced, including the completion of a new paper and a preprint in progress. Also with Wickelgren, she lead a team studying topological obstructions to rational points on Fermat curves. Finally, her pursuit of extensions of her thesis work made great strides, including the completion of a joint paper with Heard.

- **Hiro Tanaka**
  - MSRI Mentor: Andrew Blumberg
  - PhD: Northwestern University, 2013
  - Institutions before MSRI: Harvard University - Postdoc
  - Institution after MSRI: Harvard University -Postdoc

  Tanaka worked on a number of projects, pursuing his program on Lagrangian cobordisms (from this thesis), factorization homology, and a new exploration of the connections between Bridgeland stability conditions and algebraic K-theory.

- **Sean Tilson**
  - MSRI Mentor: Paul Goerss
  - PhD: Wayne State University, 2013
  - Institutions before MSRI: Royal Institute of Technology (KTH) Sweden - Postdoc
  - Institution after MSRI: University of Osnabruck - Postdoc

  Tilson spent much of his time at MSRI working on developing a research program to pursue during his postdoctoral studies, with a notable focus on power operations on extended smash powers.

- **Joseph Hirsh**
  - MSRI Mentor: Charles Rezk
  - PhD: CUNY Graduate Center, 2013
  - Institutions before MSRI: MIT - Postdoc
  - Institution after MSRI: MIT- Postdoc

  Hirsh worked on a number of projects, including deformation theory (developing his thesis work). He also pursued a joint project with Ayala and Riehl studying "model-independent" proofs of basic statements in the foundations of the theory of ∞-categories.

- **Emily Riehl**
  - MSRI Mentor: Bill Dwyer
  - PhD: University of Chicago, 2011
  - Institutions before MSRI: Harvard University - Postdoc
  - Institution after MSRI: Harvard University - Postdoc

Riehl had a very productive semester; in addition to pursuing a new project with Verity that extends their earlier work to give a unified account of descent and codescent phenomena in the ∞-categorical setting, she also wrote a paper with Ching entitled "Coalgebraic structures for combinatorial model categories", posted on the arxiv. She worked on the project with Ayala and Hirsch mentioned above, and was also one of the most active participants in various seminars.

Suggestions for improving the postdoctoral program. As mentioned above, we were delighted by our postdoctoral fellows and their contributions to the mathematical activitiy and life of the program. Nonetheless, we feel that there are two notable ways in which MSRI's structures could be changed to improve the postdoctoral experience.

Our primary critiques of the postdoctoral program are:

(1) No distinction is made between postdocs in the middle of their postdoctoral period and those at the end, and
(2) The postdoc seminar is too loosely organized to be maximally useful.

We explain each of these criticisms, along with suggestions for improvement, in turn.

Postdoc Progression. The current three distinct groups for MSRI do not match the current academic distinctions of postdoc, assistant professor, associate professor, and full professor, nor do they even approximate them. Someone starting their first tenure track job (or even within a few years of starting a tenure track job) cannot possibly compete with someone who has been a full professor for years, but the current system requires these groups to be compared when considering research members. To ensure a large collection of young people, those who are at the end of their postdocs are collapsed into the postdoc category. In this arena, they can most easily compete and a more relevant comparison is possible. However, this aggregation makes the "one size fits all" approach to a postdoctoral program less effective.

The advising needs of postdocs just leaving graduate school and postdocs who have already secured their first tenure track position are radically different. The former need guidance for determining how to apply for jobs, how to find new projects, how to cultivate research collaborations, and some how to apply for external funding. In contrast, the latter need instead information about balancing teaching, research, and service; applying for external funding; and transitioning to a more established period of their career. **MSRI's current system of grouping people in "Research Professors", "Research Members", and "Postdocs" combines early and late stage postdocs to the detriment of both groups.**

We suggest that MSRI consider moving to four groups of members, allowing us to group people not into "rockstars", "mathematicians in the field", and "young people", but rather "distinguished professors", "established mathematicians in the field", "up-and-coming mathematicians in the field", and "postdocs". In concert with this reclassification, we think that tailoring advising for the two categories of younger mathematicians is essential.

Postdoc Seminar. A dedicated seminar training postdocs to speak to broader audiences is clearly an important part of professional training. Giving effective general

talks is one of the most difficult skills for young mathematicians to master, and additional practice and feedback are essential to developing it. Unfortunately, we found that this latter step is lacking in the current implementation. We strongly believe that **there must be a formal method to provide detailed feedback to students about their talks.**

Towards the middle of the semester, several of our postdocs became quite frustrated with the seminar; this was communicated to various organizers privately. They felt like they would give their talks almost in a vacuum — they received no feedback at all and often attendance of other postdocs was very spotty. While a postdocs mentor can provide essential feedback, they are in the same field and have similar backgrounds. Feedback from postdocs in the other program can help let a student know exactly where their talk became technical and how they can better keep an audience for longer. Even something as simple as forms each attendee fills out after the talk would go a long way to ensure that the speaker finds the seminar pedagogically meaningful and that all postdocs attend. Better yet, we would suggest that each post-doc have a committee of three people specifically assigned to give them feedback on their talk. This committee would include their postdoctoral mentor, a post-doc from the program, and a post-doc from the complementary program. After giving their talk the postdoc would schedule a 30 minute meeting with their feedback committee to receive comments about their presentation. In the absence of feedback, the current format of the postdoc seminar does not making sense. Formalizing a feedback mechanism is essential.

6. Graduate students

There was a large and enthusiastic crowd of graduate students present throughout the semester. Many of the research professors, members, and organizers brought graduate students for various periods, the workshops were heavily attended by graduate student participants, and there were a number of local students (from Berkeley and Stanford) who were regular seminar visitors. All of the graduate students (both informally and on the exit surveys from those who responded) reported that it was exhilarating to be surrounded by so much activity and so many of the active researchers in the field. We think this was a particularly important aspect of the MSRI semester, since algebraic topology is a little bit fragmented and underrepresented at top universities; many students often feel somewhat isolated.

There was also a great deal of productive contact between senior participants and graduate students; all of the organizers, and notably Dwyer and Goerss report spending substantial amounts of time on mentoring and talking to students. Many of the graduate students in residence were able to make progress on thesis problems, facilitated by interaction with experts in residence at MSRI during the semester. We regard the graduate training aspects of the program as one of the distinct successes.

7. Diversity

There was a good representation of female mathematicians in the Algebraic Topology program. Four of the nine postdoctoral fellows in the program were

women (Bohmann, Osorno, Stojanoska, and Riehl). Additionally three of the Research Professors (Hess, Lindenstrauss, and Wahl), four of the Research Members (Bergner, Richter, Shipley, and Wickelgren), and one of the Organizers (Gerhardt) were women. The Algebraic Topology program had three Latino participants (Adem, Ayala, and Osorno).

The women participating in the Algebraic Topology program met weekly for a Women in Topology brown bag lunch. Participants ranged from graduate students to senior women in the field. This diversity of career stages, as well as the participants' openness, provided a wonderful opportunity for interesting and substantial discussions about life as a mathematician. Several early career women, in particular, noted that these casual mentoring lunches were very helpful, in addition to being fun. This activity was quite successful and we recommend that other programs consider similar regular gatherings of women in the program.

8. Synergistic activities

Unfortunately, there was little interaction between participants in the Algebraic Topology program and the concurrent Model Theory program. Indeed throughout the semester several people commented that it would have been nice if the two programs were mathematically closer to one another. One way in which the two programs did interact was through a joint postdoc seminar.

There were, however, several opportunities for outreach that participants in the Algebraic Topology program took advantage of. Andre Henriques (Research Member), Ayelet Lindenstrauss (Research Professor), and Sean Tilson (Postdoc) all gave talks at the Berkeley Math Circle. Ayelet Lindenstrauss also gave a talk for the UC Santa Cruz Noetherian Ring women in mathematics group. Teena Gerhardt (Organizer) and Emily Riehl (Postdoc) worked with the MSRI-sponsored Numberphile youtube channel to create mathematics videos that are accessible to the general public.

9. Nuggets and Breakthroughs

In all branches of algebraic topology, from the abstract categorical underpinnings to connections with algebraic geometry and number theory to specific computations, exciting progress was made.

(1) Algebraic K-theory is an extremely important invariant in number theory, and performing basic computations with which would settle several important and outstanding conjectures. Homotopical methods are one of the best ways to understand the algebraic K-theory of rings, especially rings which are nilpotent extensions of other rings. The most important example of this sort is the sphere spectrum, a categorification of the integers. Blumberg and Mandell proved several very surprising and exciting results describing exactly how the algebraic K-groups of the sphere behave.
(2) Trace methods are the primary tool by which homotopy theory attacks algebraic K-theory computations. Greenlees completely explained how some observed duality results arise quite predictably and how they are a reflection of a very natural condition on a map of rings.
(3) Stojanoska and her coauthors used similar duality results to approach number theory via the theory of topological modular forms. They show that the beautiful and unexpected dualities appearing in spectra are naturally

related to the derived dualities occurring in algebraic geometry, and they can use this to approach the problem of rational points.

(4) Heller and Ormsby continued in this geometric thread, comparing motivic stable homotopy over a field (developed by Voevodsky in his solution to the Milnor conjecture) with genuine equivariant homotopy theory (used by Hill-Hopkins-Ravenel in their solution to the Kervaire invariant one problem). They analyzed a natural map linking the two and explored the extent to which it fails to be an equivalence.

(5) More abstractly, Bergner and Rezk pushed our understanding of higher homotopical categories, determining ways to compare various models for higher categories. These have rich applications to topological field theories and therefore in physics, but until this work, it was unclear how competing models fit together.

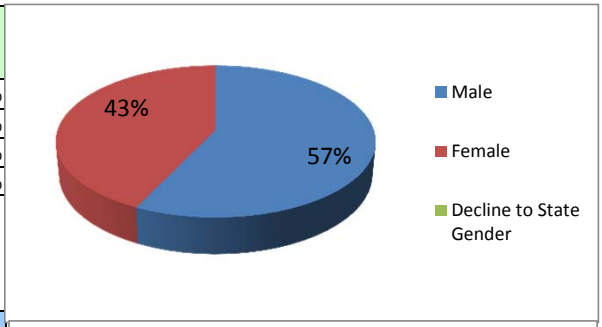
Postdoc Pre/Post-MSRI Institution Group

Family Name	First Name	Pre-MSRI Institution Group	Post-MSRI Institution Group	Pre-MSRI Institution Name	Placement Institution Name
Ayala	David	Group I Private	Group III	USC	Montana State University
Bohmann	Anna Marie	Group I Private	Group I Private	Northwestern University	Northwestern University
Grigoriev	Ilya	Group I Private	Group I Private	University of Chicago	University of Chicago
Osorno	Angelica	Nongroup	Nongroup	Reed College	Reed College
Stojanoska	Vesna	Group I Private	Foreign	Massachusetts Institute of Technology	Max Planck, Germany
Tanaka	Hiro	Group I Private	Group I Private	Harvard University	Harvard University
Tilson	Sean	Foreign	Foreign	KTH, Sweden	Universitat of Osnabruck

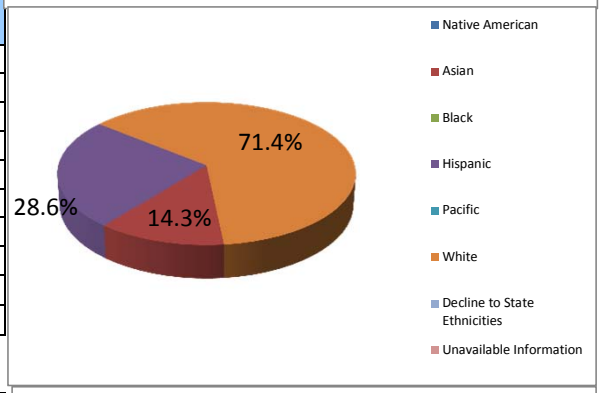
2013–14 Postdoctoral Fellows Demographic Summary

Gender	#	% (No Decl.)*	%
# of Members	7		100.0%
Male	4	57.14%	57.1%
Female	3	42.86%	42.9%
Decline to State Gender	0		0.0%

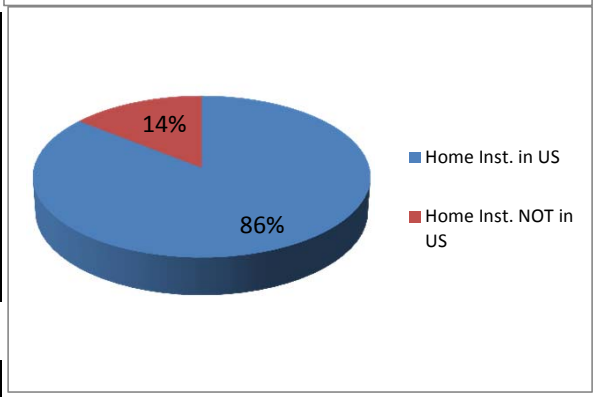
Members are distinct within each academic year.



Ethnicities	#	% (No Decl.)*	%
Native American	0	0.00%	0.0%
Asian	1	12.50%	14.3%
Black	0	0.00%	0.0%
Hispanic	2	25.00%	28.6%
Pacific	0	0.00%	0.0%
White	5	62.50%	71.4%
Decline to State Ethnicities	0		0.0%
Unavailable Information	0		0.0%
Minorities	1		25.0%

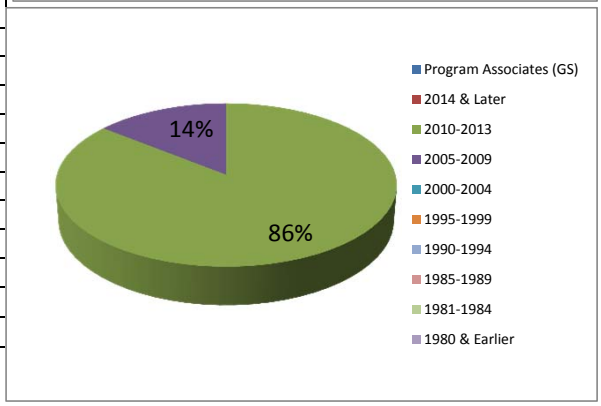


Citizenships	#		%
US Citizens & Perm. Residents	5		71.4%
Foreign	2		28.6%
Unavailable information	0		0.0%
# of Members	7		100.0%
US Citizens	4		57.1%
Perm Residents	1		14.3%
Home Inst. in US	6		85.71%



Year of Ph.D	#		%
Program Associates (GS)	0		0.0%
2014 & Later	0		0.0%
2010-2013	6		85.7%
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 Members	7		100.0%

**Statistic Calculation based on all members who did not decline to state.*



Algebraic Topology

Program Summary

Role	# of Distinct Members	%	# of Citizens & Perm. Res.	%	US Citizens	# of Female	%	# of Minorities[1]	%
Organizers	5	7.6%	4	80.0%	4	1	20.0%	0	0.0%
Research Professors	14	21.2%	9	64.3%	9	3	21.4%	0	0.0%
Postdoctoral Fellows	7	10.6%	5	71.4%	4	3	42.9%	1	25.0%
PD/RM	2	3.0%	2	100.0%	2	1	50.0%	0	0.0%
Research Members	21	31.8%	15	71.4%	14	4	19.0%	1	7.1%
Program Associates	17	25.8%	5	29.4%	5	1	5.9%	0	0.0%
Total # of Distinct Members	***66***	***100%***	***40***	***61%***	***38***	***13***	***20%***	***2***	***5.3%***

[1] *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.*

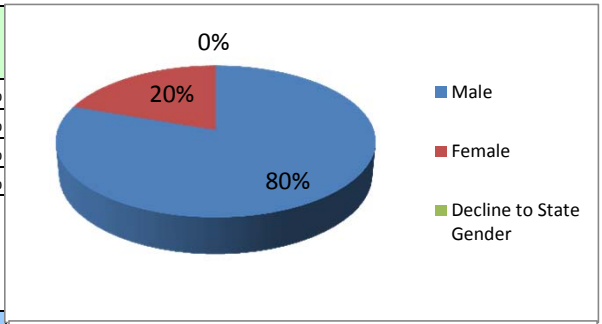
Home Institute Grouping

	US								
Role	**Group I Private**	**Group I Public**	**Group II**	**Group III**	**Group IV**	**Group M**	**Non-Group**	**Foreign**	**Total**
Organizers	1	3	0	0	0	0	0	1	5
Research Professors	2	5	1	0	0	0	0	6	14
Postdoctoral Fellows	4	0	0	1	0	0	1	1	7
PD/RM	2	0	0	0	0	0	0	0	2
Research Members	3	6	2	0	1	0	1	8	21
Program Associates	3	6	0	0	0	0	0	8	17
Total	**15**	**20**	**3**	**1**	**1**	**-**	**2**	**24**	**66**
%	***22.7%***	***30.3%***	***4.5%***	***1.5%***	***1.5%***	***0.0%***	***3.0%***	***36.4%***	***100.0%***

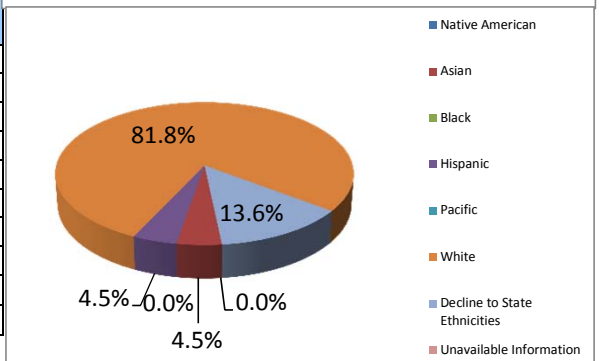
2013–14 Program Members Demographic Summary

Gender	#	% (No Decl.)*	%
# of Members	66		100.0%
Male	53	80.30%	80.3%
Female	13	19.70%	19.7%
Decline to State Gender	0		0.0%

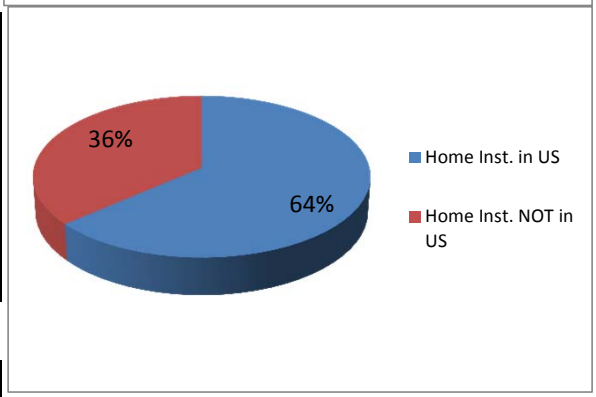
Members are distinct within each academic year.



Ethnicities	#	% (No Decl.)*	%
Native American	0	0.00%	0.0%
Asian	3	5.00%	4.5%
Black	0	0.00%	0.0%
Hispanic	3	5.00%	4.5%
Pacific	0	0.00%	0.0%
White	54	90.00%	81.8%
Decline to State Ethnicities	9		13.6%
Unavailable Information	0		0.0%
Minorities	2		5.3%

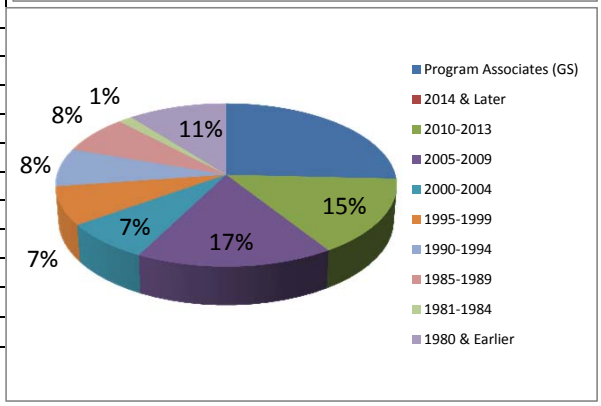


Citizenships	#		%
US Citizens & Perm. Residents	40		60.6%
Foreign	26		39.4%
Unavailable information	0		0.0%
# of Members	66		100.0%
US Citizens	38		57.6%
Perm Residents	2		3.0%
Home Inst. in US	42		63.64%



Year of Ph.D	#		%
Program Associates (GS)	17		25.8%
2014 & Later	0		0.0%
2010-2013	10		15.2%
2005-2009	11		16.7%
2000-2004	5		7.6%
1995-1999	5		7.6%
1990-1994	5		7.6%
1985-1989	5		7.6%
1981-1984	1		1.5%
1980 & Earlier	7		10.6%
Unavailable Info.	0		0.0%
Total # of Members	66		100.0%

**Statistic Calculation based on all members who did not decline to state.*



RESPONSIBLE CONDUCT OF RESEARCH (RCR) TRAINING CERTIFICATION FORM

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Instructions: Principal Investigators (PIs) must certify on a per award basis, that all students and postdoctoral scholars supported by his or her NSF award have completed RCR training **within 60 days of the individual's becoming supported by NSF funding**. This certification document must be submitted to the Research Administration and Compliance Office, c/o Rebecca Armstrong - RCR Coordinator, **initially within 90 days of the award being made; and annually thereafter on the anniversary date of the award for the duration of the project, updating any additions of students and postdocs since the last report and certifying the training has occurred as required**.

As Principal Investigator/Project Director, I certify that I have read and understand the National Science Foundation's requirement on Responsible Conduct of Research (RCR) training, and I certify the following:

Project Title: Mathematical Sciences Research Institute (MSRI)

~~Fall 2013~~ Programs-Postdoctoral Fellowships Spring 2014

NSF Award Number: 0932078

☒ All students (undergraduate and graduate) and postdoctoral scholars who are supported by the grant to conduct research have been trained in the Responsible Conduct of Research within 60 days of beginning work on this project. (Please complete the next two sections; continue on additional page if necessary.)

- Provide name(s) of students and postdoctoral scholars and title(s) of RCR education program(s) completed, and check the correct box for UCB status (undergraduate, graduate, or postdoc):

Name(s) of students and postdoctoral scholars:	UCB Status: UG | G | PD	Education program(s) completed:
Sean Tilson	☐ | ☐ | ☒	Collaborative Institutional Training Initiative (CITI)
Hiroaki Tanka	☐ | ☐ | ☒	Collaborative Institutional Training Initiative (CITI)
Anna Marie Bohmann	☐ | ☐ | ☒	Collaborative Institutional Training Initiative (CITI)
Angelica Osorno	☐ | ☐ | ☒	Collaborative Institutional Training Initiative (CITI)
David Ayala	☐ | ☐ | ☒	Collaborative Institutional Training Initiative (CITI)
Cameron Hill	☐ | ☐ | ☒	Collaborative Institutional Training Initiative (CITI)
Margaret Thomas	☐ | ☐ | ☒	Collaborative Institutional Training Initiative (CITI)

- If any RCR education program(s) or activities were used other than the UC System Handout for Undergrads or the UCB CITI Program for graduate students and posdocs, then provide brief, one-sentence description(s) of the RCR education program(s) or activities:

☐ No additional students or postdocs are or have been supported since previous certification for this project.

Principal Investigator Name: David Eisenbud
(Please type or print.)

D Eisenbud
PI Signature

4/1/14
Date

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Name(s) of students and postdoctoral scholars:	UCB Status: UG | G | PD	Education program(s) completed:
Artem Chernikov	☐ | ☐ | ☒	Collaborative Institutional Training Initiative (CITI)
Uri Andrews	☐ | ☐ | ☒	Collaborative Institutional Training Initiative (CITI)
Vesna Stojanoska	☐ | ☐ | ☒	Collaborative Institutional Training Initiative (CITI)
Pierre Simmon	☐ | ☐ | ☒	Collaborative Institutional Training Initiative (CITI)
Martin Bays	☐ | ☐ | ☒	Collaborative Institutional Training Initiative (CITI)
Joseph Hirsh	☐ | ☐ | ☒	Collaborative Institutional Training Initiative (CITI)
Ilya Grigoriev	☐ | ☐ | ☒	Collaborative Institutional Training Initiative (CITI)

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Principal Investigator Name: David Eisenbud
(Please type or print.)

D Eisenbud
PI Signature

4/1/14
Date

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Name(s) of students and postdoctoral scholars:	UCB Status: UG | G | PD	Education program(s) completed:
Taylor Dupuy	☐ | ☐ | ☒	Collaborative Institutional Training Imitative (CITI)
	☐ | ☐ | ☐	
	☐ | ☐ | ☐	
	☐ | ☐ | ☐	
	☐ | ☐ | ☐	
	☐ | ☐ | ☐	
	☐ | ☐ | ☐	

- If any RCR education program(s) or activities were used other than the UC System Handout for Undergrads or the UCB CITI Program for graduate students and posdocs, then provide brief, one-sentence description(s) of the RCR education program(s) or activities:

☐ No additional students or postdocs are or have been supported since previous certification for this project.

Principal Investigator Name: David Eisenbud
(Please type or print.)

D Eisenbud
PI Signature

4/1/14
Date

Complementary Program 2013–14

August 19, 2013 to May 23, 2014

MSRI

Berkeley, CA

USA

Bjorner Anders
Royal Institute of Technology (KTH)
Sweden

Research Member of Complementary Program 2013–14

At MSRI, Bjorner mainly collaborated with Michelle Wachs. He produced a paper titled *A tropical Lefschetz theorem*. He commented that he benefited the most from the "good environment for math work" while at MSRI.

Bourgain Jean
Institute for Advanced Study
Princeton, NJ
United States

Research Member of Complementary Program 2013–14
No comment from member

Capraro Valerio
University of Southampton
Department of Mathematics
33 8 Palmerston Road
Southampton, SO141LP
United Kingdom

Research Member of Complementary Program 2013–14

Capraro collaborated with MSRI Deputy Director, Helene Barcelo. Together they worked on a publication titled Discrete Homology Theory, A solution concept for games with altruism and cooperation. He had opportunity to start two new papers and, more generally, a long-term fruitful research.

Kaliszewski Steven
Arizona State University
Tempe, AZ
United States

Research Member of Complementary Program 2013–14
No comment from member

Peeva Irena
Cornell University
Ithaca, NY
United States

Research Member of Complementary Program 2013–14
No comment from member

Schreyer Frank-Olaf
Universitat des Saarlandes
Germany

Research Member of Complementary Program 2013–14

At MSRI, Schreyer mainly collaborated with David Eisenbud, MSRI's Director. They established Tate resolutions on products of projective space. He commented that "being in the complementary program, my research interest, and the running programs had not very much in common."

Wachs Michelle
University of Miami
Miami, FL
United States

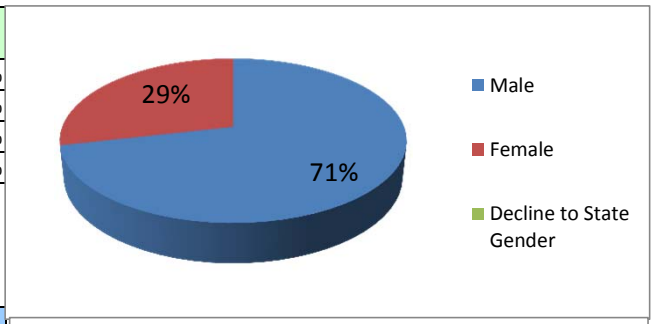
Research Member of Complementary Program 2013–14

At MSRI, Wachs learned about interesting connections between her work and work of others and she collaborated with Hélène Barcelo, Anders Bjorner, and Lauren Williams. Wachs produced these works titled *Chromatic Quasisymmetric Functions, Eulerian quasisymmetric functions, stellohedra, and Eulerian numbers, Weighted partition posets and graph associahedra, On the h-vector of stellohedra.* She also commented that "the complementary program was beneficial to me. I discussed research problems with Helene Barcelo, Anders Bjorner, my Ph. D. student Rafael Gonzalez D'Leon, and David Eisenbud's Ph.D. student Thanh Vu."

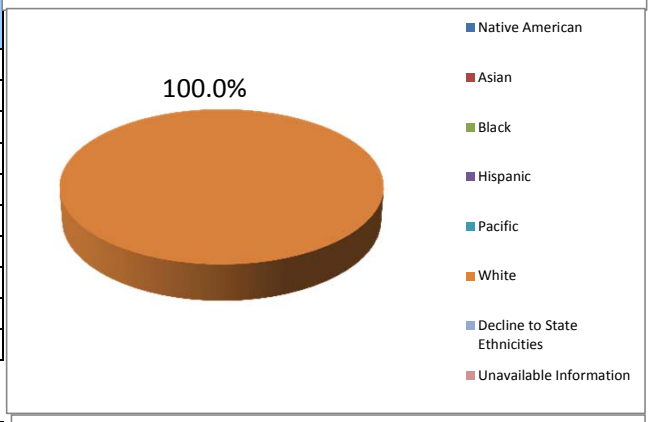
2013–14 Complementary Program Members Demographic Summary

Gender	#	% (No Decl.)*	%
# of Members	7		100.0%
Male	5	71.43%	71.4%
Female	2	28.57%	28.6%
Decline to State Gender	0		0.0%

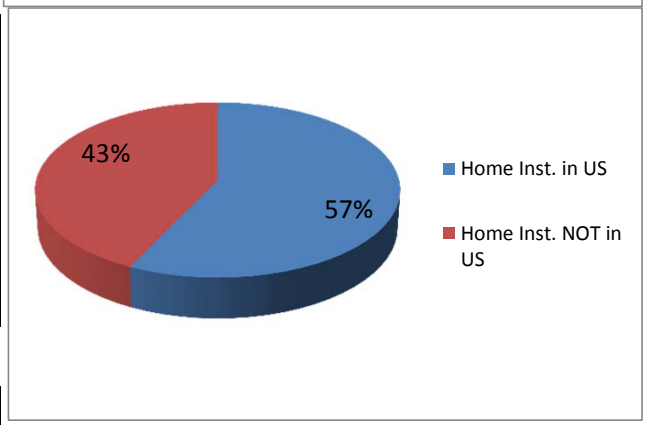
Members are distinct within each academic year.



Ethnicities	#	% (No Decl.)*	%
Native American	0	0.00%	0.0%
Asian	0	0.00%	0.0%
Black	0	0.00%	0.0%
Hispanic	0	0.00%	0.0%
Pacific	0	0.00%	0.0%
White	7	100.00%	100.0%
Decline to State Ethnicities	0		0.0%
Unavailable Information	0		0.0%
Minorities	0		0.0%

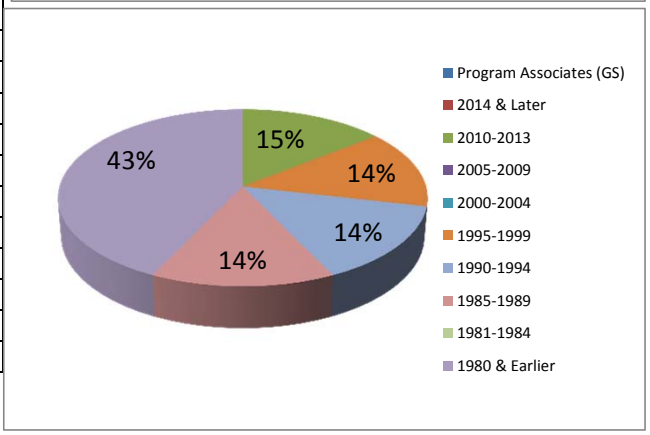


Citizenships	#		%
US Citizens & Perm. Residents	4		57.1%
Foreign	3		42.9%
Unavailable information	0		0.0%
# of Members	7		100.0%
US Citizens	2		28.6%
Perm Residents	2		28.6%
Home Inst. in US	4		57.14%



Year of Ph.D	#		%
Program Associates (GS)	0		0.0%
2014 & Later	0		0.0%
2010-2013	1		14.3%
2005-2009	0		0.0%
2000-2004	0		0.0%
1995-1999	1		14.3%
1990-1994	1		14.3%
1985-1989	1		14.3%
1981-1984	0		0.0%
1980 & Earlier	3		42.9%
Unavailable Info.	0		0.0%
Total # of Members	7		100.0%

**Statistic Calculation based on all members who did not decline to state.*



Connections for Women on Optimal Transport: Geometry and Dynamics

August 22 to 23, 2013

MSRI, Berkeley, CA, USA

Organizers:

Sun-Yung Alice Chang (Princeton University)

Panagiota Daskalopoulos (Columbia University)

Robert McCann (University of Toronto)

Maria Westdickenberg (RWTH Aachen)

REPORT ON THE MSRI WORKSHOP CONNECTIONS FOR WOMEN ON OPTIMAL TRANSPORT: GEOMETRY AND DYNAMICS, 22-23 AUGUST, 2013

SUN-YUNG ALICE CHANG, PANAGIOTA DASKALOPOULOS, ROBERT MCCANN, AND MARIA G. WESTDICKENBERG

This Connections for Women workshop was the first event of the MSRI semester on Optimal Transportation: Geometry and Dynamics. The two-day event aimed to connect female graduate students and beginning researchers with established female researchers who use optimal transportation in their work and can serve as professional contacts and potential role-models. It showcased a selection of lectures by female scientists, both established leaders such as Andrea Bertozzi (UCLA) and Alice Chang (Princeton University) and emerging researchers such as Marina Chugunova (Claremont University), Julie Delon (CNRS / Paris Telecom), and Maria Westdickenberg (RWTH Aachen University). These lectures were interspersed with networking and social events over the course of the two days such as a panel discussion, a workshop dinner, and an informal lunchtime mixer. Participants were encouraged to stay for the Introductory Workshop the following week.

1. Scientific description

The optimal transportation problem of Monge (1781) and Kantorovich (1942) has its roots in economics, statistics, and geometry. It can be caricatured as follows: given a distribution μ^+ of iron mines throughout the countryside, and a distribution μ^- of factories consuming iron ore, decide which mines should supply which factories so as to minimize total transportation costs. When the mines and factories are distributed continuously over a pair of manifolds $M^{\pm}$, with a function $c \in C(M^+ \times M^-)$ encoding the cost of transporting ore from a mine at $x \in M^+$ to a factory at $y \in M^-$, then the transportation problem that results turns out to have deep connections to a wide range of problems in mathematics and application areas.

The semester-long program on Optimal Transportation explores current research topics in the field and connections with fields including geometry, partial differential equations, nonlinear dynamics, earth sciences, image processing, and and economics.

2. Highlights of presentations

The workshop opened with talks by Christina Sormani and Alice Chang. Sormani spoke about convergence of Riemannian manifolds and metric measure spaces, summarizing classical results as well as presenting recent and current work. She is a long-term visitor at MSRI and pointed out connections with talks from the upcoming introductory workshop and a reading seminar that she will offer at MSRI this semester. Work in progress includes work with Guofang Wei, also in residence. In the second talk, Chang spoke about higher order isoperimetric inequalities, exploring connections among isoperimetric inequalities, convexity, and optimal transportation. Somewhat unusual today and an interesting aspect of the morning was that both were blackboard talks.

The afternoon of the first day brought the audience into aspects of the applications with a talk by Julie Delon involving applications of optimal transportation to image processing and a talk by Andrea Bertozzi on dynamics of aggregation equations. In the evening, some young participants expressed the opinion that they had appreciated the broad overview and array of examples to which they had been exposed in the afternoon talks.

Lectures on the second day gave a similar mixture of theoretical and application-oriented results. Maria Westdickenberg gave an introduction to logarithmic Sobolev inequalities (LSI) and spoke about joint work on sufficient conditions for LSI with Grunewald, Otto, and Villani. Eleanora Cinti spoke about some refined interpolation inequalities that she developed during her postdoc with Otto.

In the afternoon of the second day, Marina Chugunova spoke about mass concentration for a thin-film equation, pointing out open questions and limitations of the current theory in answering the questions that arise in applications. In the final talk of the workshop, Claudia Klüppelberg spoke about joint work with her colleague Gero Friesecke and former postdoc Codina Cotar, applying optimal transportation to the study of electron correlations in the semiclassical limit of quantum mechanics. In addition to the scientific content, Klüppelberg's talk traced how a collaboration between mathematicians from different areas can develop and highlighted the particular contributions that Cotar — who was also in attendance at the workshop — made to their joint work.

3. Networking events

Towards the end of the first day, the workshop included a panel discussion with panelists Alice Chang, Marina Chugunova, Eleanora Cinti, Wilfrid Gangbo (active in advocating for underrepresented minorities

and having served recently as NSF program officer), and Maria Westdickenberg. After brief introductions and summaries of their career paths, the panelists opened the floor to questions from the audience. Workshop participants asked about a range of topics including for instance grant applications, job searches and negotiations, and how to handle two-body problems.

The evening of the first day continued with a dinner hosted by MSRI at a local restaurant. This woman-only event gave participants a chance to exchange questions and ideas in a private setting. (As a personal note, I had the impression that the younger participants were particularly open with questions in this setting.)

During lunch on the second day, an informal "Lunch with the experts" was arranged by inviting younger participants to sit with more senior participants whom they had not yet met or for whom they had questions regarding science or careers. In addition, an informal dinner at the end of the second day was organized by the participants.

4. Other outcomes

The CfW workshop brought together leading experts in the field of optimal transportation and experts in related fields who use its tools. At the same time, it gathered young scientists (at the Master's, PhD, and postdoctoral level) and provided a collaborative environment in which these participants were encouraged to discuss with each other and with the senior scientists. As commented on by several senior participants, a significant number of master's and early PhD students were in attendance.

The younger participants were exposed to some of the diverse areas in which optimal transportation can be applied, the basic techniques of the field, and open challenges on the horizon. In addition, younger participants were actively encouraged (for instance via the networking events described above) to ask questions of senior scientists and use the workshop in order to gather new perspective on career development.

Organizers		
First Name	**Last Name**	**Institution**
Sun-Yung Alice	Chang	Princeton University
Panagiota	Daskalopoulos	Columbia University
Robert	McCann	University of Toronto
Maria	Westdickenberg	RWTH Aachen

Speakers		
First Name	**Last Name**	**Institution**
Andrea	Bertozzi	University of California, Los Angeles
Sun-Yung Alice	Chang	Princeton University
Marina	Chugunova	Claremont Graduate University
Eleonora	Cinti	Universita di Bologna
Julie	Delon	Telecom PARISTECH
Wilfrid	Gangbo	Georgia Institute of Technology
Claudia	Kluppelberg	TU Munchen
Christina	Sormani	CUNY, Graduate Center
Maria	Westdickenberg	RWTH Aachen

Connections for Women:
Optimal Transport: Geometry and Dynamics

August 22-23, 2013

Schedule

Thursday, August 22, 2013			
9:15AM - 9:30AM	Simons Auditorium		Welcome
9:30AM - 10:30AM	Simons Auditorium	Christina Sormani	Convergence of Riemannian manifolds and Metric Measure Spaces
10:30AM - 11:00AM	Atrium		Tea
11:00AM - 12:00PM	Simons Auditorium	Sun-Yung Alice Chang	Higher order isoperimetric inequalities - an approach via the method of optimal transport
12:00PM - 2:00PM	Atrium		Lunch
2:00PM - 3:00PM	Simons Auditorium	Julie Delon	Applications of optimal transportation and Wasserstein barycenters in computer vision, image and video processing.
3:00PM - 3:30PM	Atrium		Tea
3:30PM - 4:30PM	Simons Auditorium	Andrea Bertozzi	Dynamics of kinematic aggregation equations
4:30PM - 5:30PM	Commons		Panel Discussion
6:30PM - 8:30PM			Dinner at the Taste of the Himalayas

Friday, August 23, 2013			
9:30AM - 10:30AM	Simons Auditorium	Maria Westdickenberg	A two-scale approach to logarithmic Sobolev inequalities and the hydrodynamic limit
10:30AM - 11:00AM	Atrium		Tea
11:00AM - 12:00PM	Simons Auditorium	Eleonora Cinti	Pattern formation, optimal transport and interpolation inequalities
12:00PM - 2:00PM	Atrium		Lunch
2:00PM - 3:00PM	Simons Auditorium	Marina Chugunova	Mass concentration phenomena for the long-wave unstable thin-film equation
3:00PM - 3:30PM	Atrium		Tea
3:30PM - 4:30PM	Simons Auditorium	Claudia Kluppelberg	Density functional theory and optimal transportation with Coulomb cost

Participants

First Name	Last Name	Institution
Sara	Andrade	Agilent Technologies, Inc.
Gerard	Awanou	University of Illinois at Chicago
Romeo	Awi	Georgia Institute of Technology
Andrea	Bertozzi	University of California, Los Angeles
Oksana	Bihun	Concordia College, Moorhead, MN
Yann	Brenier	Ecole Polytechnique
Sun-Yung Alice	Chang	Princeton University
Marina	Chugunova	Claremont Graduate University
Eleonora	Cinti	Universita di Bologna
Katy	Craig	Rutgers University
Julie	Delon	Telecom PARISTECH
Matthias	Erbar	Rheinische Friedrich-Wilhelms-Universitat Bonn
Wilfrid	Gangbo	Georgia Institute of Technology
Alexi	Hoeft	Virginia Commonwealth University
Emanuel	Indrei	Carnegie Mellon University
Nahid	Jafari	Commonwealth Scientific and Industrial Research Organization
Yasmin	Khorramzadeh	Virginia Polytechnic Institute and State University
Claudia	Kluppelberg	TU Munchen
Sajjad	Lakzian	Universitst Bonn
Rosemonde	Lareau-Dussault	University of Toronto
Philippe	LeFloch	Universite Pierre et Marie Curie
Janna	Lierl	Rheinische Friedrich-Wilhelms-Universitat Bonn
Jean	Louet	Universite de Paris XI (Paris-Sud)
Jan	Maas	Rheinische Friedrich-Wilhelms-Universitat Bonn
Davi	Maximo	Stanford University
Robert	McCann	University of Toronto
Kristen	Moore	Potsdam University
Marina	Papkovich	Polotsk State University
Raquel	Perales Aguilar	SUNY
Ludovic	Rifford	Universite de Nice Sophia Antipolis
Benjamin	Schachter	University of Toronto
Chen	Shibing	University of Toronto
Zahra	Sinaei	Ecole Polytechnique Federale de Lausanne
Stephanie	Somersille	Dartmouth College
Christina	Sormani	CUNY, Graduate Center
Suresh	Srinivasamurthy	Kansas State University
Guofang	Wei	University of California, Santa Barbara
Maria	Westdickenberg	RWTH Aachen
Haotian	Wu	MSRI - Mathematical Sciences Research Institute
Ling	Xiao	Johns Hopkins University
Jinxin	Xue	University of Chicago
Shuangjian	Zhang	University of Toronto

Officially Registered Participant Information

Participants		**42**

Gender		**42**
Male	45.24%	19
Female	52.38%	22
Declined to state	2.38%	1

Ethnicity*		**42**
White	59.52%	25
Asian	19.05%	8
Hispanic	4.76%	2
Pacific Islander	0.00%	0
Black	9.52%	4
Native American	0.00%	0
Mixed	0.00%	0
Declined to state	7.14%	3

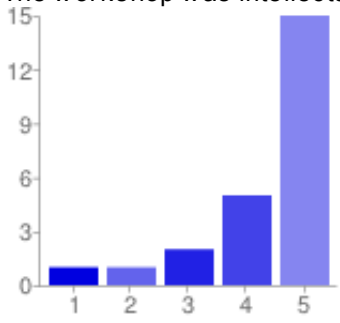
* ethnicity specifications are not exclusive

24 responses

Summary See complete responses

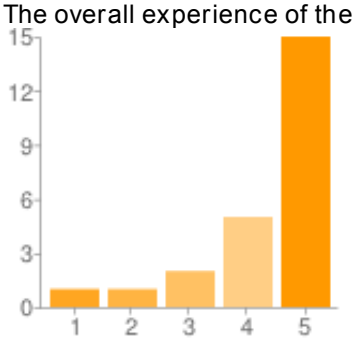
Workshop assessment

The workshop was intellectually stimulating



1 -	Not at all	1	4%
2		1	4%
3		2	8%
4		5	21%
5 -	Very	15	63%

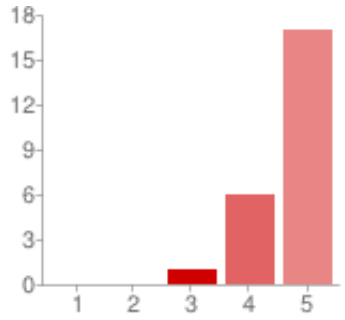
The overall experience of the workshop was worthwhile



1 -	Not at all	1	4%
2		1	4%
3		2	8%
4		5	21%
5 -	Very	15	63%

The time between lectures was adequate for discussion

1 -	Not al all	0	0%
2		0	0%
3		1	4%
4		6	25%
5 -	Very	17	71%



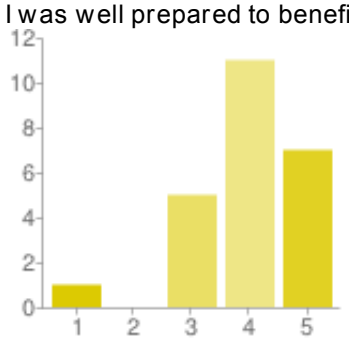
Not al all Very

Additional comments on the workshop organization

Very Good! The strings on the nametags should be shorter to raise them closer to eye level. The font of the names should also be much larger. The only way to read them now is by squinting at someone' ...

Personal assessment

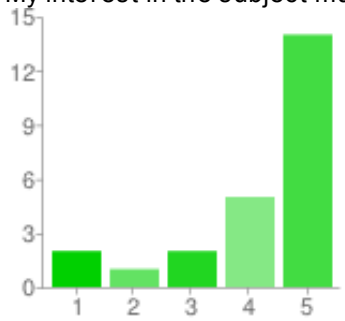
I was well prepared to benefit from the lectures



Not at all Very

1 -	Not at all	1	4%
2		0	0%
3		5	21%
4		11	46%
5 -	Very	7	29%

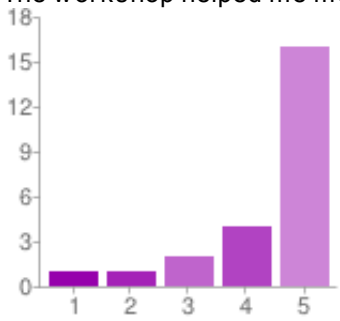
My interest in the subject matter was increased by the workshop



1 -	Niot at all	2	8%
2		1	4%
3		2	8%
4		5	21%
5 -	Very	14	58%

Niot at all Very

The workshop helped me meet people with similar scientific interests



Not at all Very Much

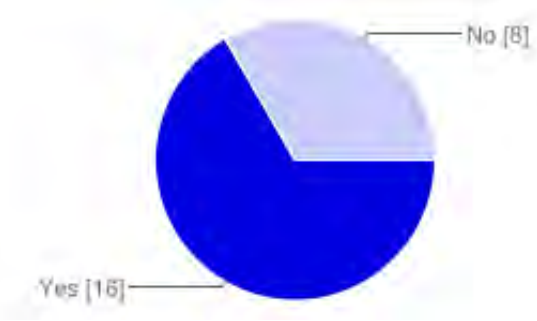
1 -	Not at all	1	4%
2		1	4%
3		2	8%
4		4	17%
5 -	Very Much	16	67%

Additional comments on your personal assessment

Very Good! The Connection for Women could also be after the Introductory Workshop week so we have more background knowledge. I would have prefer to have the introduction workshop before the connection ...

Additional Activities

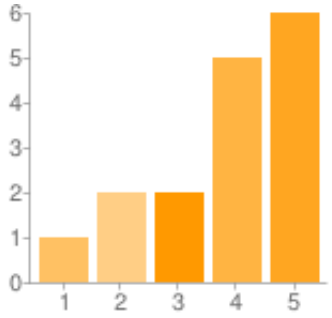
Did you attend the panel discussion?



Yes	16	67%
No	8	33%

If you did attend the panel discussion, did you find it worthwhile?

1 -	Not at all	1	4%
2		2	8%
3		2	8%

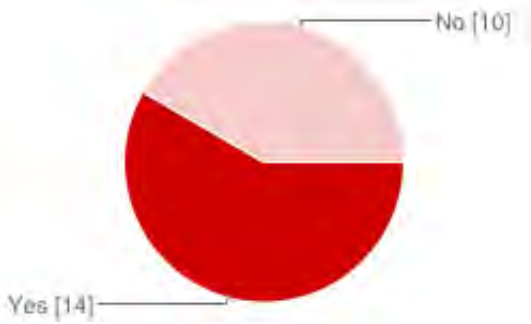


4		5	21%
5 -	Very much	6	25%

What other subjects should be addressed in future panel discussions?

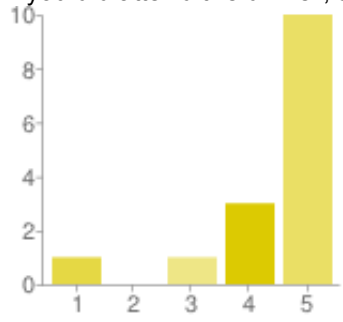
Women's (or minorities) issues, including work-life balance, how to find a mentor, how to react to sexist behavior or when someone makes a joke or degrading statement about women. It may be better t ...

Did you attend the dinner?



Yes	14	58%
No	10	42%

If you did attend the dinner, did it help to solidify the contacts you made in the workshop?



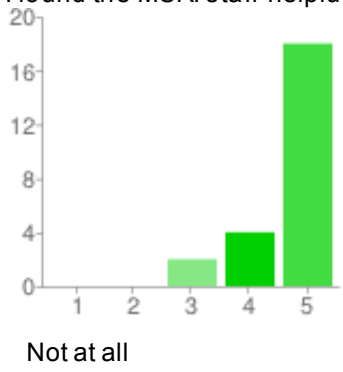
1 -	Not at all	1	4%
2		0	0%
3		1	4%
4		3	13%
5 -	Very much	10	42%

Please provide any comments on the dinner

I am a man. Three or four males mentioned on independent occasions that they would have liked to come. everyone should introuce oneself a round table would help us to talk to more participants.

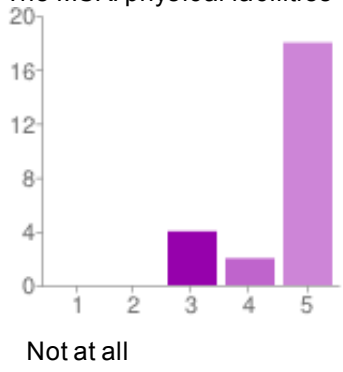
Venue

I found the MSRI staff helpful



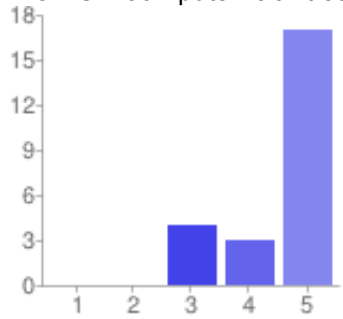
1 -	Not at all	0	0%
2		0	0%
3		2	8%
4		4	17%
5 -	Very	18	75%

The MSRI physical facilities were conducive for such a workshop



1 -	Not at all	0	0%
2		0	0%
3		4	17%
4		2	8%
5 -	Very	18	75%

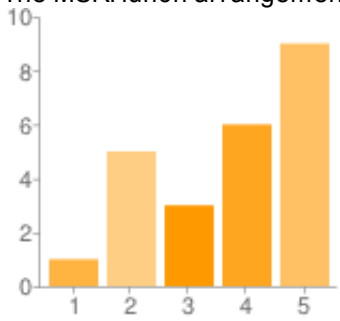
The MSRI computer facilities were adequate for such a workshop



1 -	Not at all	0	0%
2		0	0%
3		4	17%
4		3	13%
5 -	Very	17	71%

Not at all Very

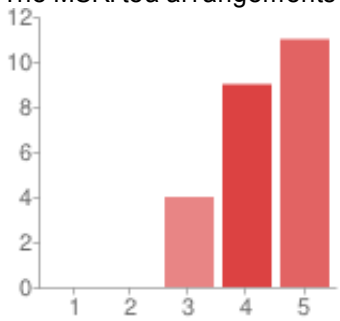
The MSRI lunch arrangements were satisfactory



Not at all Very

1 -	Not at all	1	4%
2		5	21%
3		3	13%
4		6	25%
5 -	Very	9	38%

The MSRI tea arrangements were satisfactory



Not at all Very

1 -	Not at all	0	0%
2		0	0%
3		4	17%
4		9	38%
5 -	Very	11	46%

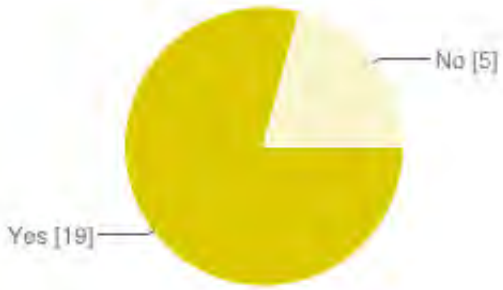
Additional comments on the venue

I would have liked to have less strong tea Very Good! The all-day tea and coffee station is excellent, the lunch caterers had delicious and healthy options. The facilities here are wonderful! less swe ...

MSRI Wireless Network

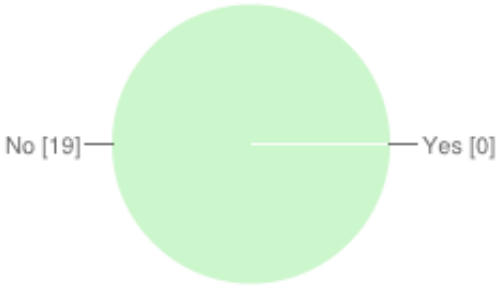
Did you use MSRI's wireless network?

Yes	19	79%
No	5	21%



Did you experience any difficulties with the network?

Yes	0	0%
No	19	79%



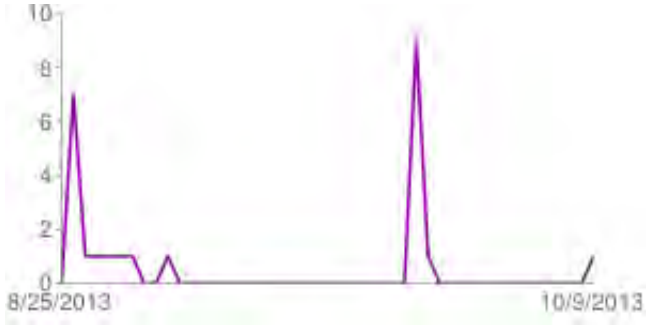
If you did experience difficulties with the network, please explain:

Thank you for completing this survey

We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.

The title of the workshop was confusing. Moreover I couldn't see connection between women. Excellent! There seems to be an issue with the chalk trays on the chalkboards in Simons Auditorium as most sp ...

Number of daily responses


10
8
6
4
2
0
8/25/2013
10/9/2013

Connections for Women Workshop on Optimal Transport: Geometry and Dynamics August 22 - 23, 2013

Additional Survey Responses

Additional comments on your personal assessment

- Very Good!
- The Connection for Women could also be after the Introductory Workshop week so we have more background knowledge.
- I would have prefer to have the introduction workshop before the connection for women. I would have felt better prepared.

Additional comments on the venue

- I would have liked to have less strong tea
- Very Good!
- The all-day tea and coffee station is excellent, the lunch caterers had delicious and healthy options. The facilities here are wonderful!
- less sweet, more health stuff if possible
- need air conditioning
- Healthier tea options would be good.

We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.

- The title of the workshop was confusing. Moreover I couldn't see connection between women.
- Excellent!
- There seems to be an issue with the chalk trays on the chalkboards in Simons Auditorium as most speakers have had trouble with the chalk falling off the chalk trays during the talk which is distracting for them and us.

What other subjects should be addressed in future panel discussions?

- Women's (or minorities) issues, including work-life balance, how to find a mentor, how to react to sexist behavior or when someone makes a joke or degrading statement about women. It may be better to have a discussion or give the opportunity to ask questions without men in the audience.
- The topics can be controlled by the audience, which is nice. But perhaps the audience would be helped out with some starter questions for the panel (since the audience was very quiet at the beginning and then really got more involved toward the end).
- Women panelists should speak with an audience of women alone. The men in the audience starting answering questions.

Additional comments on the workshop organization

- Very Good!
- The strings on the nametags should be shorter to raise them closer to eye level. The font of the names should also be much larger. The only way to read them now is by squinting at someone's stomach :).
- I really liked the relax schedule, more conferences a day would be too much.
- It would be better to have a one day woman workshop with a panel for women only during the intro workshop as it is difficult for women to come two weeks in a row. Also the panel consisted mostly of men in the audience giving advice.
- Everything was great!

Introductory Workshop on
Optimal Transport: Geometry and Dynamics

August 26 to 30, 2013

MSRI, Berkeley, CA, USA

Organizers:

Luigi Ambrosio (Scuola Normale Superiore)

Lawrence Evans (University of California, Berkeley)

Alessio Figalli* (University of Texas)

Report on the MSRI Workshop "Introductory Workshop on Optimal Transport: Geometry and Dynamics" August 26-30, 2013

Organizers:
Luigi Ambrosio (Scuola Normale Superiore of Pisa)
Lawrence Craig Evans (University of California, Berkeley)
Figalli, Alessio (University of Texas, Austin)

1. Scientific description

Understanding the optimal way of transporting mass distributions is a fundamental and highly nontrivial problem in science, whose mathematical formulation was first posed by Monge in his 1781 memoir "*Mémoire sur la théorie des déblais et des remblais*". This problem was later rediscovered and investigated by Kantorovich in the 1940's. By the end of the 1980's, the seminal work of Brenier in "*Décomposition polaire et réarrangement des champs de vecteurs*" paved the way to connecting optimal mass transportation to partial differential equations and related areas. Brenier's theory lead in particular to McCann's displacement convexity and Otto's differential geometry of the space of probability measures. As a consequence, the theory of mass transportation became applicable to wide range of problems in differential geometry, geometric and functional inequalities, and nonlinear diffusions. It additionally stimulated Caffarelli, Urbas, and many others, to develop regularity theory of Monge-Ampère equations.

The MSRI "Introductory Workshop on Optimal Transport: Geometry and Dynamics" (held August 26-30, 2013) was intended to give an overview of the research landscape surrounding optimal transportation, including its connections to geometry, design applications, and fully nonlinear partial differential equations. It featured three minicourses of 3 hours each by distinguished visitors and/or a few of the organizers of the theme semester, amounting to a kind of summer school. These were complemented by a sampling of research lectures and short presentations from a spectrum of invited guests and other participants, including some who attended the previous week's "Connections for Women" workshop.

The introductory workshop aimed to familiarize graduate students, postdocs, and non-experts to major and new topics of the current program. Though the audience was expected to have a general mathematical background, knowledge of technical terminology and recent findings was not assumed.

One of the remarkable features of the workshop was the interaction with the "Connection for Women" workshop, hosted by MSRI the week immediately before the "Introductory Workshop on Optimal Transport: Geometry and Dynamics". This highlighted the research accomplishment of young women working in optimal transportation. Our committee coordinated offers of financial support with the organizing committee of the "Connection for Women" workshop, hence many participants at their meeting received funding and stayed on for ours. In addition, one of the main guidelines in making funding decisions was to offer support to participants in earlier stages of their careers, with little access to personal or institutional grants, while encouraging more senior participants to use such grants for their expenses whenever possible. As a result, women and young mathematicians were more heavily represented at our workshop than at a typical conference in the subject, thus contributing to an exciting diverse week.

We definitely regard this workshop as a success, with talks on several important research directions in the field. And we received lots of compliments from participants, especially for the format of three minicourses of 3 hours each complemented by research lectures.

2. Highlights of presentations

The workshop started with a talk by Luis Caffarelli (UT Austin) on some non-local versions of the Monge-Ampère equation. Caffarelli is an expert on the regularity theory of the Monge-Ampère equation which naturally arises in optimal transportation, and in his lecture he has presented several interesting non-local versions of such equations and described the delicate regularity properties of solutions.

Then Robert McCann (U. Toronto) started with the first of the three minicourses. His course contrasted some recent developments concerning Monge's original version of this problem with a capacity constrained variant in which a bound is imposed on the quantity transported between each given producer and consumer. In particular, he gave a new perspective on Kantorovich's linear programming duality and showed

how more subtle questions relating the structure of the solution are intimately connected to the differential topology and geometry of the chosen transportation cost. In the later lectures, he illustrated how different aspects of curvature (sectional, Ricci and mean) enter into the game.

The other two minicourses have been given by Nicola Gigli (U. Nice) and by Filippo Santambrogio (Paris XI). Gigli's course provided an introduction to the field of synthetic treatment of lower Ricci curvature bounds via optimal transport, and he covered the basic definitions and the crucial aspects of the theory, showing applications to both analysis and geometry.

Santambrogio instead focussed on Monge's problem. Recall that the classical Monge problem (with cost $|x - y|$) has an equivalent counterpart which is the minimization of the L^1 norm of a vector field v, subject to the constraint $\nabla \cdot v = \mu - \nu$. This is a minimal flow problem introduced by the economist M. Beckmann in the 1950s. It has recently come back into fashion because of its possible variants, where the cost rather than being linear as in the L^1 norm can be made convex (thus taking into account for congestion effects) or concave (favoring joint transportation). Also, well-posedness of this problem and regularity issues about the optimal v have brought many questions about the so-called transport density, a measure of the local amount of traffic during the transportation. In his lectures, Santambrogio presented the problem using in particular some recent approach based on the flow by Dacorogna-Moser, and gave the main results on the transport density.

Tatiana Toro (U. Washington) will discussed several results with a common theme: "the regularity of a measure is determined by the extent to which the measure can be is approximated by flat measures". This notion of approximation involves the Wasserstein distance, and to some extent is reminiscent of other approximation coefficients which appear in the Geometric Measure Theory literature.

Xu-Jia Wang (ANU) and Guido De Philippis (U. Bonn) discussed the regularity properties of optimal transport maps. The potential functions in the optimal transportation satisfy a Monge-Ampère type equation. When the cost function $c(x, y) = |x - y|^2$, it is the standard Monge-Ampère equation, and has been studied by many people. For more general cost functions, Ma-Trudinger-Wang obtained the regularity under a structural condition on the cost. Wang discussed the

regularity issue in the case of the Monge cost $|x-y|$, while De Philippis presented some partial regularity results for general cost functions.

Jan Maas (U. Bonn) discussed the interpretation of diffusion equations as gradient flows of the entropy in the Wasserstein space of probability measures, and showed how this interpretation extends to the setting of non-commutative probability. More precisely, he constructed a class of Riemannian metrics on the space of density matrices, which may be regarded as non-commutative analogues of the 2-Wasserstein metric. These metrics allowed him to formulate quantum Markov semigroups as gradient flows of the von Neumann entropy. He presented transportation inequalities in this setting and obtained as well non-commutative versions of results by Bakry-Emery and Otto-Villani.

Two short talk were given by Katy Craig (Rutgers University) and Adrian Butscher (Max-Planck-Institut für Informatik). Craig spoke about gradient flows in the 2-Wasserstein Metric and a gave a Crandal-Liggett type proof of the exponential formula in the Wasserstein space. Butsher showed the importance of optimal transportation in the numerical computation of so-called "soft" harmonic maps.

Benoit Kloeckner (U. Grenoble) discussed expanding circle maps as the simplest examples of discrete-time dynamical systems on manifolds exhibiting a chaotic behavior. The goal of his talk was to explain in this simple context how tools from optimal transport can shed new light on dynamical systems. More precisely, he computed the derivative of the action on measures of an expanding circle map and its absolutely continuous invariant measure, and studied the corresponding spectral properties.

Guofang Wei (UC Santa Barbara) showed how to extend the monotonicity formulas, introduced by Colding and Colding-Minicozzi on manifolds with nonnegative Ricci curvature, to Bakry-Emery Ricci curvature.

The final talk was given by Christian Leonard (Paris X). This was devoted to some advanced results about discrete metric graphs. In 1931, Schrödinger addressed a problem of statistical physics nature that amounts to minimizing the relative entropy of Markov random processes on a state space X, subject to prescribed initial and final marginal distributions. The time marginal flow of the minimizing Markov process interpolates between the prescribed marginals on the space

$Prob(X)$ of probability measures on X. Large deviations arguments show that slowing the processes down towards a no-motion process leads to a dynamical Monge-Kantorovich problem whose transport cost function is related to the random dynamics. The corresponding entropic interpolations are smooth paths on $Prob(X)$ which converge to some displacement interpolation. For instance, if one takes the Brownian motion as reference process, the limiting interpolation is that introduced by McCann. Considering random walks on a discrete set X with a graph structure and passing to the slowing down limit allows us to define natural displacement interpolations on $Prob(X)$ that are geodesics with respect to an intrinsic graph distance. As shown by Leonard in his the talk, this opens the way for investigating curvature of graphs by tracking Lott-Sturm-Villani theory.

Organizers		
First Name	**Last Name**	**Institution**
Luigi	Ambrosio	Scuola Normale Superiore
Lawrence	Evans	University of California, Berkeley
Alessio	Figalli	University of Texas

Speakers		
First Name	**Last Name**	**Institution**
Adrian	Butscher	Max-Planck-Institut fur Informatik
Luis	Caffarelli	University of Texas
Katy	Craig	Rutgers University
Guido	De Philippis	Hausdorff Center of Mathematics
Nicola	Gigli	Universite de Nice Sophia Antipolis
Benoit	Kloeckner	Universite de Grenoble I (Joseph Fourier)
Christian	Leonard	Universite de Paris X (Paris-Nanterre)
Jan	Maas	Rheinische Friedrich-Wilhelms-Universitat Bonn
Robert	McCann	University of Toronto
Filippo	Santambrogio	Universite de Paris XI (Paris-Sud)
Tatiana	Toro	University of Washington
Xu-Jia	Wang	Australian National University
Guofang	Wei	University of California, Santa Barbara

Introductory Workshop on Optimal Transport: Geometry and Dynamics

August 26-30, 2013

Schedule

Monday, August 26, 2013			
9:15 AM - 9:30 AM	Simons Auditorium		Welcome
9:30 AM - 10:30 AM	Simons Auditorium	Luis Caffarelli	Some non local versions of the Monge Ampere equation
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00 PM	Simons Auditorium	Robert McCann	Optimal transport: Old and New, part 1
12:00 PM - 2:00 PM	Atrium		Lunch
2:00 PM - 3:00 PM	Simons Auditorium	Tatiana Toro	Determining the regularity of a measure via the Wasserstein distance
3:00 PM - 3:30 PM	Atrium		Tea
4:00 PM - 5:00 PM	UC Berkeley's Evans Hall	Andrea Bertozzi	MSRI/Evans Lecture: Swarming by Nature and by Design
5:00 PM - 6:30 PM	Laval's Pizza		Pizza Dinner

Tuesday, August 27, 2013			
9:30 AM - 10:30 AM	Simons Auditorium	Nicola Gigli	Optimal transport and lower Ricci curvature bounds, part 1
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00 PM	Simons Auditorium	Filippo Santambrogio	Prescribed-divergence problems in optimal transportation
12:00 PM - 2:00 PM	Atrium		Lunch
2:00 PM- 3:00 PM	Simons Auditorium	Robert McCann	Optimal transport: Old and New, part 2
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:30 PM	Simons Auditorium	Xu-Jia Wang	Regularity in optimal transportation
4:30 PM - 6:30 PM	Atrium		Reception

Wednesday, August 28, 2013			
9:00 AM - 10:00 AM	Simons Auditorium	Filippo Santambrogio	Prescribed-divergence problems in optimal transportation, part 2
10:00 AM - 10:30 AM	Atrium		Tea
10:30 AM - 11:30 AM	Simons Auditorium	Jan Maas	Optimal transport in non-commutative probability
11:35 AM - 12:00 PM	Simons Auditorium	Katy Craig	Gradient Flow in the 2-Wasserstein Metric: a Crandall and Liggett type proof of the exponential formula
12:05 PM - 12:30 PM	Simons Auditorium	Adrian Butscher	Numerical Computation of Soft Harmonic Maps

Thursday, August 29, 2013			
9:30 AM - 10:30 AM	Simons Auditorium	Nicola Gigli	Optimal transport and lower Ricci curvature bounds, part 2
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00 PM	Simons Auditorium	Guido De Philippis	Partial regularity of optimal transport maps
12:00 PM - 2:00 PM	Atrium		Lunch
2:00 PM- 3:00 PM	Simons Auditorium	Robert McCann	Optimal transport: Old and New, part 3
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:30 PM	Simons Auditorium	Benoît Kloeckner	Optimal transport and dynamics of expanding circle maps

Friday, August 30, 2013			
9:30 AM - 10:30 AM	Simons Auditorium	Filippo Santambrogio	Prescribed-divergence problems in optimal transportation, part 3
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00 PM	Simons Auditorium	Christian Leonard	The Schrödinger problem: a probabilistic analogue of optimal transport
12:00 PM- 2:00 PM	Atrium		Lunch
2:00 PM - 3:00 PM	Simons Auditorium	Guofang Wei	Monotonicity Formulas for Bakry-Emery Ricci Curvature
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:30 PM	Simons Auditorium	Nicola Gigli	Optimal transport and lower Ricci curvature bounds, part 3

Participants		
First Name	**Last Name**	**Institution**
Luigi	Ambrosio	Scuola Normale Superiore
Sara	Andrade	Agilent Technologies, Inc.
Gerolin	Augusto	Universita di Pisa
Gerard	Awanou	University of Illinois at Chicago
Romeo	Awi	Georgia Institute of Technology
Myoungjean	Bae	Pohang University of Science and Technology
Hantaek	Bae	University of California, Davis
Oksana	Bihun	Concordia College, Moorhead, MN
Malcolm	Bowles	University of Victoria
Yann	Brenier	Ecole Polytechnique
Adrian	Butscher	Max-Planck-Institut fur Informatik
Luis	Caffarelli	University of Texas
Jean-Baptiste	Caillau	Universite de Bourgogne (Dijon)
Carla	Cederbaum	Tubingen University
Geng	Chen	Pennsylvania State University
Xiaoyang	Chen	University of Notre Dame
Otis	Chodosh	Stanford University
Piotr	Chrusciel	Universitat Wien
Marina	Chugunova	Claremont Graduate University
Eleonora	Cinti	Universita di Bologna
Maria	Colombo	Scuola Normale Superiore
Codina	Cotar	University College
Katy	Craig	Rutgers University
Andrea	Davini	Universita di Roma "La Sapienza"
Guido	De Philippis	Hausdorff Center of Mathematics
Matias	Delgadino	University of Maryland
Julie	Delon	Telecom PARISTECH
Matthias	Erbar	Rheinische Friedrich-Wilhelms-Universitat Bonn
Lawrence	Evans	University of California, Berkeley
Albert	Fathi	Ecole Normale Superieure de Lyon
Alessio	Figalli	University of Texas
Taryn	Flock	University of California, Berkeley
Wilfrid	Gangbo	Georgia Institute of Technology
Tingran	Gao	Duke University
Nicola	Gigli	Universite de Nice Sophia Antipolis
Matthew	Gill	University of California, Berkeley
Roger	Hernandez	Venezuelan Institute of Scientific Investigation
Alexi	Hoeft	Virginia Commonwealth University
Emanuel	Indrei	Carnegie Mellon University
Varun	Jog	University of California, Berkeley
Seick	Kim	Yonsei University
Young-Heon	Kim	University of British Columbia
Jun	Kitagawa	MSRI - Mathematical Sciences Research Institute

Benoit	Kloeckner	Universite de Grenoble I (Joseph Fourier)
Olivier	Kneuss	UC Berkeley Math Faculty
Sajjad	Lakzian	Universitat Bonn
Rosemonde	Lareau-Dussault	University of Toronto
Hanjin	Lee	Handong Global University
Philippe	LeFloch	Universite Pierre et Marie Curie
Christian	Leonard	Universite de Paris X (Paris-Nanterre)
Janna	Lierl	Hausdorff Center for Mathematics
Zhiwu	Lin	Georgia Institute of Technology
Kevin	Lin	University of Arizona
Johannes	Lorenz	Max Planck Institute fur Gravitationsphysik, AEI
John	Lott	University of California, Berkeley
Jean	Louet	Universite de Paris XI (Paris-Sud)
Jan	Maas	Rheinische Friedrich-Wilhelms-Universitat Bonn
John	Maidens	University of California, Berkeley
Agueh	Martial	University of Victoria
Davi	Maximo	Stanford University
Robert	McCann	University of Toronto
Peyman	Morteza	University of Wisconsin
Anh	Nguyen	University of California, Berkeley
Yewande	Olubummo	Spelman College
Paulo	Orenstein	Catholic University of Rio de Janeiro (PUC)
Raquel	Perales Aguilar	SUNY
Christopher	Policastro	University of California, Berkeley
Pedro juao	Puati	Mulheres de futuro ONG
Samuel	Punshon-Smith	University of Maryland
Ludovic	Rifford	Universite de Nice Sophia Antipolis
Hans	Ringstrom	Royal Institute of Technology (KTH)
Ilan	Roth	UC Berkeley
Filippo	Santambrogio	Universite de Paris XI (Paris-Sud)
Benjamin	Schachter	University of Toronto
Chen	Shibing	University of Toronto
Bismark	Singh	University of Texas
Stephanie	Somersille	Dartmouth College
Christina	Sormani	CUNY, Graduate Center
Suresh	Srinivasamurthy	Kansas State University
Jarno	Talponen	University of Eastern Finland
Wenpin	Tang	University of California
Tatiana	Toro	University of Washington
Hung	Tran	University of Chicago
Konstantina	Trivisa	University of Maryland
Xu-Jia	Wang	Australian National University
Yi	Wang	Stanford University
Micah	Warren	University of Oregon
Guofang	Wei	University of California, Santa Barbara

Yitzhak	Weit	University of Haifa
Clare	Wickman	The Johns Hopkins University Applied Physics Lab
Willie	Wong	Ecole Polytechnique Federale de Lausanne
Lijiang	Wu	Carnegie-Mellon University
Haotian	Wu	MSRI - Mathematical Sciences Research Institute
Ling	Xiao	Johns Hopkins University
Jinxin	Xue	University of Chicago
Wee Meng	Yeo	Georgia Institute of Technology
Shuangjian	Zhang	University of Toronto
Te	Zhang	University of California, Berkeley
Wei	Zhou	University of Minnesota Twin Cities
Xin	Zhou	Massachusetts Institute of Technology

Officially Registered Participant Information

Participants		100

Gender		100
Male	74.00%	74
Female	25.00%	25
Declined to state	1.00%	1

Ethnicity*		100
White	50.00%	50
Asian	31.00%	31
Hispanic	5.00%	5
Pacific Islander	0.00%	0
Black	7.00%	7
Native American	0.00%	0
Mixed	2.00%	2
Declined to state	5.00%	5

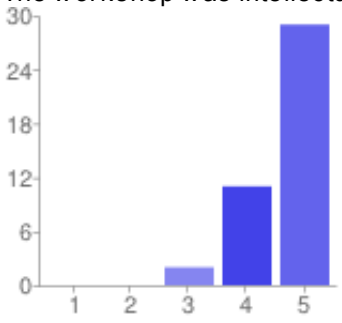
* ethnicity specifications are not exclusive

42 responses

Summary See complete responses

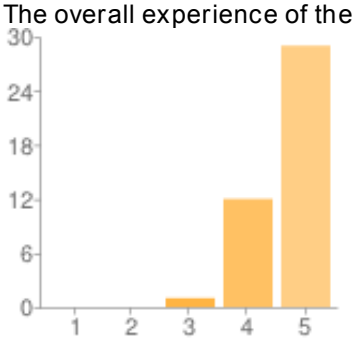
Workshop assessment

The workshop was intellectually stimulating



1 -	Not at all	0	0%
2		0	0%
3		2	5%
4		11	26%
5 -	Very	29	69%

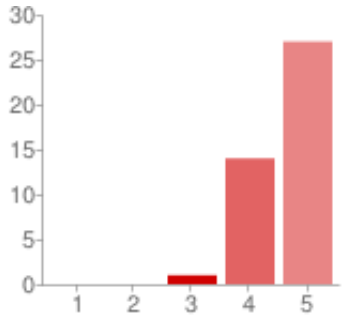
The overall experience of the workshop was worthwhile



1 -	Not at all	0	0%
2		0	0%
3		1	2%
4		12	29%
5 -	Very	29	69%

The time between lectures was adequate for discussion

1 -	Not al all	0	0%
2		0	0%
3		1	2%
4		14	33%
5 -	Very	27	64%



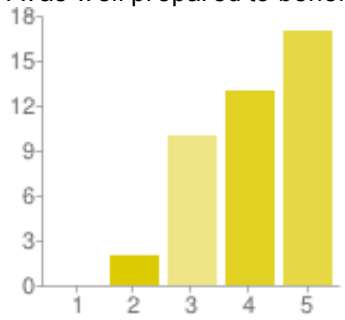
Not al all Very

Additional comments on the workshop organization

Good! Very welcoming organizers and participants--this was perhaps the most valuable aspect of this workshop in particular not my speciality An e-mail informing me of acceptance as a workshop participa ...

Personal assessment

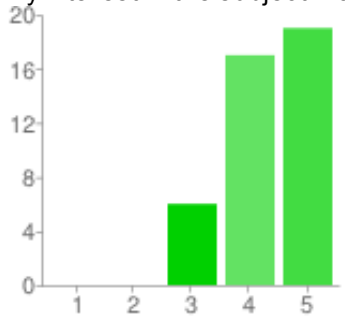
I was well prepared to benefit from the lectures



Not at all Very

1 -	Not at all	0	0%
2		2	5%
3		10	24%
4		13	31%
5 -	Very	17	40%

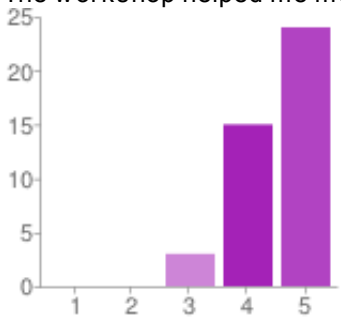
My interest in the subject matter was increased by the workshop



1 -	Niot at all	0	0%
2		0	0%
3		6	14%
4		17	40%
5 -	Very	19	45%

Niot at all Very

The workshop helped me meet people with similar scientific interests



Not at all Very Much

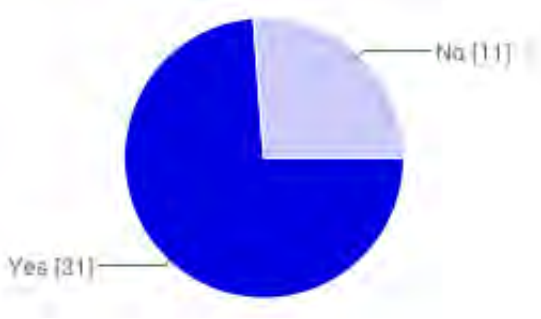
1 -	Not at all	0	0%
2		0	0%
3		3	7%
4		15	36%
5 -	Very Much	24	57%

Additional comments on your personal assessment

Really nice and warm welcome! Did met with people in the community and even more! The lecturers were chosen from a wide range of corners of optimal transport, so we got a representative view of the r ...

Additional Activities

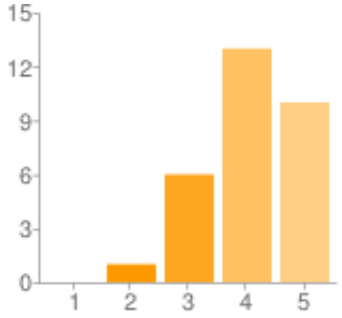
Did you attend the reception?



Yes	31	74%
No	11	26%

If you did attend the reception, did it help to solidify the contacts you made in the workshop?

1 -	Not at all	0	0%
2		1	2%
3		6	14%



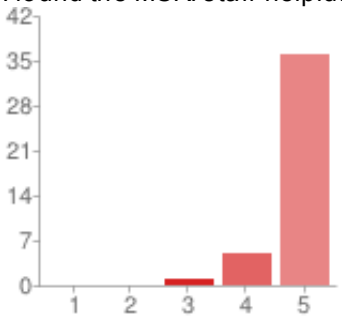
4		13	31%
5 -	Very much	10	24%

Please provide any comments on the reception

Good! Beautifully done and it far exceeded expectations The reception was women only. It would have been nice to have a separate event orgnanized for the men who participated. Very friendly

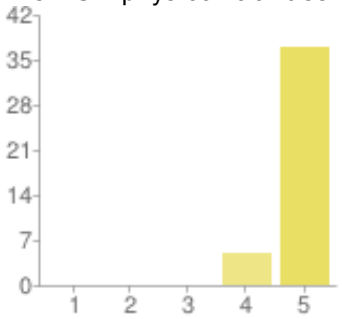
Venue

I found the MSRI staff helpful



1 -	Not at all	0	0%
2		0	0%
3		1	2%
4		5	12%
5 -	Very	36	86%

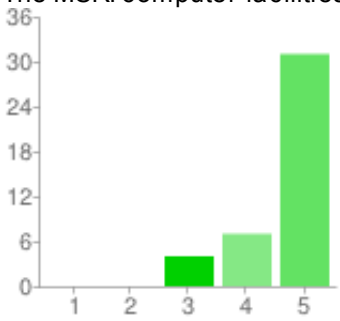
The MSRI physical facilities were conducive for such a workshop



1 -	Not at all	0	0%
2		0	0%
3		0	0%
4		5	12%
5 -	Very	37	88%

Not at all Very

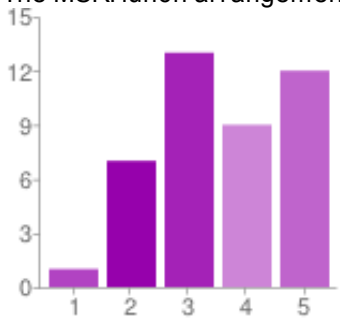
The MSRI computer facilities were adequate for such a workshop



Not at all Very

1 -	Not at all	0	0%
2		0	0%
3		4	10%
4		7	17%
5 -	Very	31	74%

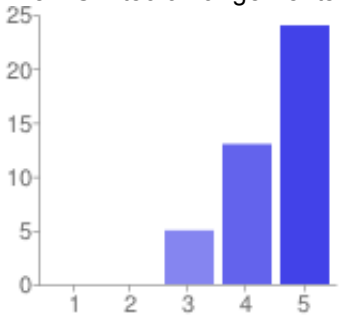
The MSRI lunch arrangements were satisfactory



Not at all Very

1 -	Not at all	1	2%
2		7	17%
3		13	31%
4		9	21%
5 -	Very	12	29%

The MSRI tea arrangements were satisfactory



Not at all Very

1 -	Not at all	0	0%
2		0	0%
3		5	12%
4		13	31%
5 -	Very	24	57%

Additional comments on the venue

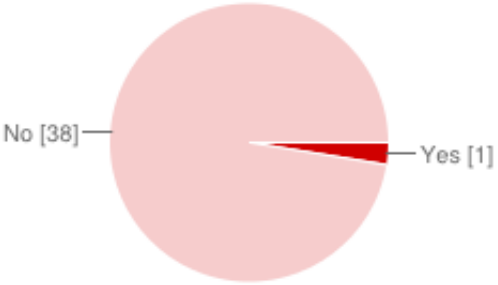
Great! The Wednesday online lunch order (although it was announced once) caught a few people off guard and left them without lunch. Maybe announce the online lunch ordering system a bit more or have ...

MSRI Wireless Network

Did you use MSRI's wireless network?

Yes	36	86%
No	6	14%

Did you experience any difficulties with the network?



Yes	1	2%
No	38	90%

If you did experience difficulties with the network, please explain:

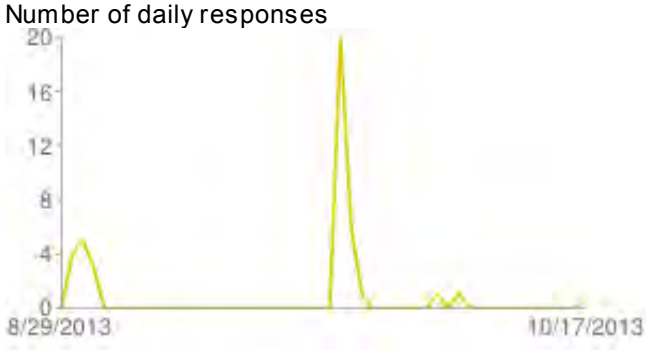
Great network, very fast! And thank you for not having a password on the wifi. Sometimes when I was running windows or linux in my laptop there a very weak wifi signal on the second and third floor. ...

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! The pre-workshop for women helped its participants to get more out of the main workshop. Congratulations for all MSRI Stuff! MSRI is a wonderful place to work. Whenever the workshop is meant ...

Number of daily responses



Introductory Workshop on
Optimal Transport: Geometry and Dynamics
August 26 - 30, 2013

Additional Survey Responses

Additional comments on your personal assessment

- Really nice and warm welcome! Did met with people in the community and even more!
- The lecturers were chosen from a wide range of corners of optimal transport, so we got a representative view of the research going on in OT
- The workshop was announced as accessible to general mathematical community and non-experts, but most of the lectures were targeted to experts.
- Though it was supposed to be an introductory workshop, I am not sure how many would agree with the title. I enjoyed it in any case.
- About second item: I'm already very much involved in the subject so that increasing is difficult

Additional comments on the venue

- Great!
- The Wednesday online lunch order (although it was announced once) caught a few people off guard and left them without lunch. Maybe announce the online lunch ordering system a bit more or have the caterer come on the short day, too.
- the heating/cooling was not very well working
- I would improve the quality and variety of the food.
- Healthier tea options would be good.
- It would be very good if MSRI could arrange the option of projecting slides / laptop beside instead of on top of the blackboard.

We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.

- Excellent!
- The pre-workshop for women helped its participants to get more out of the main workshop.
- Congratulations for all MSRI Stuff! MSRI is a wonderful place to work.
- Whenever the workshop is meant to be 'introductory', it might be worth having separate lectures during the afternoon for 'real' beginners; I met several people who could not follow the lectures they wanted because the lectures were too advanced.
- MSRI is a great place to do research.
- Thank you! What a wonderful week it was.

Please provide any comments on the reception

- Good!
- Beautifully done and it far exceeded expectations
- The reception was women only. It would have been nice to have a separate event orgnanized for the men who participated.
- Very friendly

Additional comments on the workshop organization

- Good!
- Very welcoming organizers and participants--this was perhaps the most valuable aspect of this workshop in particular
- not my speciality
- An e-mail informing me of acceptance as a workshop participant was received only two weeks before the workshop began! Workshop participants, especially those coming from out of town and needing to make flight and housing arrangements need to be contacted at least one month before the start of the workshop.
- It was as good as it could be!
- Wonderful
- I skipped some lectures in order to have time to communicate and that is fine because different people may be more interested in different subtopics.

Fluid Mechanics, Hamiltonian Dynamics, and Numerical Aspects of Optimal Transportation

October 14 to 18, 2013

MSRI, Berkeley, CA, USA

Organizers:

Yann Brenier (École Polytechnique)

Michael Cullen (Met Office)

Wilfrid Gangbo (Georgia Institute of Technology)

Allen Tannenbaum (SUNY)

REPORT ON THE FALL 2013 MSRI WORKSHOP " FLUID MECHANICS, HAMILTONIAN DYNAMICS, AND NUMERICAL ASPECTS OF OPTIMAL TRANSPORTATION

1. Organizers

Yann Brenier (Ecole Polytechniques de Paris, France)
Michael Cullen (Meteo Office, Exeter, UK)
Wilfrid Gangbo (Georgia Institute of Technology, USA)
Allen Tannenbaum (SUNY, Stony Brook, USA)

2. Scientific content

The October 14 – 18 workshop was devoted to emerging approaches to fluid mechanical, geophysical and kinetic theoretical flows based on optimal transportation. It also explored numerical approaches to optimal transportation problems.

The topic interests of the workshop focus around a fundamental optimization problem which can be sketched as follows: Given a distribution of iron mines throughout the surface of the countryside, and a distribution of factories which are consuming iron ore, decide which mines should supply ore to which factories so as to minimize total transportation costs. Modeling the distributions using Borel probability spaces (Ω_0, μ_0) and (Ω_1, μ_1), with a function $c(x, y)$ on their product $\Omega_0 \times \Omega_1$ representing the transportation cost, the problem is to minimize the expectation

$$W_c(\mu_0, \mu_1) := \min_{\gamma} \int_{\Omega_0 \times \Omega_1} c(x, y)\gamma(dx, dy) \tag{2.1}$$

among joint measures $\gamma \geq 0$ on $\Omega_0 \times \Omega_1$ having μ_0 and μ_1 for marginals. Formulated here as an infinite dimensional linear program as done by Kantorovich, this problem has deep connections to geometry, topology, and nonlinear partial differential equations, when the mines and factories are distributed (continuously) over a pair of manifolds whose relationship to each other is encoded in the given function $c(x, y)$. On the other hand, the same problem embeds into models for surprisingly diverse phenomena, including dynamical systems, kinetic theory, atmospheric weather patterns, computer vision, and optimal decision problems facing informational asymmetry. Despite substantial recent progress, several fundamental issues have not yet been resolved, and so, this workshop provided a good environment for discussing many of them.

Date: November 15, 2013.

Another interesting direction concerns transportation on a multi spaces $N = \Omega_1 \times \cdots \times \Omega_k$. Such problems arise when it is necessary to combine k different ingredients to form a mixture, or k different kinds of individuals to form a team, as studied by G. Carlier and I. Ekeland in 2007. In this case, the cost function $c \in C(N)$, and the minimization (2.1) takes place over all measures $\gamma \geq 0$ on the space N with given marginal projections f_i on Ω_i for $i = 1, \cdots, k$. A typical cost function is $c(x_1, \cdots, x_k) = \sum_{i \neq j}^{k} h(x_i - x_j)$ where $h(z) = |z|^2$. The case where h is the Coulomb potential has recently attracted a lot of attention

3. Highlights of presentation

The workshop lasted 5 days and attracted participants from all over the world, including Canada, Germany, France, United Kingdom, Italy. Several high profile mathematicians presented their work. Effort has been made to include speakers ranging from PhD students – such as M. Colombo – to senior researchers. The speakers from the USA were coming from a large variety of geographic areas.

The workshop started with a talk by C. Villani who gave a review on transport and curvature, with an interesting list of open questions. M.Feldman exploited a relaxed formulation of the mass transportation problem for geophysical flows to solve a class of problems involving singular measures. This will allow the optimal transport formulation to be used for a wider class of physically important problems. M. Colombo demonstrated that recent new work by Figalli on the regularity of the Monge-Ampere equation can be exploited in geophysical applications. The last talk by Y. Brenier described level set and volume preserving diffusions.

The next day, there was a talk on medical imaging computation and various applications of mass transport by A. Tannenbaum, and then a talk on imaging of flow from reconstruction to prediction by E. Haber. These talks gave a practical way of using the theory for a large number of engineering problems. H. Zhou presented a novel point of view on Markov Processes on graphs while E. Oudet spoke about convexity constraint problems.

Many of the problems appearing in the study of semi–geostrophic equations are Hamiltonian systems on the Wasserstein space, some of them remaining a challenge from the analytical point of view. During the third day of the conference, M. Cullen – who has been a very important source of problems from meteorology to optimal mass transport – explained the derivation of systems of equations appearing in the study of semi–geostrophic equations and suggested ways to attack them. J.-D. Benamou presented a very effective computational scheme for the second boundary value problem for the Monge–Ampère equation (which corresponds to the optimal transport problem with quadratic cost), using a suitable Hamilton-Jacobi equations along the boundary in the viscosity sense.

G. Friesecke presented a very fascinating and well motivated work on mass transportation with Coulomb potential. G. Awanou, a mathematician working at the borderline of optimal transportation, presented some numerical results which generated a lot of discussions, which may have been amplified by the fact that his

approach was new to the optimal transport community. B. Birnir showed how ideas from optimal transport can be used in geology for the modeling of erosions.

During the last day of the workshop, F. Otto presented a very original work on demixing in viscous fluids. N. Masmoudi presented his recent work on nonlinear inviscid damping in 2–d Euler, arguably one of the best works in the field for the past ten years. The final talk was given by A. Vasseur on the relative–entropy method for shock waves. So doing, he somewhat closed the loop opened by C. Villani in his introductory talk where the concept of relative-entropy played an important role in connecting optimal transport and Riemannian geometry.

Organizers

First Name	Last Name	Institution
Yann	Brenier	Ecole Polytechnique
Michael	Cullen	Met Office
Wilfrid	Gangbo	Georgia Institute of Technology
Allen	Tannenbaum	SUNY

Speakers

First Name	Last Name	Institution
Gerard	Awanou	University of Illinois at Chicago
Jean David	Benamou	Institut National de Recherche en Informatique Automatique (INRIA)
Andrea	Bertozzi	University of California, Los Angeles
Bjorn	Birnir	University of California, Santa Barbara
Yann	Brenier	Ecole Polytechnique
Maria	Colombo	Scuola Normale Superiore
Michael	Cullen	Met Office
Mikhail	Feldman	University of Wisconsin
Eldad	Haber	University of British Columbia
Boris	Khesin	University of Toronto
Nader	Masmoudi	New York University, Courant Institute
Edouard	Oudet	Universite de Grenoble I (Joseph Fourier)
Allen	Tannenbaum	SUNY
Alexis	Vasseur	University of Texas
Haomin	Zhou	Georgia Institute of Technology

Fluid Mechanics, Hamiltonian Dynamics, and Numerical Aspects of Optimal Transportation

October 14 - 18, 2013

Schedule

Monday, October 14, 2013			
9:15 AM - 9:30 AM	Simons Auditorium		Welcome
9:30 AM - 10:30 AM	Simons Auditorium	Cédric Villani	Optimal transport and curvature -- theorems and problems
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00	Simons Auditorium	Mikhail Feldman	Lagrangian solutions of semigeostrophic system with singular initial data
12:00 - 2:00 PM	Atrium		Lunch
2:00 PM - 3:00 PM	Simons Auditorium	Maria Colombo	Existence of distributional solutions to the semigeostrophic equations
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:30 PM	Simons Auditorium	Yann Brenier	Level set volume preserving diffusions

Tuesday, October 15, 2013			
9:30 AM - 10:30 AM	Simons Auditorium	Allen Tannenbaum	Optimal Mass Transport in Medical Imaging Computation
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00	Simons Auditorium	Haomin Zhou	Fokker-Planck equations, Free Energy, and Markov Processes on Graphs
12:00 - 2:00 PM	Atrium		Lunch
2:00PM - 3:00 PM	Simons Auditorium	Eldad Haber	Imaging of flow in porous media from reconstruction to prediction
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:30 PM	Simons Auditorium	Edouard Oudet	Convexity constraint and related problems
4:30 PM - 6:20 PM	Atrium		Reception

Wednesday, October 16, 2013			
9:30 AM - 10:30 AM	Simons Auditorium	Michael Cullen	Free upper boundary value problems for the semi-geostrophic equations
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00	Simons Auditorium	Jean David Benamou	A PDE approach to computing viscosity solutions of the Monge-Kantorovich problem

Thursday, October 17, 2013			
9:30 AM - 10:30 AM	Simons Auditorium	Andrea Bertozzi	Blowup Dynamics for Nonlocal Transport Problems
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00	Simons Auditorium	Gerard Awanou	Standard Finite Elements for the Numerical Resolution of the Elliptic Monge-Ampère Equation
12:00 - 2:00 PM	Atrium		Lunch
2:00 PM - 3:00 PM	Simons Auditorium	Bjorn Birnir	Simulations of Fluvial Landscapes and Optimal Transport
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:30 PM	Simons Auditorium	Gero Friesecke	Density functional theory and optimal transportation with Coulomb cost

Friday, October 18, 2013			
9:30 AM - 10:30 AM	Simons Auditorium	Felix Otto	Demixing in viscous fluids: a connection with optimal transportation
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00	Simons Auditorium	Nader Masmoudi	Nonlinear inviscid damping in 2D Euler
12:00 - 2:00 PM	Atrium		Lunch
2:00 PM - 3:00 PM	Simons Auditorium	Boris Khesin	Fluids, vortex sheets, and skew-mean-curvature flows
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:30 PM	Simons Auditorium	Alexis Vasseur	Relative entropy applied to shocks for Conservation Laws and applications"

Participants

First Name	Last Name	Institution
Gerolin	Augusto	Universita di Pisa
Gerard	Awanou	University of Illinois at Chicago
Romeo	Awi	Georgia Institute of Technology
Joshua	Ballew	University of Maryland
Shabnam	Beheshti	Rutgers University
Jean David	Benamou	Institut National de Recherche en Informatique Automatique (INRIA)
Andrea	Bertozzi	University of California, Los Angeles
Bjorn	Birnir	University of California, Santa Barbara
Malcolm	Bowles	University of Victoria
Yann	Brenier	Ecole Polytechnique
laura	caravenna	University of Oxford
Shibing	Chen	University of Toronto
Maria	Colombo	Scuola Normale Superiore
Katy	Craig	Rutgers University
Michael	Cullen	Met Office
Stefan	Doboszczak	University of Maryland
Matthias	Erbar	Rheinische Friedrich-Wilhelms-Universitat Bonn
Elias	Esselborn	Max-Planck-Institut fur Mathematik in den Naturwissenschaften
Josiane	Faria	State University of Maringa (UEM)
Max	Fathi	Universite Paris VI
Albert	Fathi	Ecole Normale Superieure de Lyon
Mikhail	Feldman	University of Wisconsin
Jin	Feng	University of Kansas
Daniel	Fusca	University of Toronto
Wilfrid	Gangbo	Georgia Institute of Technology
Eldad	Haber	University of British Columbia
Robert	Jensen	Loyola University
Sung Ha	Kang	Georgia Institute of Technology
Boris	Khesin	University of Toronto
Young-Heon	Kim	University of British Columbia
Jun	Kitagawa	MSRI - Mathematical Sciences Research Institute
Rosemonde	Lareau-Dussault	University of Toronto
Philippe	LeFloch	Universite Pierre et Marie Curie
Kevin	Lin	University of Arizona
Hailiang	Liu	Iowa State University
John	Lott	University of California, Berkeley
Jean	Louet	Universite Paris-Sud (Orsay)
Franz	Luef	University of Trondheim
Jan	Maas	Rheinische Friedrich-Wilhelms-Universitat Bonn
Agueh	Martial	University of Victoria
Nader	Masmoudi	New York University, Courant Institute
Henok	Mawi	Howard University
Robert	McCann	University of Toronto
Klas	Modin	University of Toronto
Michael	Neilan	University of Pittsburgh
Amos	Ogunsola	Ladoke Akintola University of Technology, Ogbomoso, Nigeria
Felix	Otto	Max-Planck-Institut fur Mathematik in den Naturwissenschaften

Edouard	Oudet	Universite de Grenoble I (Joseph Fourier)
Brendan	Pass	University of Alberta
Stephen	Preston	University of Colorado
Ali	Rajaei	Tarbiat Modares
Lars	Ruthotto	University of British Columbia
Christina	Sormani	CUNY, Graduate Center
Suresh	Srinivasamurthy	Kansas State University
Allen	Tannenbaum	SUNY
Konstantina	Trivisa	University of Maryland
Adrian	Tudorascu	West Virginia University
Alexis	Vasseur	University of Texas
Changyou	Wang	University of Kentucky
Yi	Wang	Stanford University
Tuo	Wang	Vienna University of Technology
Robert	Warnock	SLAC National Accelerator Laboratory
Gershon	Wolansky	Technion---Israel Institute of Technology
Marie Therese	Wolfram	University of Vienna
Haotian	Wu	MSRI - Mathematical Sciences Research Institute
Jinxin	Xue	University of Chicago
Shuangjian	Zhang	University of Toronto
Haomin	Zhou	Georgia Institute of Technology

Officially Registered Participant Information

Participants		**68**

Gender		**68**
Male	79.41%	54
Female	17.65%	12
Declined to state	2.94%	2

Ethnicity*		**68**
White	63.24%	43
Asian	22.06%	15
Hispanic	1.47%	1
Pacific Islander	0.00%	0
Black	8.82%	6
Native American	0.00%	0
Mixed	1.47%	1
Declined to state	2.94%	2

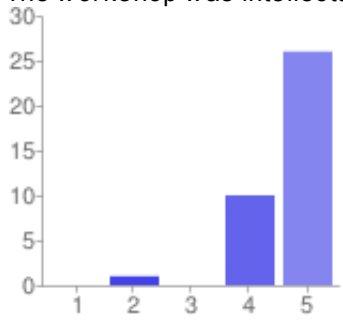
* ethnicity specifications are not exclusive

37 responses

Summary See complete responses

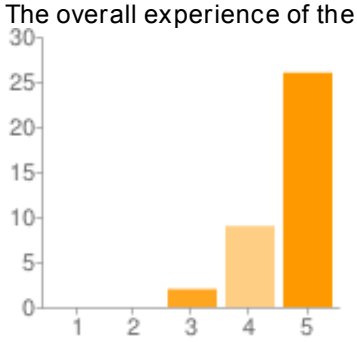
Workshop assessment

The workshop was intellectually stimulating



1 -	Not at all	0	0%
2		1	3%
3		0	0%
4		10	27%
5 -	Very	26	70%

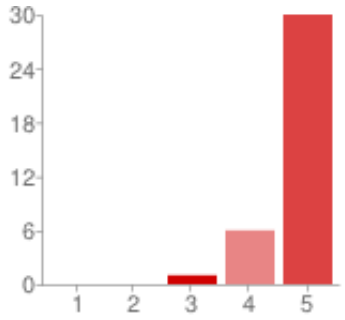
The overall experience of the workshop was worthwhile



1 -	Not at all	0	0%
2		0	0%
3		2	5%
4		9	24%
5 -	Very	26	70%

The time between lectures was adequate for discussion

1 -	Not al all	0	0%
2		0	0%
3		1	3%
4		6	16%
5 -	Very	30	81%



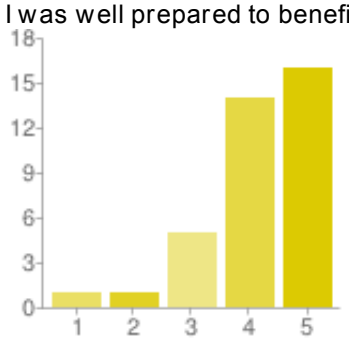
Not al all Very

Additional comments on the workshop organization

I liked the small number of high quality lectures okay Excellent selection of speakers and topics. The lectures were at a very high level providing room for stimulating discussions. The themes of the ...

Personal assessment

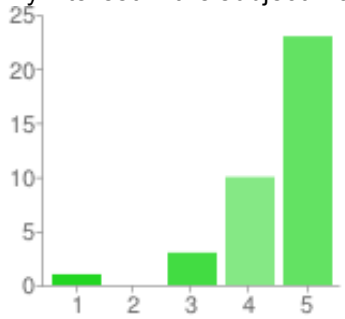
I was well prepared to benefit from the lectures



Not at all Very

1 -	Not at all	1	3%
2		1	3%
3		5	14%
4		14	38%
5 -	Very	16	43%

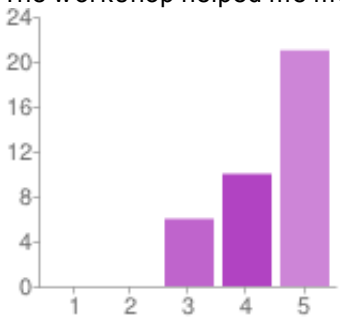
My interest in the subject matter was increased by the workshop



1 -	Niot at all	1	3%
2		0	0%
3		3	8%
4		10	27%
5 -	Very	23	62%

Niot at all Very

The workshop helped me meet people with similar scientific interests



Not at all Very Much

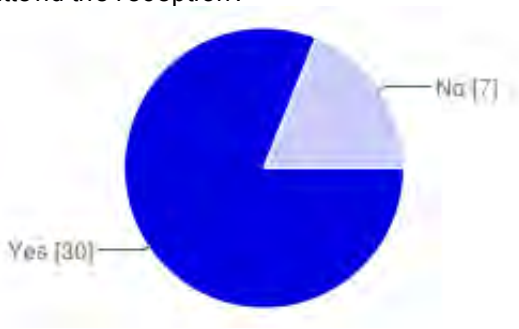
1 -	Not at all	0	0%
2		0	0%
3		6	16%
4		10	27%
5 -	Very Much	21	57%

Additional comments on your personal assessment

it is just a very nice experience. the best site for exchanging ideas with people around I found this workshop very beneficial. I have several new ideas that I am now ready to pursue.

Additional Activities

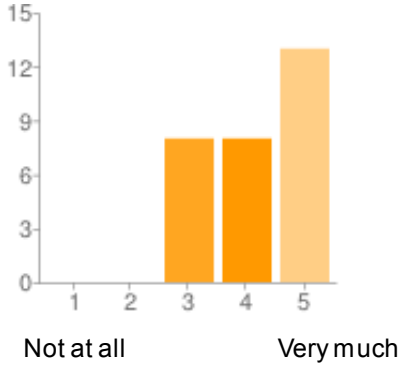
Did you attend the reception?



Yes	30	81%
No	7	19%

If you did attend the reception, did it help to solidify the contacts you made in the workshop?

1 -	Not at all	0	0%
2		0	0%
3		8	22%

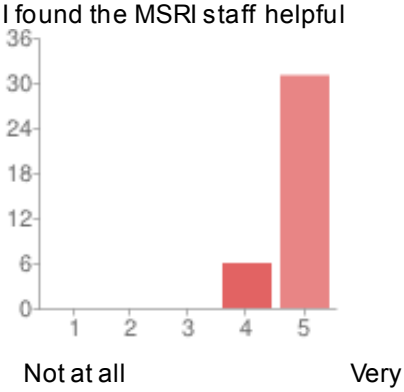


4		8	22%
5 -	Very much	13	35%

Please provide any comments on the reception

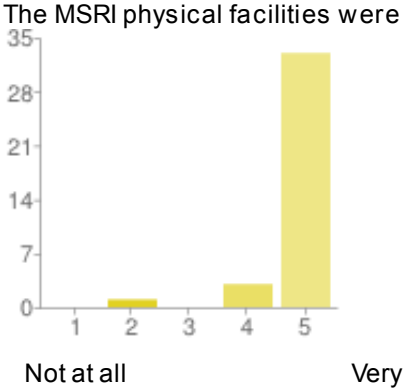
Venue

I found the MSRI staff helpful



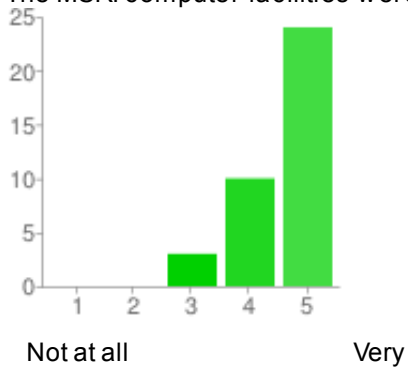
1 -	Not at all	0	0%
2		0	0%
3		0	0%
4		6	16%
5 -	Very	31	84%

The MSRI physical facilities were conducive for such a workshop



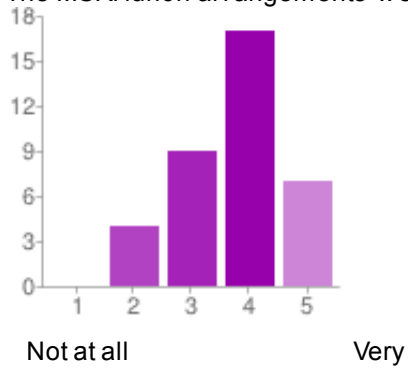
1 -	Not at all	0	0%
2		1	3%
3		0	0%
4		3	8%
5 -	Very	33	89%

The MSRI computer facilities were adequate for such a workshop



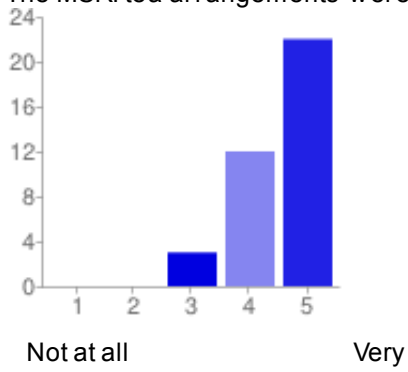
1 -	Not at all	0	0%
2		0	0%
3		3	8%
4		10	27%
5 -	Very	24	65%

The MSRI lunch arrangements were satisfactory



1 -	Not at all	0	0%
2		4	11%
3		9	24%
4		17	46%
5 -	Very	7	19%

The MSRI tea arrangements were satisfactory



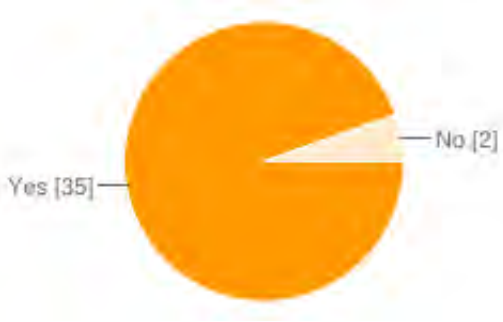
1 -	Not at all	0	0%
2		0	0%
3		3	8%
4		12	32%
5 -	Very	22	59%

Additional comments on the venue

there were only few vegetarian sandwiches need air conditioning in offices. Women are forced to dress inappropriately. Students were complaining about this. Need to improve lighting on blackboards ...

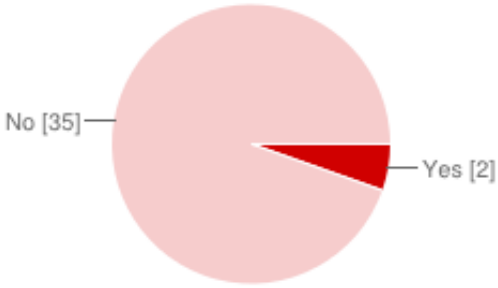
MSRI Wireless Network

Did you use MSRI's wireless network?



Yes	35	95%
No	2	5%

Did you experience any difficulties with the network?



Yes	2	5%
No	35	95%

If you did experience difficulties with the network, please explain:

Depending of the place I was at MSRI I didn't have a good wifi connection occasionally cuts out and I have to get back on.

Thank you for completing this survey

We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.

As much as the workshop is highly stimulating, it was however anticipated that workshops like this will invite not too many speakers as we have in the present case. Some speakers have to rush what ...

Number of daily responses

Fluid Mechanics, Hamiltonian Dynamics, and Numerical Aspects of Optimal Transportation
October 14 - 18, 2013

Additional Survey Responses

Additional comments on your personal assessment

- the best site for exchanging ideas with people around
- I found this workshop very beneficial. I have several new ideas that I am now ready to pursue.

Additional comments on the venue

- there were only few vegetarian sandwiches
- need air conditioning in offices. Women are forced to dress inappropriately. Students were complaining about this.
- Need to improve lighting on blackboards for those parts of the talks.
- more fruit salad would be helpful for the discussions

We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.

- As much as the workshop is highly stimulating, it was however anticipated that workshops like this will invite not too many speakers as we have in the present case. Some speakers have to rush what they prepared for, some speakers do not have enough time to entertain as many questions as necessary. Since the workshop was given a very wide and long announcements, i wish to suggest that: (1) Few experienced speakers should be invited to talk severally throughout the workshop and on schedules. The area of focus should then be treated wholistically by the speakers. (2) The aim should not just be to rub mind on the present paper research work of the instructors. (3) The teachings should be research oriented to stimulate the young Mathematicians to pursue research in the chosen area of discussion. (4) Some of us from developing Countries as well as other young scientists should be encouraged with at least free accomodation, feeding and intra campus transportation. (5) Participants transport expenses should be subsidised by the Institutes, since participants and shortlisted before the workshop. (6) Shortlisting of participants should be with consideration of the available budget for the workshop.
- Try fix talk schedule early enough (say, one month in advance), so those from a far can have time to make the travel arrangements.

If you did experience difficulties with the network, please explain:

- Depending of the place I was at MSRI I didn't have a good wifi connection
- occasionally cuts out and I have to get back on.

Please provide any comments on the reception

- No comments

Additional comments on the workshop organization

- I liked the small number of high quality lectures

- Excellent selection of speakers and topics. The lectures were at a very high level providing room for stimulating discussions. The themes of the workshop were very carefully selected! Bravo!
- I skipped a few talks to have time to engage in collaboration but that is ok because different people chose to skip different talks.

Connections for Women: Algebraic Topology

January 21 - 24, 2014

MSRI, Berkeley, CA, USA

Organizers:

Julie Bergner (University of California)

Teena Gerhardt (Michigan State University)

Brooke Shipley (University of Illinois at Chicago)

1 Workshop Description

At the heart of algebraic topology is the interplay between algebra and geometry. Foundational geometric problems are translated into algebra and meanwhile geometric tools are applied to algebraic problems. This creates a rich field of mathematics with many tools and techniques, and close ties to algebraic geometry, geometric topology, number theory, representation theory, etc. This Connections for Women workshop was the first event in the semester-long Algebraic Topology program at the Mathematical Sciences Research Institute (MSRI) in Spring 2014. The workshop was organized by Teena Gerhardt (Lead Organizer) from Michigan State University, Julie Bergner from University of California Riverside, and Brooke Shipley from University of Illinois at Chicago. The goals of the Connections for Women: Algebraic Topology Workshop were as follows:

- Highlight the outstanding work of female mathematicians in Algebraic Topology.
- Provide an introduction to several important areas of Algebraic Topology in a way that is accessible to early-career mathematicians as well as to researchers in neighboring fields of mathematics.
- Aid in the discovery and creation of mathematical connections between participants.
- Create a network of female mathematicians in Algebraic Topology where open communication about personal and professional successes and challenges is encouraged.

The workshop was very successful in meeting these goals. The workshop had three main components: mini-courses, participant talks, and a panel discussion followed by a conference dinner. These three components are discussed below.

1.1 Mini-Courses

Since one of the primary workshop goals was for it to be accessible to early-career researchers and people in neighboring fields of mathematics, the workshop was structured around 3 mini-courses each consisting of 2 one-hour lectures. All of the mini-course lecturers were prominent female mathematicians in the field: Kathryn Hess from Ecole Polytechnique Fédérale de Lausanne (EPFL), Nathalie Wahl from the University of Copenhagen, and Kirsten Wickelgren from Georgia Institute of Technology. These lecturers were chosen for both their excellence in research and their ability to communicate with a diverse audience, and indeed they gave excellent lectures. The scientific content of the mini-courses is briefly described below. Videos and typed notes for these courses are available on the MSRI website.

Operads in Algebraic Topology – Kathryn Hess
Hess provided an introduction to operads and the many important applications of operads to algebraic topology. She discussed their origin as a convenient means for understanding iterated loop spaces and ended with a discussion of Deligne's conjecture and various solutions.

Homological Stability for Families of Groups – Nathalie Wahl
Wahl discussed a host of exciting recent homological stability results. Harer's theorem for mapping class groups showed that the homology of the mapping class group stabilizes in certain degrees as

the genus of the surface grows. Such stability phenomena have had dramatic and far-reaching generalizations in recent times. Wahl outlined her own recent work on a general axiomatic approach which would subsume most known stability results.

Homotopy Theory and Arithmetic Geometry – Kirsten Wickelgren
Wickelgren discussed the use of homotopy theory to study non-abelian phenomena in the intersection of algebraic topology, algebraic geometry, and number theory. She focused on Grothendieck's anabelian conjectures which predict that certain schemes are determined by their étale fundamental group.

1.2 Participant Talks

Two important goals of the workshop were to highlight the work of female mathematicians and to create mathematical connections between participants. Thus participants were offered the opportunity to propose a short talk for the workshop, allowing early-career participants a chance to present their results and share their research interests. There were 5 twenty-minute participant talks, highlighting the work of promising early-career female algebraic-topologists: Emily Riehl from Harvard University, Simona Settepanella from Hokkaido University, Marcy Robertson from University of Western Ontario, Cristina Costoya from Universidad de Coruña, Anna Marie Bohmann from Northwestern University, and Angelica Osorno from Reed College (with the last two giving a talk together on their joint work). There were additionally 5 ten-minute participant talks during the workshop.

Participants gave lovely talks, and the talks covered a diverse set of research interests, including equivariant stable homotopy theory, category theory, structured ring spectra, fibre bundles, and braid groups. More details can be found on the MSRI website.

1.3 Panel Discussion and Conference Dinner

One of the workshop goals was to help create a network of female mathematicians in Algebraic Topology with open communication about personal and professional challenges, in addition to mathematics. To encourage such communication there was a panel discussion on the first day of the workshop. This panel discussed issues particularly relevant to early-career researchers, women, and members of under-represented groups. The lively discussion was guided by questions from the audience, and many audience members contributed their thoughts and experiences in addition to the panel members. The panel was scheduled immediately before the Conference Dinner and the conversations sparked during the panel continued informally throughout the evening. The panel was moderated by Teena Gerhardt (Assistant Professor at Michigan State University) and the panelists were:

Maia Averett – Assistant Professor – Mills College
Julie Bergner – Assistant Professor – University of California Riverside
Brenda Johnson – Professor – Union College
Emily Riehl – Postdoc – Harvard University
Brooke Shipley – Professor – University of Illinois at Chicago
Nathalie Wahl – Professor – University of Copenhagen

These panelists represented a variety of career stages and types of institutions. There were panelists both with and without children and panelists who have dealt with "two-body" problems. In an online participant survey, participants responded very positively about both the panel and the dinner. One participant noted: *"I found the panel discussion about women's experiences in their careers to be very beneficial."* Another participant commented, *"It was great to have a chance to talk with my fellow mathematicians–many of whom I'd just met– in a more casual setting while eating delicious food."*

1.4 Participant Response

The Connections for Women workshop was immediately followed by the Introductory Workshop in Algebraic Topology, also at MSRI. These two workshops together marked the beginning of the Algebraic Topology semester. Many of the participants in the Connections for Women workshop stayed to participate in the Introductory Workshop. The two workshops were closely coordinated, contributing to the success of both workshops.

Participants gave feedback on the Connections for Women workshop via an online survey. The participant feedback was overwhelmingly positive. One participant noted *"The workshop was a great opportunity to make new contacts and solidify old ones. I was able to work with collaborators on a project during lunch breaks. This was an excellent experience."* Another commented, *"I had a wonderful time and thought it was excellently organized, with lots of very intense mathematics, well-balanced with much opportunity to meet and form relationships with our fellow mathematicians."* From comments such as these as well as the huge majority of participants indicating that the overall experience was "very worthwhile," it seems clear that the goals of the workshop were met.

Organizers		
First	**Last**	**Institution**
Julie	Bergner	University of California
Teena	Gerhardt	Michigan State University
Brooke	Shipley	University of Illinois at Chicago

Speakers		
First	**Last**	**Institution**
Julie	Bergner	University of California
Anna Marie	Bohmann	Northwestern University
Safia	Chettih	University of Oregon
Cristina	Costoya	Universidade da Coruna
Teena	Gerhardt	Michigan State University
John	Harper	Ohio State University
Kathryn	Hess	Ecole Polytechnique Federale de Lausanne (EPFL)
Angelica	Osorno	Reed College
Emily	Riehl	Harvard University
Marcy	Robertson	University of Western Ontario
Carmen	Rovi	University of Edinburgh
Simona	Settepanella	Hokkaido University
Jean	Verrette	University of Hawaii at Manoa
Nathalie	Wahl	University of Copenhagen
Kirsten	Wickelgren	Georgia Institute of Technology

Connections for Women: Algebraic Topology

January 23 - 24, 2014

Schedule

Thursday, January 23, 2014			
9:00AM - 9:15AM	Simons Auditorium		Welcome
9:15AM - 10:15AM	Simons Auditorium	Kathryn Hess	Operads in algebraic topology
10:15AM - 10:45AM	Atrium		Tea
10:45AM - 11:45AM	Simons Auditorium	Kirsten Wickelgren	Homotopy theory and arithmetic geometry
11:45AM - 1:15PM	Atrium		Lunch
1:15PM - 1:35PM	Simons Auditorium	Emily Riehl	Limits of quasi-categories with (co)limits
1:45PM - 2:15PM	Simons Auditorium	Anna Marie Bohmann Angelica Osorno	A new equivariant infinite loop space machine
2:30PM - 3:30PM	Simons Auditorium	Nathalie Wahl	Homological stability for families of groups
3:30PM - 4:00PM	Atrium		Tea
4:00PM - 5:30PM	Commons Room		Panel Discussion
6:30PM - 8:30PM	MSRI		Dinner at Taste of the Himalayas

Friday, January 24, 2014			
9:00AM - 10:00AM	Simons Auditorium	Kathryn Hess	Operads in algebraic topology
10:00AM - 10:30AM	Atrium		Tea
10:30AM - 10:50AM	Simons Auditorium	Simona Settepanella	Braid groups in complex spaces and grassmannians
11:00AM - 11:20PM	Simons Auditorium	Marcy Robertson	Schematic homotopy types of operads
11:25PM - 11:45PM	Simons Auditorium	Cristina Costoya	Realizability of G-modules: on a dual of a Steenrod problem
11:45PM - 1:15PM	Atrium		Lunch
1:15PM - 2:15PM	Simons Auditorium	Kirsten Wickelgren	Homotopy theory and arithmetic geometry
2:30PM - 3:30PM	Simons Auditorium	Nathalie Wahl	Homological stability for families of groups
3:30PM - 4:00PM	Atrium		Tea
4:00PM - 5:30PM	Simons Auditorium	Mona Merling Jean Verrette Carmen Rovi John Harper Safia Chettih	Participants Talks

Participants

First	Last	Institution
Meredith	Anderson	New Mexico State University
Michael	Andrews	Massachusetts Institute of Technology
Maia	Averett	Mills College
David	Ayala	Montana State University
Jeffrey	Bailes	University of Melbourne
Lauren	Bandklayder	Northwestern University
Maria	Basterra	University of New Hampshire
marzieh	bayeh	University of Regina
Irina	Bobkova	Northwestern University
Heather	Bruch	New Mexico State University
David	Carchedi	Max Planck Institute for Mathematics
Michael	Ching	Amherst College
Michael	Donovan	Massachusetts Institute of Technology
Bjorn	Dundas	University of Bergen
William	Dwyer	University of Notre Dame
Ozlem	Ejder	University of Southern California
Elden	Elmanto	Northwestern University
Maggie	Ewing	University of Minnesota Twin Cities
Brittany	Fasy	Tulane University
John	Foley	University of Copenhagen
James	Freitag	University of California, Berkeley
Jennifer	Garbett	University of Notre Dame
Paul	Goerss	Northwestern University
Matthias	Grey	University of Copenhagen
Ilya	Grigoriev	University of Chicago
Jesper	Grodal	University of Copenhagen
Ellen	Henke	University of Copenhagen
Michael	Hill	University of Virginia
Joseph	Hirsh	Massachusetts Institute of Technology
Brenda	Johnson	Union College
Inbar	Klang	Stanford University
Aradhana	Kumari	CUNY, Graduate Center
Therese	Landry	San Francisco State University
Isabelle	Laude	University of Copenhagen
Ayelet	Lindenstrauss	Indiana University
Aaron	Mazel-Gee	University of California, Berkeley
Mona	Merling	University of Chicago
Leanne	Merrill	University of Oregon
Viktoriya	Ozornova	UniversitÃ¤t Bremen
Matthew	Pancia	University of Texas
Liz	Pannell	University of California, Santa Cruz
Kathleen	Ponto	University of Kentucky
Charles	Rezk	University of Illinois at Urbana-Champaign
Martina	Rovelli	Ecole Polytechnique Federale de Lausanne (EPFL)
Nora	Seeliger	Australian National University

Elaine	So	University of Pennsylvania
Sowmya	Srinivasan	Rutgers University
Marc	Stephan	Ecole Polytechnique Federale de Lausanne (EPFL)
Vesna	Stojanoska	Massachusetts Institute of Technology
Markus	Szymik	University of Copenhagen
Felicia	Tabing	University of California, Santa Cruz
Amelia	Tebbe	University of Illinois at Urbana-Champaign
Sean	Tilson	Royal Institute of Technology (KTH)
Massimiliano	Ungheretti	University of Copenhagen
Paul	VanKoughnett	Northwestern University
Tane	Vergili	Ege University
Deborah	Vicinsky	University of Oregon
Kay	Werndli	Ecole Polytechnique Federale de Lausanne (EPFL)
Dylan	Wilson	Northwestern University
Carol	Wood	Wesleyan University
Aliaksandra	Yarosh	University of Pittsburgh
Sarah	Yeakel	University of Illinois at Urbana-Champaign
Dimitri	Zaganidis	Ecole Polytechnique Federale de Lausanne (EPFL)

Officially Registered Participant Information

Participants		79

Gender		79
Male	36.71%	29
Female	63.29%	50
Declined to state	0.00%	0

Ethnicity*		79
White	75.95%	60
Asian	7.59%	6
Hispanic	3.80%	3
Pacific Islander	0.00%	0
Black	0.00%	0
Native American	0.00%	0
Mixed	5.06%	4
Declined to state	7.59%	6

* ethnicity specifications are not exclusive

27 responses

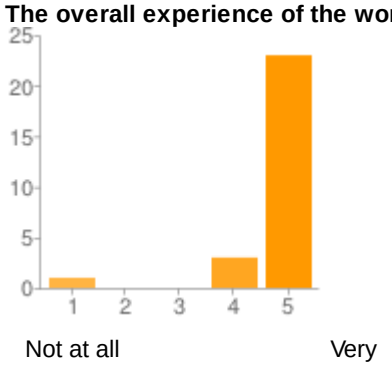
Summary See complete responses

Workshop assessment

The workshop was intellectually stimulating

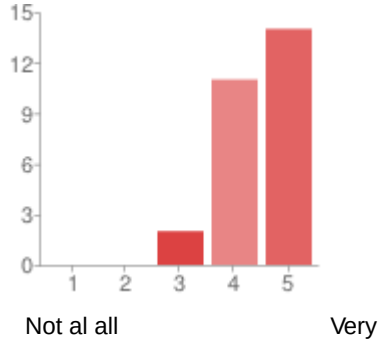
1 -	Not at all	**0**	0%
2		**0**	0%
3		**0**	0%
4		**6**	22%
5 -	Very	**21**	78%

The overall experience of the workshop was worthwhile



1 -	Not at all	**1**	4%
2		**0**	0%
3		**0**	0%
4		**3**	11%
5 -	Very	**23**	85%

The time between lectures was adequate for discussion



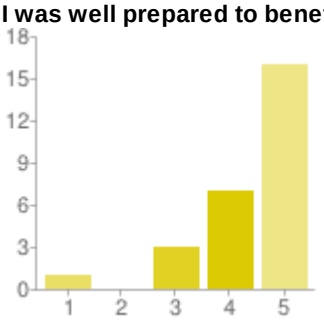
1 -	Not al all	**0**	0%
2		**0**	0%
3		**2**	7%
4		**11**	41%
5 -	Very	**14**	52%

Additional comments on the workshop organization

great I enjoyed the lunch selection, and it was very reasonably priced I sent a few emails before arriving for which I did not receive a response. I had a wonderful time and thought it was excellently ...

Personal assessment

I was well prepared to benefit from the lectures

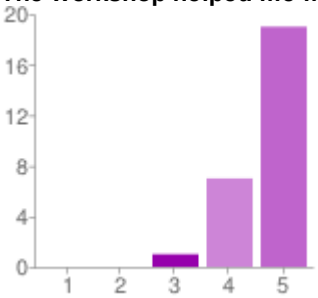


1 -	Not at all	**1**	4%
2		**0**	0%
3		**3**	11%
4		**7**	26%
5 -	Very	**16**	59%

My interest in the subject matter was increased by the workshop

1 -	Niot at all	**0**	0%
2		**0**	0%
3		**2**	7%
4		**6**	22%
5 -	Very	**19**	70%

The workshop helped me meet people with similar scientific interests



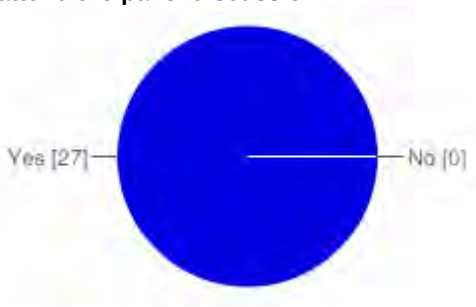
1 -	Not at all	**0**	0%
2		**0**	0%
3		**1**	4%
4		**7**	26%
5 -	Very Much	**19**	70%

Additional comments on your personal assessment

thanks!

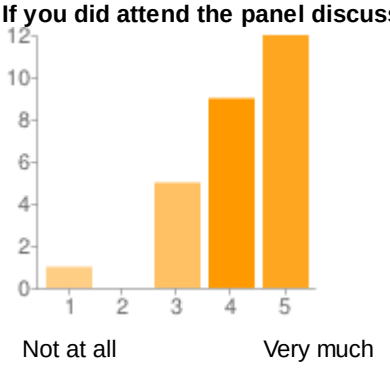
Additional Activities

Did you attend the panel discussion?



Yes		**27**	100%
No		**0**	0%

If you did attend the panel discussion, did you find it worthwhile?

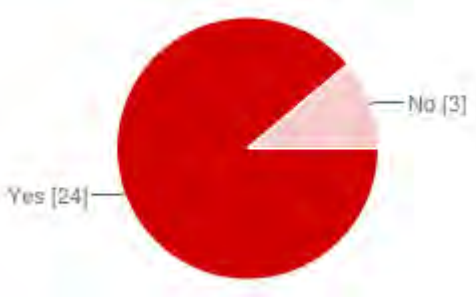


1 -	Not at all	**1**	4%
2		**0**	0%
3		**5**	19%
4		**9**	33%
5 -	Very much	**12**	44%

What other subjects should be addressed in future panel discussions?

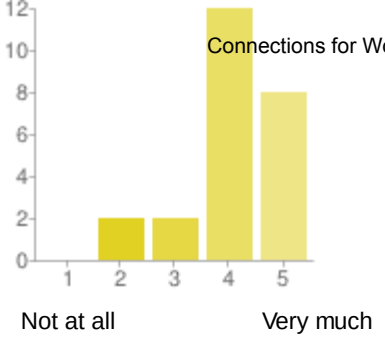
It would have been useful to have a member on the panel who did not go to Harvard. perhaps shorter more directed panels would be nice.

Did you attend the dinner?



Yes		**24**	89%
No		**3**	11%

If you did attend the dinner, did it help to solidify the contacts you made in the workshop?



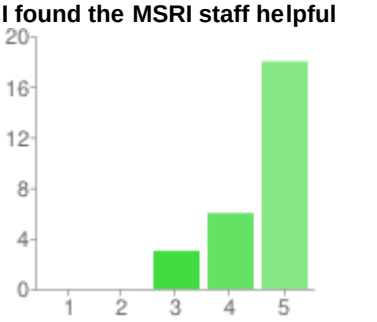
1 -	Not at all	**0**	0%
2		**2**	7%
3		**2**	7%
4		**12**	44%
5 -	Very much	**8**	30%

Please provide any comments on the dinner

more spicy food! great choice. It was great to have a chance to talk with my fellow mathematicians--many of whom I'd just met-- in a more casual setting while eating delicious food. very good food and ...

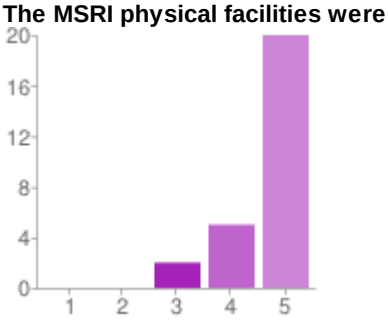
Venue

I found the MSRI staff helpful



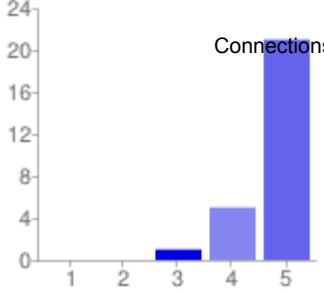
1 -	Not at all	**0**	0%
2		**0**	0%
3		**3**	11%
4		**6**	22%
5 -	Very	**18**	67%

The MSRI physical facilities were conducive for such a workshop



1 -	Not at all	**0**	0%
2		**0**	0%
3		**2**	7%
4		**5**	19%
5 -	Very	**20**	74%

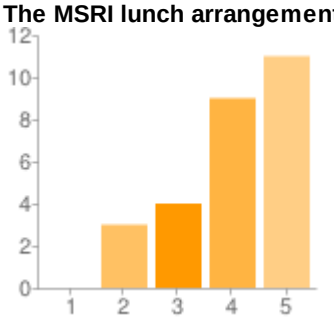
The MSRI computer facilities were adequate for such a workshop



Not at all Very

1 -	Not at all	**0**	0%
2		**0**	0%
3		**1**	4%
4		**5**	19%
5 -	Very	**21**	78%

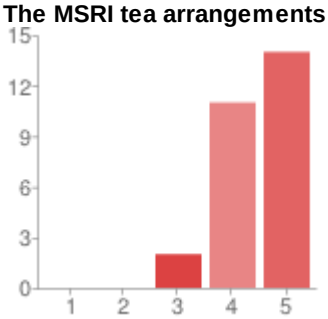
The MSRI lunch arrangements were satisfactory



Not at all Very

1 -	Not at all	**0**	0%
2		**3**	11%
3		**4**	15%
4		**9**	33%
5 -	Very	**11**	41%

The MSRI tea arrangements were satisfactory



Not at all Very

1 -	Not at all	**0**	0%
2		**0**	0%
3		**2**	7%
4		**11**	41%
5 -	Very	**14**	52%

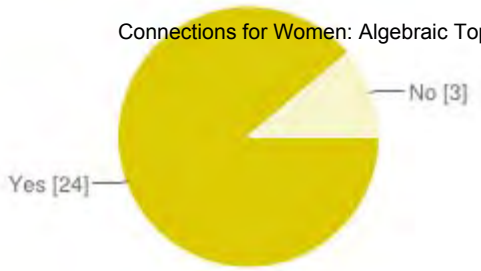
Additional comments on the venue

Excellent. A bit difficult to get to from the airport but the shuttles from campus are convenient. The lecture hall could be improved: far too few seats are good with respect to following the lecture ...

MSRI Wireless Network

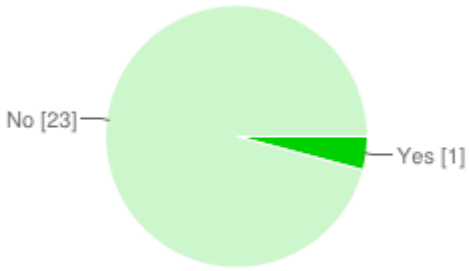
Did you use MSRI's wireless network?

Yes	**24**	89%
No	**3**	11%



Did you experience any difficulties with the network?

Yes	**1**	4%
No	**23**	85%



If you did experience difficulties with the network, please explain:

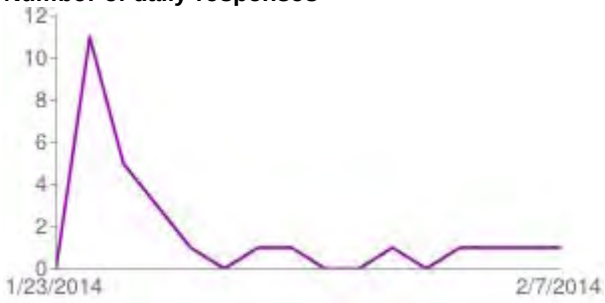
printing from my own computer was a problem. Hence I printed from a library computer instead.

Thank you for completing this survey

We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.

The workshop was a great opportunity to make new contacts and solidify old ones. I was able to work with collaborators on a project during lunch breaks. This was an excellent experience.

Number of daily responses



Connections for Women: Algebraic Topology
January 23 - 24, 2014

Additional Survey Responses

Additional comments on your personal assessment

- thanks!

Additional comments on the venue

- Excellent.
- A bit difficult to get to from the airport but the shuttles from campus are convenient.
- The lecture hall could be improved: far too few seats are good with respect to following the lectures (including being able to read the blackboard!). Temperature was also an issue.
- On Friday, we were late to tea because a talk ran long and then we took a photo. By the time we got there, a lot of the snacks were gone.
- The cash only lunch was not convenient and not good.

We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.

- The workshop was a great opportunity to make new contacts and solidify old ones. I was able to work with collaborators on a project during lunch breaks. This was an excellent experience.

If you did experience difficulties with the network, please explain:

- printing from my own computer was a problem. Hence I printed from a library computer instead.

What other subjects should be addressed in future panel discussions?

- It would have been useful to have a member on the panel who did not go to Harvard.
- perhaps shorter more directed panels would be nice.

Please provide any comments on the dinner

- more spicy food!
- great choice.
- It was great to have a chance to talk with my fellow mathematicians--many of whom I'd just met-- in a more casual setting while eating delicious food.
- very good food and company

Additional comments on the workshop organization

- great
- I enjoyed the lunch selection, and it was very reasonably priced
- I sent a few emails before arriving for which I did not receive a response.
- I had a wonderful time and thought it was excellently organized, with lots of very intense mathematics, well-balanced with much opportunity to meet and form relationships with our fellow mathematicians.
- I found the panel discussion about women's experiences in their careers to be very beneficial.

- The latches in the restrooms are not working properly.
- could have been more variety in lecture topics, enjoyed the short lectures
- Thank you!
- Because of the large number of people, it was a bit difficult to make new connections. It did help solidify old connections.

Introductory Workshop: Algebraic Topology

January 27 - 31, 2014

MSRI, Berkeley, CA, USA

Organizers:

Teena Gerhardt (Michigan State University)

Jesper Grodal (University of Copenhagen)

Kathryn Hess (École Polytechnique Fédérale de Lausanne)

Michael Hill (University of Virginia)

1 Workshop Description

This workshop was one of the first events of the semester long program in Algebraic Topology at MSRI, the first such program in twenty-five years. Building on the Connections for Women Workshop in Algebraic Topology, held January 23-24, the Introductory Workshop provided a stable foundation, grounding the hot research topics and introducing researchers to some of the exciting developments in the field.

Algebraic topology blends algebraic and geometric methods, using each to inform and solve problems in the other. These connections of late have been fantastically successful, as tools and techniques from algebraic and algebraic geometry have been imported directly into algebraic topology, resulting in work that freely uses and applies deep results in algebra, number theory, and representation theory to better explain topological phenomena.

The workshop centered around talks given by experts in various branches of algebraic topology, more details of which are elaborated below. The focus of the talks was expository, introducing people, especially early-career researchers, to other areas in algebraic topology. Though focusing on background and techniques, the talks also described some of the ongoing avenues of research, helping people feel comfortable with the ideas and language used by the experts.

Over 170 mathematicians at all stages of their careers participated in the workshop, making it one of the largest held at MSRI. Reception was uniformly positive, and the talks provided the perfect balance of historical overview and cutting edge mathematics.

2 Introductory Lectures

We were extremely impressed with the quality and caliber of the introductory lectures. The focus was exactly right, allowing the audience to get a taste of the area and the problems with it.

In contrast to most workshops, topics were chosen for speakers, rather than by speakers. This worked quite well, although many speakers found it curious at first. Speakers were chosen because of their ability to give clear but broad-scoped lectures in their speciality, and the lecturers came from many career stages, allowing some younger mathematicians to showcase their areas.

The lectures were groups loosely thematically by day. Full videos of all of the talks and careful transcripts of the lectures are also available at http://www.msri.org/workshops/685 We present here, however, a short summary of each talk. The goal of this is to stress the extreme care taken by the speakers to present talks with a clear, coherent story that explained the importance of the topic and how the topic fit into the broader topology framework.

Monday - Operads and algebras

Bill Dwyer (University of Notre Dame) - Introduction to operads

Operads have become to central way to describe algebraic structures “up to homotopy”. Dwyer gave a careful treatment, building up from well known examples of just monoids in sets to symmetric sequences and then operads. He spent time on examples, and then moved to duality in operads, the tensor product of operads, and then a large list of fundamental results in homotopy theory (many of which are quite recent) that needed operads in an essential way to solve. He finished with some similar results in algebra, closing with several very natural conjectures.

Michael Ching (University of Massachusetts, Amherst) -Goodwillie's calculus of functors

Goodwillie calculus is a way to decompose an arbitrary functor into a sequence of increasingly good "polynomial approximations" to that functor. Ching spent time describing exactly what we might mean by "polynomial" and "approximation". Much of the talk was spent discussing "linear functors", showing how the abstract formalism can be readily understood in this context. This then motivated the higher levels of Goodwillie's Taylor tower.

Brooke Shipley (University of Illinois at Chicago) -Morita theory in stable homotopy

Morita theory is the name used to describe a family of results about the equivalence of categories of modules over rings. The modern point-set notions of spectra allowed similarly questions to be stated in homotopy theory. Shipley began by discussing carefully the classical Morita theory, and then she moved into discussing derived Morita theory (in particular Morita theory over DGAs). The talk closed with recent discussions of spaces of equivalences, higher categorical versions, and the Brauer group.

Lars Hesselholt (Nagoya University) -MSRI/Evans Lecture: Topological cyclic homology

Hesselholt's lecture was also an MSRI/Evans lecture. As such, the focus was even more broad than a survey talk for an algebraic topology crowd. Hesselholt described several results and problems in algebraic K-theory, showing how basic questions in the algebraic K-theory of the integers are tied to deep and classical questions in number theory (for example, the Kummer-Vandiver conjecture). He also described the general homotopical approach to algebraic K-theory via topological cyclic homology.

Tuesday -K-theories and higher categories

John Rognes (University of Oslo)-Chromatic redshift

Rognes' redshift conjecture is one of the most important in the algebraic K-theory of structured ring spectra. Foundational work of Quillen showed that the algebraic K-theory functor takes height 0 information (in this case discrete rings) to height 1 information (built from topological K-theory). Rognes described the classical data supporting the conjecture and then described computations providing additional support. Rognes finished by exploring several future directions in this area.

Andrew Blumberg (University of Texas)-Higher categories and algebraic K-theory

Blumberg gave an introduction to the modern approaches and applications of algebraic K-theory. Starting with a very general mantra of "K-theory is a functor from the homotopical category of (certain) homotopical categories to spectra", he outlined several classical constructions (most notably Waldhausen's) of algebraic K-theory. He then moved into the natural question of how one could show that really the K-theory functor should depend only on the underlying homotopical category. He used this as a springboard to then talk about what algebraic K-theory does in a higher-categorical context, focusing on Waldhausen's Additivity Theorem, and then he moved into more recent work (Barwick, Blumberg-Gepner-Tabuada) exploring the universal formulations of algebraic K-theory.

Christopher Douglas (University of Oxford) -Towards explicit models for higher K-theories

Douglas spoke on a long-term project seeking to build geometric cycles for some of the chromatically higher height versions of K-theory described by Hopkins and Miller. He began by describing the various approaches to the height 1 case, topological K-theory. A careful retelling of the Fredholm operator approach allowed him to transition into higher versions of quantum field theories, out of which he described their conjectural model.

Julie Bergner (University of California Riverside)-Models for homotopical higher categories

Bergner gave a detailed introduction to the very active field of higher categories. Motivating everything with bordism categories (important in the Baez-Dolan Conjecture, solved recently by Lurie), Bergner described exactly what subtleties arise in the higher contexts and how they are solved. Bergner then described Rezk's model structure on θ_n-spaces and how this is a model for (∞,n)-categories.

Wednesday -Computations

Mark Behrens (Massachusetts Institute of Technology) -Computations in the stable homotopy groups of spheres

The determination of the homotopy groups of spheres is a central and fundamental problem in algebraic topology with deep implications in fields outside of the area. Behrens spoke about the major approaches to computing the homotopy groups of spheres, starting with foundational work of Serre and then moving into the more modern techniques pioneered by Adams, Mahowald, and Miller-Ravenel-Wilson. He closed with a collection of important open problems in the area, describing them in the context of prior work and exploring their importance.

Daniel Isaksen (Wayne State University) -Computations in motivic homotopy theory

Motivic homotopy exploded onto the scene with Voevodsky's proof of the Milnor conjecture. Computations in this area blend algebraic geometry and classical stable homotopy techniques, and few are known. Isaksen presented a summary of ways one can approach the computation of the (bi-graded) motivic homotopy groups of spheres and explained how these can give new insight into the classical picture described by Behrens. He then explored some purely motivic implications, looking at recent computations with Guillou on the homotopy of the "η-inverted sphere", an object with no classical analogue.

Craig Westerland (University of Minnesota Twin Cities) -Views on the J-homomorphism

The J-homomorphism is a fantastic tool to build elements in the homotopy groups of spheres. Westerland described a modern take on the classical construction of the J-homomorphism, and then moved into analogues of the J-homomorphism for higher chromatic heights.

Thursday -Groups and homotopy

Bob Oliver (Universit´e de Paris XIII)-Local structure of groups and their classifying spaces

Oliver spoke on how much of the classifying space of a Lie group is determined by the collection of finite subgroups therein. This data is described as "p-local structure" for a finite group. Oliver stated some beautiful results about the structure of algebraic groups in general, then indicated how such things are proved using homotopy theoretic methods. He described "fusion systems", a way to abstract the data that a p-Sylow subgroup of a finite group G, and recast several classical results in

this language. He finished describing the compact Lie analogue.

Michael Hopkins (Harvard University) -Equivariant homotopy and localization

Hopkins gave an extremely gentle introduction to equivariant stable homotopy theory. Building on classical results from geometry, he introduced some of the basic problems in equivariant homotopy theory. He then walked the audience through how the standard techniques for stabilization in ordinary homotopy are insufficient to describe the kinds of things we want (like Poincar´e duality). This is a subtle point that was made quite clear. He moved from there to computing the 0th equivariant stable homotopy group of spheres, reproving in a concise way a result of Segal and tom Dieck. He then closed with several important connections to other problems, highlighting how the basic issues that arose with stabilization are endemic to the subject and how an understanding of them in this basic example helps build intuition.

Nitya Kitchloo (Johns Hopkins University) -Homotopy theory of Kac-Moody groups

Kac-Moody groups are a well-studied generalization of compact Lie groups. Kitchloo described how a homotopy theorist can understand these objects and work with them. He began by carefully reminding people of the classical cases of a compact Lie group, and then he moved into an illuminating example of a more general form of a Weyl group acting on a maximal torus. Out of this, he described a way to build a topological group with the desired properties, and he determined the basic invariants like its homology and cohomology. The talk was extremely concrete: he focused on an individual special case in some detail, indicating then how everything he did in this case generalizes essentially without change in higher cases.

Tyler Lawson (University of Minnesota Twin Cities) -Topological automorphic forms

Lawson gave an introduction to the recently developed area of “topological automorphic forms”, a generalization of the Goerss-Hopkins-Miller theory of “topological modular forms”. The focus was predominantly on the classical results of Quillen’s which tie algebraic topology and algebraic geometry together via formal groups. Lawson showed some fundamental examples including curves and K-theory, then he moved into higher height theories. He underscored the computational importance of families of examples rather than of simply having a single example, stressing that this makes problems more tractable.

Friday -Manifolds and homotopy

Thomas Church (Stanford University) -Representation stability and applications to homological stability

Church described his long standing joint work on explaining how to understand many of the stabilization results of classical invariants of families of groups. He began by recasting a traditional stabilization result (namely the cohomology of the moduli space of n-points in a manifold) as a problem of the representation theory of symmetric groups. He then produced a new, more algebraic model of this which allowed a determination of the representations arising from these cohomology groups. He moved into a discussion of a more general family of stabilization problems, exploring a notion of an “FI-module” (sometimes called an I-space in the literature), showing how this framework can be used to better understand classical results and prove new ones.

Oscar Randal-Williams (University of Cambridge) -Stability of moduli spaces of manifolds

This talk and the next were somewhat coordinated. Randal-Williams described the basic questions posed by moduli spaces of manifolds and what one means by “stability”. He focused on moduli of manifolds with extra structure on their normal bundle, describing recent work with Galatius and of younger students, then he explained how one proves classes of these theorems.

Soren Galatius (Stanford University) -Stable homology of moduli spaces of manifolds

Galatius explored the theory of stability in the homology of moduli space of manifolds from a more computational approach. Beginning with some of the classical reformulations in terms of Thom spectra of manifolds, Galatius sketched some of the fundamental and early results. He cast everything in homotopy theoretic terms, but also underscored the connections with geometry. He finished with the very concrete connection to the classical κ classes of manifold bundles, showing how this can be used to produce classes in the stable cohomology of certain diffeomorphism groups.

Constantin Teleman (UC Berkeley) -Loop Groups, TQFTs, and algebraic geometry

Teleman wrapped up the workshop describing the connections between algebraic topology and mathematical physics. After describing the underlying physical problems in terms of bundles, he described how an equivariant version of index theory gives rise to certain computations in twisted equivariant K-theory. He finished by exploring how this foundational work with Freed and Hopkins could be extended from twisting by line bundles to other vector bundles.

Organizers		
First	**Last**	**Institution**
Teena	Gerhardt	Michigan State University
Jesper	Grodal	University of Copenhagen
Kathryn	Hess	Ecole Polytechnique Federale de Lausanne (EPFL)
Michael	Hill	University of Virginia

Speakers		
First	**Last**	**Institution**
Mark	Behrens	Massachusetts Institute of Technology
Julie	Bergner	University of California
Michael	Ching	Amherst College
Thomas	Church	Stanford University
Christopher	Douglas	University of Oxford
William	Dwyer	University of Notre Dame
Soren	Galatius	Stanford University
Lars	Hesselholt	Nagoya University
Michael	Hopkins	Harvard University
Daniel	Isaksen	Wayne State University
Nitya	Kitchloo	Johns Hopkins University
Tyler	Lawson	University of Minnesota Twin Cities
Bob	Oliver	Universite Paris 13
Oscar	Randal-Williams	University of Cambridge
John	Rognes	University of Oslo
Brooke	Shipley	University of Illinois at Chicago
Constantin	Teleman	UC Berkeley Math Faculty
Craig	Westerland	University of Minnesota Twin Cities

Introductory Workshop: Algebraic Topology

January 27 - 31, 2014

Schedule

Monday, January 27, 2014			
9:15 AM - 9:30 AM	Simons Auditorium		Welcome
9:30 AM - 10:30 AM	Simons Auditorium	William Dwyer	Introduction to operads
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00 PM	Simons Auditorium	Michael Ching	Goodwillie's calculus of functors
12:00 PM- 2:00 PM	Atrium		Lunch
2:00 PM - 3:00 PM	Simons Auditorium	Brooke Shipley	Morita theory in stable homotopy
3:00 PM - 3:20 PM	Atrium		Tea
4:10 PM - 5:00 PM	**60 Evans Hall**	**Lars Hesselholt**	**MSRI/Evans Lecture:Topological cyclic homology**

Note: Special Charter buses will leave MSRI at 3:10 and 3:40 for Evans Hall

Tuesday, January 28, 2014			
9:30 AM - 10:30 AM	Simons Auditorium	John Rognes	Chromatic redshift
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00 PM	Simons Auditorium	Andrew Blumberg	Higher categories and algebraic K-theory
12:00 PM- 2:00 PM	Atrium		Lunch
2:00 PM - 3:00 PM	Simons Auditorium	Christopher Douglas	Towards explicit models for higher K-theories
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:30 PM	Simons Auditorium	Julie Bergner	Models for homotopical higher categories
4:30 PM - 6:20 PM	Atrium		Reception

Wednesday, January 29, 2014			
9:00 AM - 10:00 AM	Simons Auditorium	Mark Behrens	Computations in the stable homotopy groups of spheres
10:00 AM - 10:30 AM	Atrium		Tea
10:30 AM - 11:30 AM	Simons Auditorium	Daniel Isaksen	Computations in motivic homotopy theory
11:30 AM- 12:30 PM	Simons Auditorium	Craig Westerland	Views on the J-homomorphism

Thursday, January 30, 2014			
9:30 AM - 10:30 AM	Simons Auditorium	Bob Oliver	Local structure of groups and of their classifying spaces
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00 PM	Simons Auditorium	Michael Hopkins	Equivariant homotopy and localization
12:00 PM - 2:00 PM	Atrium		Lunch
2:00 PM- 3:00 PM	Simons Auditorium	Nitya Kitchloo	Homotopy theory of Kac-Moody groups
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:30 PM	Simons Auditorium	Tyler Lawson	Topological automorphic forms

Friday, January 31, 2014			
9:30 AM - 10:30 AM	Simons Auditorium	Thomas Church	Representation stability and applications to homological stability
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00 PM	Simons Auditorium	Oscar Randal-Williams	Stability of moduli spaces of manifolds
12:00 PM- 2:00 PM	Atrium		Lunch
2:00 PM - 3:00 PM	Simons Auditorium	Soren Galatius	Stable homology of moduli spaces of manifolds
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:30 PM	Simons Auditorium	Constantin Teleman	Loop Groups, TQFTs and algebraic geometry

Registered Participants

First	Last	Institution
Daniel	Alvarez-Gavela	Stanford University
Michael	Andrews	Massachusetts Institute of Technology
Gabriel	Angelini-Knoll	Wayne State University
Benjamin	Antieau	University of Washington
Nerses	Aramyan	University of Illinois at Urbana-Champaign
David	Ayala	Montana State University
Jeffrey	Bailes	University of Melbourne
Lauren	Bandklayder	Northwestern University
Matthew	Barber	University of California
Tobias	Barthel	Harvard University
Maria	Basterra	University of New Hampshire
Agnes	Beaudry	University of Chicago
Petter	Bergh	Norwegian University of Science and Technology (NTNU)
Hakon	Bergsaker	Massachusetts Institute of Technology
Daniel	Berwick-Evans	Stanford University
Irina	Bobkova	Northwestern University
Anna Marie	Bohmann	Northwestern University
anthony	bordg	Universite de Nice Sophia Antipolis
Eric	Bunch	Kansas State University
Jonathan	Campbell	University of Texas
Federico	Cantero	Universitat Munster
David	Carchedi	Max Planck Institute for Mathematics
Greg	Chadwick	University of California
Virgil	Chan	University of California, Davis
Mei-Chu	Chang	University of California
Artem	Chernikov	Institut de Mathematiques de Jussieu - Paris Rive Gauche
Safia	Chettih	University of Oregon
Boris	Chorny	University of Haifa--Oranim
Ralph	Cohen	Stanford University
Lee	Cohn	University of Texas
Dominic	Culver	University of Notre Dame
James	Davis	Indiana University
Michael	Donovan	Massachusetts Institute of Technology
Emanuele	Dotto	Massachusetts Institute of Technology
Bjorn	Dundas	University of Bergen
Taylor	Dupuy	University of California, Los Angeles
Philip	Egger	Northwestern University
Elden	Elmanto	Northwestern University
Maggie	Ewing	University of Minnesota Twin Cities
melissa	fabros	University of California, Merced
Daniel	Flores	Instituto de Ciencias Nucleares
John	Foley	University of Copenhagen
Ernest	Fontes	University of Texas
Michael	Freedman	University of California
James	Freitag	University of California, Berkeley

Jennifer	Garbett	University of Notre Dame
David	Gepner	Purdue University
Paul	Goerss	Northwestern University
Matthias	Grey	University of Copenhagen
Ilya	Grigoriev	University of Chicago
Bertrand	Guillou	University of Kentucky
Robert	Hank	University of Minnesota Twin Cities
Joe	Hannon	Boston University
John	Harper	Ohio State University
Rune	Haugseng	Max-Planck-Institut fur Mathematik
Fabian	Hebestreit	Westfalische Wilhelms-Universitat Munster
Ellen	Henke	University of Copenhagen
Joseph	Hirsh	Massachusetts Institute of Technology
Geoffroy	Horel	Universitat Munster
Marc	Hoyois	Northwestern University
John	Huerta	Instituto Superior Tecnico
Samuel	Hutchinson	University of Sheffield
Brenda	Johnson	Union College
Sara	Kalisnik	Stanford University
Daniel	Kaplan	University of Texas
Inbar	Klang	Stanford University
Benjamin	Knudsen	Northwestern University
Johan	Konter	Northwestern University
Alexander	Kupers	Stanford University
Robert	Legg	Northwestern University
Guchuan	Li	Northwestern University
Ayelet	Lindenstrauss	Indiana University
Cary	Malkiewich	Stanford University
Maryanthe	Malliaris	University of Chicago
Aaron	Mazel-Gee	University of California, Berkeley
John	McCleary	Vassar College
Leanne	Merrill	University of Oregon
Haynes	Miller	Massachusetts Institute of Technology
Sage (Ann)	Moore	Mills College
Apurva	Nakade	Johns Hopkins University
Peter	Nelson	University of Illinois at Urbana-Champaign
Oscar	Ocampo	University of Sao Paulo (USP)
Cihan	Okay	PIMS - Pacific Institute for the Mathematical Sciences
Kyle	Ormsby	MIT / Reed College
Angelica	Osorno	Reed College
Viktoriya	Ozornova	Universitat Bremen
Martin	Palmer	Westfalische Wilhelms-Universitat Munster
Matthew	Pancia	University of Texas
Liz	Pannell	University of California, Santa Cruz
Dmitri	Pavlov	Westfalische Wilhelms-Universitat Munster
Nathan	Perlmutter	University of Oregon
Eric	Peterson	University of California, Berkeley

Jeremiah	Peterson	University of Minnesota Twin Cities
Kathleen	Ponto	University of Kentucky
Michael	Pors	University of Calgary
Matan	Prasma	Radboud Universiteit Nijmegen
Tomasz	Prytula	University of Copenhagen
Truls	Raeder	Norwegian University of Science and Technology (NTNU)
Charles	Rezk	University of Illinois at Urbana-Champaign
Emily	Riehl	Harvard University
Martina	Rovelli	Ecole Polytechnique Federale de Lausanne (EPFL)
Carmen	Rovi	University of Edinburgh
Aaron	Royer	University of Texas
Steffen	Sagave	Rheinische Friedrich-Wilhelms-UniversitÃ¤t Bonn
Mychael	Sanchez	University of Illinois at Urbana-Champaign
Beren	Sanders	University of California, Los Angeles
Jenny	Santoso	Universitat Stuttgart
Matthew	Sartwell	University at Buffalo (SUNY)
Jerome	Scherer	Ecole Polytechnique Federale de Lausanne (EPFL)
Nora	Seeliger	Australian National University
Andrew	Senger	University of Minnesota Twin Cities
Shan	Shah	Rijksuniversiteit te Utrecht
Shiyu	Shen	University of Illinois at Urbana-Champaign
Scott	Slinker	University of Virginia
Elaine	So	University of Pennsylvania
David	Sprehn	University of Washington
Mentor	Stafa	Tulane University
Don	Stanley	University of Regina
Nathaniel	Stapleton	Massachusetts Institute of Technology
Marc	Stephan	Ecole Polytechnique Federale de Lausanne (EPFL)
Augusto	Stoffel	University of Notre Dame
Vesna	Stojanoska	Massachusetts Institute of Technology
Yuri	Sulyma	University of Alberta
Markus	Szymik	University of Copenhagen
Felicia	Tabing	University of California, Santa Cruz
Hiro	Tanaka	Harvard University
Amelia	Tebbe	University of Illinois at Urbana-Champaign
Marius	Thaule	Norwegian University of Science and Technology (NTNU)
Sean	Tilson	Royal Institute of Technology (KTH)
Peter	Ulrickson	University of Notre Dame
Massimiliano	Ungheretti	University of Copenhagen
Dmitry	Vagner	Duke University
Paul	VanKoughnett	Northwestern University
Tane	Vergili	Ege University
Jean	Verrette	University of Hawaii at Manoa
Christine	Vespa	Universite de Strasbourg
Deborah	Vicinsky	University of Oregon
Juan	Villeta-Garcia	University of Illinois at Urbana-Champaign
Nathalie	Wahl	University of Copenhagen

Kay	Werndli	Ecole Polytechnique Federale de Lausanne (EPFL)
Jacob	West	University of California
Kirsten	Wickelgren	Georgia Institute of Technology
Brian	Williams	Northwestern University
Dylan	Wilson	Northwestern University
W Stephen	Wilson	Johns Hopkins University
Kevin	Wray	University of California, Berkeley
Sarah	Yeakel	University of Illinois at Urbana-Champaign
Dimitri	Zaganidis	Ecole Polytechnique Federale de Lausanne (EPFL)
Inna	Zakharevich	University of Chicago

Officially Registered Participant Information

Participants		171

Gender		171
Male	74.27%	127
Female	25.15%	43
Declined to state	0.58%	1

Ethnicity*		171
White	78.36%	134
Asian	6.43%	11
Hispanic	4.09%	7
Pacific Islander	0.58%	1
Black	0.00%	0
Native American	0.00%	0
Mixed	3.51%	6
Declined to state	7.02%	12

* ethnicity specifications are not exclusive

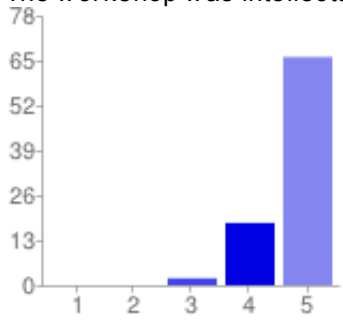
86 responses

86 responses/171 participants = 50% response rate

Summary See complete responses

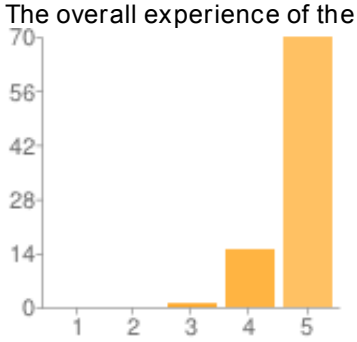
Workshop assessment

The workshop was intellectually stimulating



1 -	Not at all	0	0%
2		0	0%
3		2	2%
4		18	21%
5 -	Very	66	77%

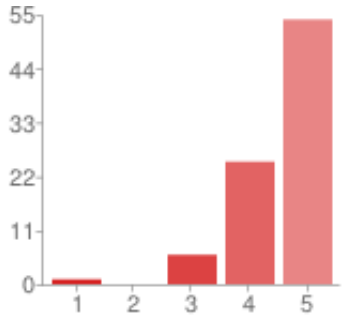
The overall experience of the workshop was worthwhile



1 -	Not at all	0	0%
2		0	0%
3		1	1%
4		15	17%
5 -	Very	70	81%

The time between lectures was adequate for discussion

1 -	Not al all	1	1%
2		0	0%
3		6	7%
4		25	29%
5 -	Very	54	63%



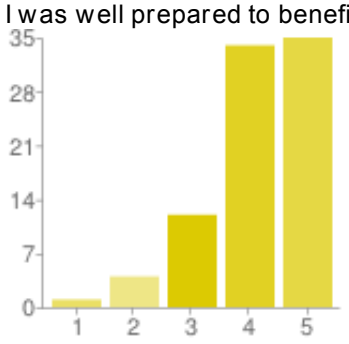
Not al all Very

Additional comments on the workshop organization

Please increase time intervals between talks. The selection of the talks was very nicely done. While some of the talks towards the end of the week started running over time, in general however the spe ...

Personal assessment

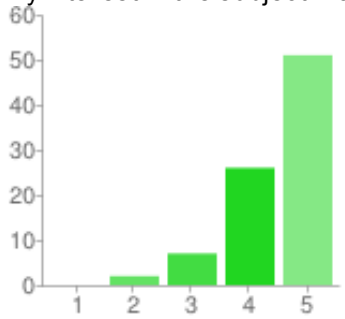
I was well prepared to benefit from the lectures



Not at all Very

1 -	Not at all	1	1%
2		4	5%
3		12	14%
4		34	40%
5 -	Very	35	41%

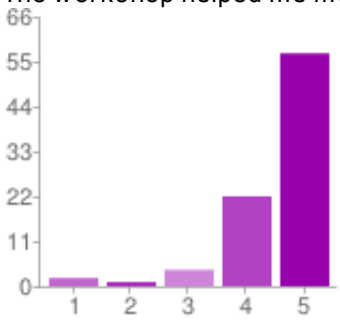
My interest in the subject matter was increased by the workshop



1 -	Niot at all	0	0%
2		2	2%
3		7	8%
4		26	30%
5 -	Very	51	59%

Niot at all Very

The workshop helped me meet people with similar scientific interests



Not at all Very Much

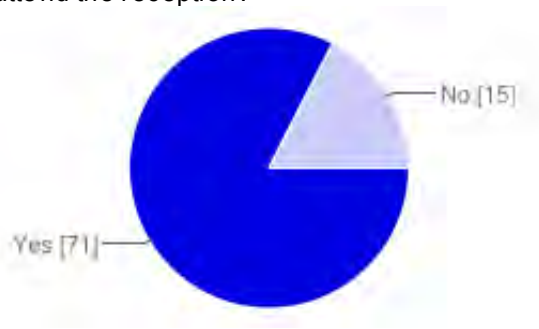
1 -	Not at all	2	2%
2		1	1%
3		4	5%
4		22	26%
5 -	Very Much	57	66%

Additional comments on your personal assessment

This was useful to topologists of all ranks. The workshop was a great opportunity to both meet up with people, and get to know people. I'm not an algebraic topologist and many talks were actually most ...

Additional Activities

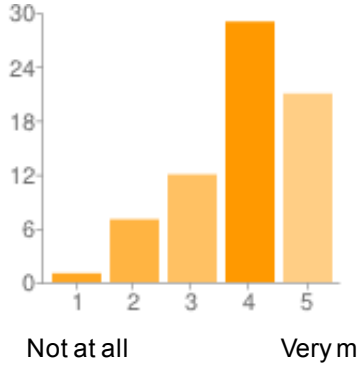
Did you attend the reception?



Yes	71	83%
No	15	17%

If you did attend the reception, did it help to solidify the contacts you made in the workshop?

1 -	Not at all	1	1%
2		7	8%
3		12	14%



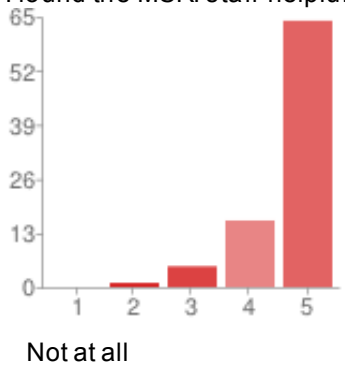
4		29	34%
5 -	Very much	21	24%

Please provide any comments on the reception

very nice It was highly enjoyable! The reception ended while the social inertia was still high. The wine and food could have been prolonged. I didn't attend because I was ill and not because I didn' ...

Venue

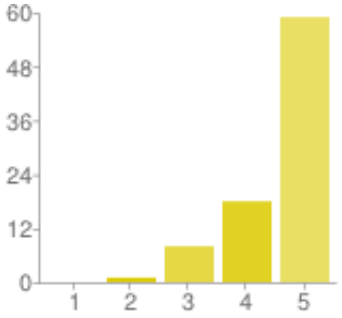
I found the MSRI staff helpful



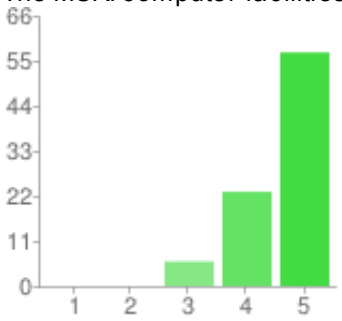
1 -	Not at all	0	0%
2		1	1%
3		5	6%
4		16	19%
5 -	Very	64	74%

The MSRI physical facilities were conducive for such a workshop

1 -	Not at all	0	0%
2		1	1%
3		8	9%
4		18	21%
5 -	Very	59	69%

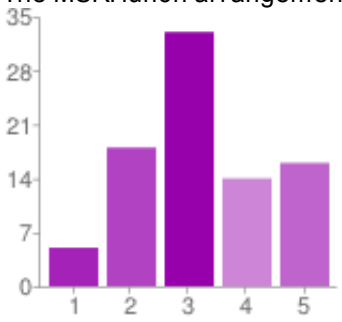


The MSRI computer facilities were adequate for such a workshop



1 -	Not at all	0	0%
2		0	0%
3		6	7%
4		23	27%
5 -	Very	57	66%

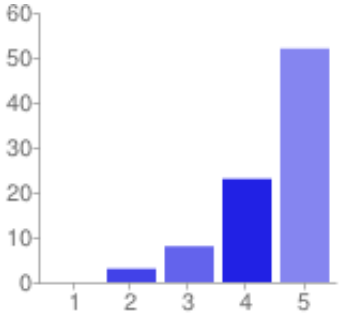
The MSRI lunch arrangements were satisfactory



1 -	Not at all	5	6%
2		18	21%
3		33	38%
4		14	16%
5 -	Very	16	19%

The MSRI tea arrangements were satisfactory

1 -	Not at all	0	0%
2		3	3%
3		8	9%
4		23	27%
5 -	Very	52	60%



Not at all Very

Additional comments on the venue

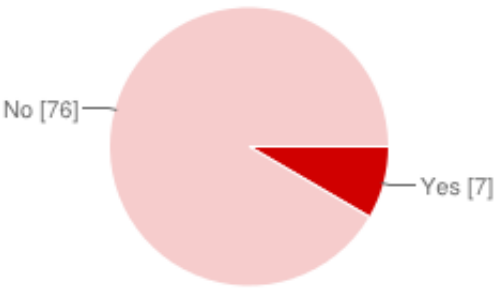
Lunch logistics need to be improved. Please increase the selection of tea and/or provide loose tea. tea & coffee are needed while listening to talks!! Gorgeous location! You have to fix the heating syst ...

MSRI Wireless Network

Did you use MSRI's wireless network?

Yes	78	91%
No	8	9%

Did you experience any difficulties with the network?



Yes	7	8%
No	76	88%

If you did experience difficulties with the network, please explain:

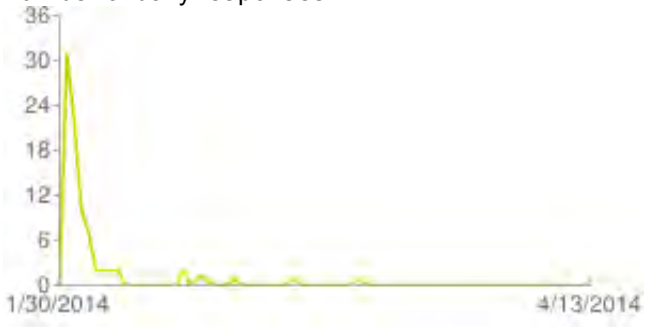
Extremely slow slow connection (failure to skype) On-campus wifi is essential, especially for long term visitors like me. I tried to skype home for around 10 minutes and the call was bad quality At time ...

Thank you for completing this survey

We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.

You should not require answers to survey questions - or at least allow N/A as an answer. Thanks for holding this fantastic workshop! It would be nice to have more people serving lunch when there are s ...

Number of daily responses



Introductory Workshop: Algebraic Topology
January 27 - 31, 2014

Additional Survey Responses

Additional comments on your personal assessment

- This was useful to topologists of all ranks.
- The workshop was a great opportunity to both meet up with people, and get to know people.
- I'm not an algebraic topologist and many talks were actually mostly aimed to the other algebraic topologists in the room. So the workshop didn't quite live up to my expectation of an introductory workshop where the talks can be followed with a general mathematical background.
- great attention
- Slightly too introductory for my taste but excellent nonetheless.

Additional comments on the venue

- Lunch logistics need to be improved.
- Please increase the selection of tea and/or provide loose tea.
- tea & coffee are needed while listening to talks!!
- Gorgeous location!
- You have to fix the heating system in the lecture room! Also, the screen/blackboard system is not optimal. The screen is too small, and the blackboards reflect too much from some angles.
- Logistically, lunch was a disaster. The arrangements were totally inadequate for a conference of this size.
- Several presentations were affected by projector. Some colors did not display at all, and the screen was too small. It would be ideal to have two projectors.
- More food or at least more sustaining food during the lunch breaks would have been needed. We were forced to leave the Institute at lunch entailing a walk back up the hill. Also, the waste production during tea breaks was abhorrent.
- If the food were set on two smaller tables (separated from each other) instead of one long one it would help participants to flow through the area better. Often only one section of the food table was being fully utilized, and that contributed to a backup. Otherwise the teas were great.
- Something to keep in mind for the future is that MSRI is much farther away from the attendees' residences than the average hotel-to-math-department distance of these things. The start time of the workshop was a little early -- I'd rather have traded a fraction of the tea times and of lunch in for a later start, just in the interest of having adequate time to get up the hill.
- The "Stuffed Inn" catering service provided much tastier food than the other catering service.
- the staff was amazing, the lunch was fine but would prefer more variety
- Better selection and an additional line would be appreciated.
- There were a lot of people and so food was less than convenient. However, the caterer was very efficient.
- 2 or more lunch lines for large crowds would be helpful.
- The venue seemed a little bit small for the size of the workshop
- It is sad that coffee is not allowed in the auditorium. That would make things a lot more pleasant. Apart from the fact that I was not overwhelmed by the quality of the lunch, the main

problem was the set up. One (long) table is hardly sufficient for such a group. Several lines, with several tables of food and cashiers, would have greatly benefited the experience. In a similar way the snacks for tea could be distributed over the round tables already present.
- There was not always enough food for everyone at tea.
- The conference room does not have so many good seats. The space is not used optimally, in particular because the first three rows take so much space.
- There was no earl grey tea!

We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.
- You should not require answers to survey questions - or at least allow N/A as an answer.
- Thanks for holding this fantastic workshop!
- It would be nice to have more people serving lunch when there are so many participants.
- The name "Introductory Workshop" was perhaps slightly misleading since only a few of the talks could, for graduate students, really be called introductory. Many demanded a substantial background in the topic from the listener.
- If anything, perhaps too many talks. The time between talks was the most rewarding.
- I'm really pleased that the Connections for Women workshop happened immediately before this. I think it changed the tenor of the main workshop in a great way. Thanks for that!
- Thank you so much! I learned a lot, and I really enjoyed meeting other graduate students as well as mathematicians with similar interests to my own.
- This workshop was a great follow up to the connections for women and I'm glad they were arranged back to back. Thanks for the opportunity to learn more at MSRI!

If you did experience difficulties with the network, please explain:
- Extremely slow
- slow connection (failure to skype)
- On-campus wifi is essential, especially for long term visitors like me.
- I tried to skype home for around 10 minutes and the call was bad quality
- At times the network would only work for a short time after connecting
- Too slow for most skype conversations.
- I missed Andrew Blumberg's talk, and when I went to watch it later in the day, the local network was too slow to load the video (50 minutes for load for ~5 minutes of video). I'd expect video hosted on the MSRI server to be of exceptionally fast access to someone on-site, so that was surprising. Otherwise, everything was perfectly fine.

Please provide any comments on the reception
- very nice
- It was highly enjoyable!
- The reception ended while the social inertia was still high. The wine and food could have been prolonged.
- I didn't attend because I was ill and not because I didn't find it worthwhile.
- It was really nice to have such a social event right there at MSRI with all the other attendees!
- Too short.
- I took the reception time to meet with someone that I had met at the conference whose work was similar to my own.

Additional comments on the workshop organization

- Please increase time intervals between talks.
- The selection of the talks was very nicely done.
- While some of the talks towards the end of the week started running over time, in general however the speakers and organizers were really good at keep everything moving efficiently and on-time. A highly non-trivial task.
- If the workshop was aimed at grad students and postdocs, then I may have not been in the target audience.
- The organizers did a very good job in steering speakers to pitch their talks at a useful level. There were instructive contrasts in style.
- Perfect, even the buses.
- I would like to thank the organizers.
- Having people give accessible surveys was a wonderful idea
- Awesome
- Incredibly well done
- The numer of lectures per day and the timing of them was great. I wouldn't change a thing.
- excellent job
- Flawless
- Talks on topics, chosen by the organizers, given by the speakers, led to better introductions. Great idea!!
- the location was too small for the number of participants.
- Was excelent.
- Thanks to the organizers!
- very well put together
- exceptional
- I loved the talks. The ones that started with basics and built up to recent results were very good. It's always useful to me as a grad student to hear experts discuss the basics.
- All the organizers and staff spoke quite well.
- Terrific workshop -- there should be more in algebraic topology

Model Theory in Geometry and Arithmetic

May 12 - 16, 2014

MSRI, Berkeley, CA, USA

Organizers:

Raf Cluckers (Université de Lille I)

Jonathan Pila (University of Oxford)

Thomas Scanlon (University of California, Berkeley)

Final report on MSRI Workshop 686
Model Theory in Geometry and Arithmetic

MSRI, Berkeley, May12-16 2014

Organisers:
Raf Cluckers (Leuven and Lille),
Jonathan Pila (Oxford), and
Thomas Scanlon (Berkeley)

Background

Model theory proper is the study of the mathematical structures providing the semantic interpretations of the syntax of formal logical languages. While such foundational concerns have been at the core of the internal development of the subject, from its earliest days, its practitioners have recognized that its methods and its perspective which is somewhat askew to that of more classical mathematics may be applied to solve problems in number theory and geometry or at the very least to put the problems on a new footing. For example, with their work in the 1960s on the logical theory of the p-adic numbers, Ax and Kochen gave a precise sense to the idea that in the limit the fields $\mathbb{Q}_p$ and $\mathbb{F}_p((t))$ are the same thereby proving an asymptotic version of Artin's conjecture on homogeneous forms while suggesting where counterexamples to the original conjecture may be found.

In recent years, the web of connections between model theory, number theory and arithmetic geometry has both broadened and deepened, with deep results and techniques from model theory finding their way into the study of diophantine equations, algebraic differential equations, p-adic analytic geometry, additive combinatorics, and the theory of special points on Shimura varieties to name just a few areas. The Spring 2014 MSRI semester long program on Model Theory, Arithmetic Geometry and Number Theory provided a concentrated, but extended, period during which experts in model theory and these allied fields to work in close proximity learning from each other in an interdisciplinary context.

In keeping with the theme of the parent programme, this Concluding Workshop aimed to present a diverse picture of the current state of these interactions. It further provided a venue for those mathematicians working at the boundary between model theory, geometry and arithmetic, but who were unable to participate in the longer programme, to meet and to present their work. The organisers were also mindful to achieve a balanced mix of those whose background is primarily in model theory with those whose background is primarily in number theory/geometry, and of senior and early-career researchers.

The workshop

The scientific contributions of the workshop speakers can be divided into the following broad areas (though several talks had relevance under more than one area):

Diophantine geometry
O-minimality
Algebraic differential and difference equations
Valued fields and motivic integration
NIP and simple theories
Other: Non-commutative geometry, additive combinatorics.

Diophantine geometry. By this we mean the study of algebraic relations and inequalities on arithmetically interesting points from the point of view of their relation to algebraic geometry, is a multifaceted subject on which model theory impinges at many junctures.

The talk by Rossler described recent progress in the area of the function field Mordell-Lang conjecture. This is the site of perhaps the most celebrated application of model theory to diophantine geometry, namely Hrushovski's proof of the Mordell-Lang conjecture over function fields in positive characteristic.

The earliest, and still the deepest, connections between logic and number theory come from Gödel's Incompleteness Theorem. With Matiyasevich's theorem that every recursively enumerable subset of $\mathbb{Z}$ may be realized as a diophantine set, one sees that it is impossible to find an algorithm to decide whether a general system of diophantine equations has a solution. Using the Hasse principle for quadratic forms, J. Robinson showed that there is no general procedure to decide the truth or falsity of formal first-order statements about the rational numbers. If it were possible to represent the integers as a diophantine subset of the rational numbers, then by relativizing Matiyasevich's theorem, one would deduce the impossibility of deciding the solvability of polynomial equations in the rationals.

The talk by Eisentraeger described generalisations of Hilbert's 10th problem in which one seeks to study degrees of unsolvability.

The talk by Koenigsmann, on the absolute Galois groups of fields, is cognate with Diophantine geometry.

O-minimality. The defining condition underlying o-minimality was isolated in the 1980s by van den Dries (for structures on the real numbers) and then generally by Pillay and Steinhorn as the appropriate axiomatic framework for studying real analysis as geometric theory. Using the theory of o-minimality, he methods and results for real algebraic geometry have been widely generalized and improved to such theories as that of exponential geometry, semi-local real analytic geometry, and of quasi-analytic geometry. The Counting Theorem of Pila-Wilkie has, via a strategy proposed by Zannier, found startling recent application in Diophantine geometry. A basic ingredient in this strategy is a suitable functional transcendence statement which in many cases has also been achieved via o-minimality. Two talks in this area described recent progress.

A talk by Wilkie described a theorem giving finer control of rational points using o-minimal techniques.

A talk by Tsimerman described an "Ax-Schanuel" theorem for the j-function, obtained by a combination of methods from complex geometry and o-minimality (including point counting). It is related to the Zilber-Pink conjectures in Diophantine geometry, in particular to strategies to prove cases of the conjecture via o-minimality.

A related talk by Loeser described recent work (with Cluckers and Comte) establishing analogues of the Counting Theorem, and the parameterisation techniques which go into it, in the context of valued fields.

Algebraic differential and difference equations. The theories of difference and differential fields and the classification of the definable sets in these structures have played important roles in the applications of model theory to diophantine geometry. At a more fundamental level, the model theoretic treatments have enriched the theories of algebraic difference and differential equations. For example, the work of A. Robinson and Blum provided universal domains for the study of algebraic differential equations in characteristic zero. Differential Galois theory, by which we mean the study of the relation between symmetries of differential equations and algebraic or differential algebraic groups, has been studied for well over a century, but model theoretic approaches and algebraic approaches influenced by the model theoretic treatments are actively studied now.

The talk by Moosa showed how to apply the model theory of differential fields to solve an open problem in Poisson algebras.

The talk by Tsimerman (already mentioned under o-minimality and Diophantine geometry) is also relevant here, as the theorem can be expressed as a result in differential algebra and continues a line of results starting with those of Ax in the 1960s using methods from differential algebra.

The model theory of difference fields has been developed in parallel to the theory of differential fields. Many results, including the fundamental twisted Lang-Weil estimate of Hrushovski, have found significant applications in algebraic dynamics.

The talk by Chatzidakis described further applications of the model theory of differential fields to algebraic dynamics. The theorem gives conditions under which an algebraic dynamical system defined over a function field $k(t)$ is dominated by a system defined over the base field k, and depends on a study of types and internality.

Valued fields and motivic integration. As we noted in the introduction, one of the first sophisticated applications of model theory came from the model theory of valued fields as initiated by Ax, Ershov and Kochen. Over the years, the class of valued fields and expansions of the structures for which theorems in the style Ax-Kochen-Ershov have been proven has greatly expanded so as to include, for example, structures admitting actions by continuous automorphisms and p-adic analytic functions.

The talk by Chambert-Loir described (joint with Loeser applying the Hrushovski-Kazdan motivic Poisson summation formula to motivic height zeta functions connected with geometric analogues of the Manin conjectures about asymptotic point-counting.

The talk by Haskell reported on joint work with Ealy and Marikova in studying the extent to which a T-convex expansion of a real closed field is determined by its value group and residue field.

The talk by Rideau (joint work with Hrushovski and Martin) explained how to transfer elimination of imaginaries from algebraically closed valued fields to the p-adics.

The talk by Loeser explained his recent work with Cluckers and Comte giving an analogue of Yomdin-Gromov parametrizations in non-archimedean settings with application to analogues of the Pila-Wilkie point-counting theorem in these settings.

The talk by Gordon described applications of motivic integration to harmonic analysis.

NIP and simple theories. The model-theoretic classification of theories (stable, NIP, simple,...) and their basic properties is a central part of pure model theory, and the fundamental theorems describing definable sets in such structures have long been a source of applications.

The talk by Simon described the structure of definably amenable NIP groups.

The talk by Pillay described results on definable topological dynamics in such settings.

The talk by Malliaris described complexity classes of simple theories determined by certain criteria in infinite combinatorics.

Other.

The talk by Zilber described his approach to a model-theoretic semantics for non-commutative geometry.

The talk by Helfgott surveyed the current state in approximate subgroups. The work of Hrushovski applying stability theory to approximate subgroups was a key part of the recent enormous progress in this area.

Conclusion

Anecdotal reports indicate that the workshop was very successful, with a uniformly high standard of talks and a lot of interaction around the talks and in the breaks.

The organisers are grateful to MSRI for their excellent organisation, and to the NSF and NSA, who provided funding for participants.

Organizers		
First	**Last**	**Institutions**
Raf	Cluckers	Universite de Lille I (Sciences et Techniques de Lille Flandres Artois)
Jonathan	Pila	University of Oxford
Thomas	Scanlon	University of California, Berkeley

Speakers		
First	**Last**	**Institutions**
Antoine	Chambert-Loir	Universite Paris-Sud (Orsay)
Zoe	Chatzidakis	Centre National de la Recherche Scientifique (CNRS)
Kirsten	Eisentraeger	Pennsylvania State University
Julia	Gordon	University of British Columbia
Deirdre	Haskell	McMaster University
Harald	Helfgott	Centre National de la Recherche Scientifique (CNRS)
Jochen	Koenigsmann	University of Oxford
Francois	Loeser	Universite de Paris VI (Pierre et Marie Curie)
Maryanthe	Malliaris	University of Chicago
Rahim	Moosa	University of Waterloo
Anand	Pillay	University of Notre Dame
Damian	Rossler	Universite de Toulouse III (Paul Sabatier)
Silvain	Rideau	Ecole Normale Superieure
Pierre	Simon	Centre national de la recherche scientifique (CNRS)
Jacob	Tsimerman	Harvard University
Alex	Wilkie	University of Manchester
Yimu	Yin	University Pierre and Marie Curie
Boris	Zilber	University of Oxford

Model Theory in Geometry and Arithmetic

May 12 - 16, 2014

Schedule

Monday, May 12, 2014			
9:15 AM - 9:30 AM	Simons Auditorium		Welcome
9:30 AM - 10:30 AM	Simons Auditorium	Chambert-Loir	Hrushovski-Kazhdan's motivic Poisson formula and motivic height zeta functions
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00 PM	Simons Auditorium	Haskell	Towards a theory of residue field domination for convexly valued ordered fields
12:00 PM - 2:00 PM	Atrium		Lunch
2:00 PM - 3:00 PM	Simons Auditorium	Chatzidakis	An application of difference fields to algebraic dynamics.
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:30 PM	Simons Auditorium	Rideau	Transferring imaginaries: from ACVF to Qp (joint work with E. Hrushovski and B. Martin)

Tuesday, May 13, 2014			
9:30 AM - 10:30 AM	Simons Auditorium	Loeser	Non-archimedean Yomdin-Gromov parametrizations and points of bounded height
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00 PM	Simons Auditorium	Gordon	Applications of motivic integration to harmonic analysis
12:00 PM - 2:00 PM	Atrium		Lunch
2:00 PM - 3:00 PM	Simons Auditorium	Helfgott	Growth in groups: ideas and perspectives
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:30 PM	Simons Auditorium	Pillay	Definable topological dynamics
4:30 PM - 6:20 PM	Atrium		Reception

Wednesday, May 14, 2014			
9:30 AM - 10:30 AM	Simons Auditorium	Tsimerman	An Ax-Schanuel theorem for the modular curve and the j-function
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00	Simons Auditorium	Wilkie	Uniform bounds for derivatives of definable functions with a diophantine application

Thursday, May 15, 2014			
9:30 AM - 10:30 AM	Simons Auditorium	Moosa	An application of the model theory of differential fields to Poisson algebras
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00 PM	Simons Auditorium	Zilber	On the semantics of non-commutative geometry and exotic summation formulas.
12:00 PM - 2:00 PM	Atrium		Lunch
2:00 PM - 3:00 PM	Simons Auditorium	Koenigsmann	To p or not to p: Galois' first glimpse of Hensel on wild grounds
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:30 PM	Simons Auditorium	Eisentraeger	Generalizations of Hilbert's Tenth Problem

Friday, May 16, 2014			
9:30 AM - 10:30 AM	Simons Auditorium	Malliaris	Complexity classes of simple theories
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00 PM	Simons Auditorium	Simon	Definably amenable NIP groups
12:00 PM - 2:00 PM	Atrium		Lunch
2:00 PM- 3:00 PM	Simons Auditorium	Rossler	On the group of purely inseparable points of an abelian variety defined over a function field of positive characteristic
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:30 PM	Simons Auditorium		

Participants		
First	**Last**	**Institutions**
Nate	Ackerman	Harvard University
Uri	Andrews	University of Wisconsin
Will	Anscombe	University of Leeds
Matthias	Aschenbrenner	University of California, Los Angeles
Franck	Benoist	Universite Paris-Sud (Orsay)
Thomas	Blossier	Universite Claude-Bernard (Lyon I)
Anton	Bobkov	University of California, Los Angeles
Will	Boney	Carnegie-Mellon University
Lee	Butler	University of Bristol
Santiago	Camacho	University of Illinois at Urbana-Champaign
Mei-Chu	Chang	University of California
Artem	Chernikov	Institut de Mathematiques de Jussieu - Paris Rive Gauche
Derya	Ciray	Universitat Konstanz
Georges	Comte	Universite de Savoie (Chambery)
Gabriel	Conant	University of Illinois
Gregory	Cousins	University of Notre Dame
Reid	Dale	University of Washington
Joao Alberto	de Faria	Florida Institute of Technology
Jamshid	Derakhshan	University of Oxford
Antoine	Ducros	Universite Paris VI
Taylor	Dupuy	University of California, Los Angeles
Clifton	Ealy	Western Illinois University
Pantelis	Eleftheriou	Universitat Konstanz
Arthur	Forey	Ecole Normale Superieure
James	Freitag	University of California, Berkeley
Dario	Garcia	Universidad de los Andes
Allen	Gehret	University of Illinois at Urbana-Champaign
Petr	Glivicky	Academy of Sciences of the Czech Republic
Haydar	Goral	Universite Claude-Bernard (Lyon I)
Rebecca	Gordon	Rutgers University
Vincent	Guingona	University of Notre Dame
Adam	Gutter	Carnegie Mellon University
Charlotte	Hardouin	Universite de Toulouse III (Paul Sabatier)
Gwyneth	Harrison-Shermoen	UC Berkeley Math Faculty
Michael	Haskel	University of Notre Dame
Robert	Henderson	University of East Anglia
Martin	Hils	Universite de Paris VII (Denis Diderot)
Meng-Che	Ho	University of Wisconsin
Remi	Jaoui	Ecole Normale Superieure
William	Johnson	University of California, Berkeley
Byungheup	Jun	Yonsei University
Tobias	Kaiser	University of Passau
Mary	Karker	Wesleyan University
Hirotaka	Kikyo	Kobe University
Byunghan	Kim	Yonsei University

Inkang	Kim	Korea Institute for Advanced Study
Jonathan	Kirby	University of East Anglia
Piotr	Kowalski	University of Wroclaw
Holly	Krieger	Massachusetts Institute of Technology
Alex	Kruckman	University of California, Berkeley
Krzysztof	Krupinski	Uniwersytet Wroclawski
Tristan	Kuijpers	Katholieke Universiteit Leuven
JUNGUK	LEE	Yonsei University
Eva	Leenknegt	Purdue University
Omar	Leon Sanchez	McMaster University
Yun	Lu	Kutztown University of PA
Matthew	Luther	McMaster University
H.	Macpherson	University of Leeds
Edson	Makuluni	University of Wisconsin
Vincenzo	Mantova	Universita di Camerino
Jana	Marikova	Western Illinois University
David	Marker	University of Illinois
Chris	Miller	Ohio State University
Samaria	Montenegro-Guzman	Universite de Paris VII (Denis Diderot)
Eudes	Naziazeno	Federal University of Pernambuco
Victoria	Noquez	University of Illinois
le gal	olivier	Universite de Savoie
Alf	Onshuus	Universidad de los Andes
Donghoon	Park	Yonsei University
Rehana	Patel	Olin College of Engineering
Ya'acov	Peterzil	University of Haifa
Luis	Pinto Castaneda	Universite de Paris VII (Denis Diderot)
Francoise	Point	Universite de Mons
Michel	Raibaut	Universite de Savoie
Serge	Randriambololona	Galatasaray Universitesi
Nathalie	Regnault	Universite Libre de Bruxelles
Philip	Scowcroft	Wesleyan University
Alisa	Sedunova	Ecole Normale Superieure
Alexandra	Shlapentokh	East Carolina University
Michael	Singer	North Carolina State University
Jozsef	Solymosi	University of British Columbia
Sergei	Starchenko	University of Notre Dame
Charles	Steinhorn	Vassar College
Dmitry	Sustretov	Hebrew University
Caroline	Terry	University of Illinois at Chicago
Margaret	Thomas	Universitat Konstanz
Adam	Topaz	University of California, Berkeley
Thomas	Tucker	University of Rochester
Pinar	Ugurlu	Istanbul Bilgi University
Sebastien	Vasey	Carnegie Mellon University
Carlos	Videla	Mount Royal University
Somayeh	Vojdani	University of Notre Dame

Frank	Wagner	Universite Claude-Bernard (Lyon I)
Michael	Wan	University of California, Berkeley
Roman	Wencel	University of Wroclaw
Nicholas	Wentzlaff	Ecole Polytechnique
Carol	Wood	Wesleyan University
Daniel	Wood	University of Leeds
Austin	Yim	University of Oxford

Officially Registered Participant Information

Participants		120

Gender		120
Male	74.17%	89
Female	22.50%	27
Declined to state	3.33%	4

Ethnicity*		120
White	59.17%	71
Asian	13.33%	16
Hispanic	5.83%	7
Pacific Islander	0.00%	0
Black	1.67%	2
Native American	0.00%	0
Mixed	1.67%	2
Declined to state	18.33%	22

* ethnicity specifications are not exclusive

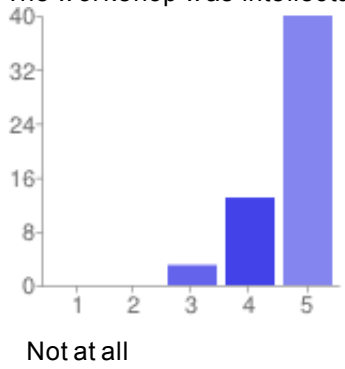
56 responses

56 responses/120 participants = 47% response rate

Summary See complete responses

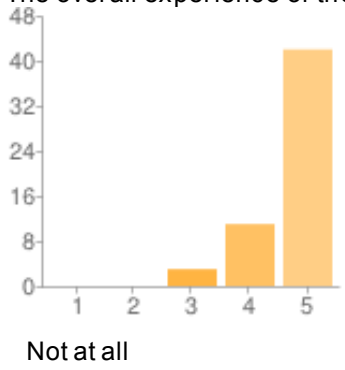
Workshop assessment

The workshop was intellectually stimulating



1 -	Not at all	0	0%
2		0	0%
3		3	5%
4		13	23%
5 -	Very	40	71%

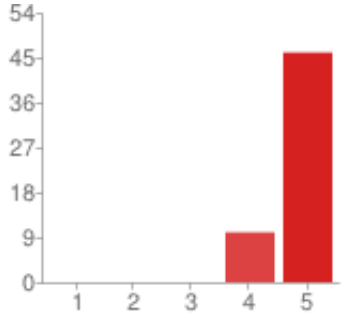
The overall experience of the workshop was worthwhile



1 -	Not at all	0	0%
2		0	0%
3		3	5%
4		11	20%
5 -	Very	42	75%

The time between lectures was adequate for discussion

1 -	Not al all	0	0%
2		0	0%
3		0	0%
4		10	18%
5 -	Very	46	82%



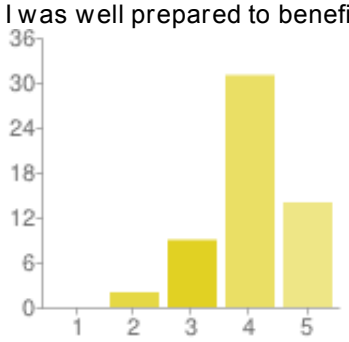
Not al all Very

Additional comments on the workshop organization

The organization was fantastic! Thank you! the talks were quite good and the schedule was well organized There are not so many bus to go to MSRI. Thank you It ran extremely smoothly -- organization was ...

Personal assessment

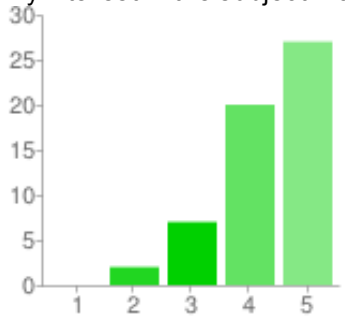
I was well prepared to benefit from the lectures



Not at all Very

1 -	Not at all	0	0%
2		2	4%
3		9	16%
4		31	55%
5 -	Very	14	25%

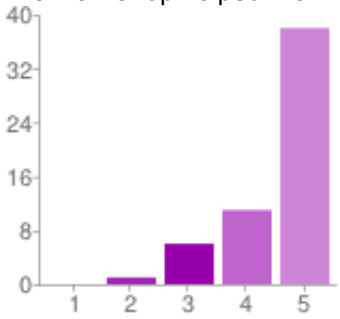
My interest in the subject matter was increased by the workshop



1 -	Niot at all	0	0%
2		2	4%
3		7	13%
4		20	36%
5 -	Very	27	48%

Niot at all Very

The workshop helped me meet people with similar scientific interests



Not at all Very Much

1 -	Not at all	0	0%
2		1	2%
3		6	11%
4		11	20%
5 -	Very Much	38	68%

Additional comments on your personal assessment

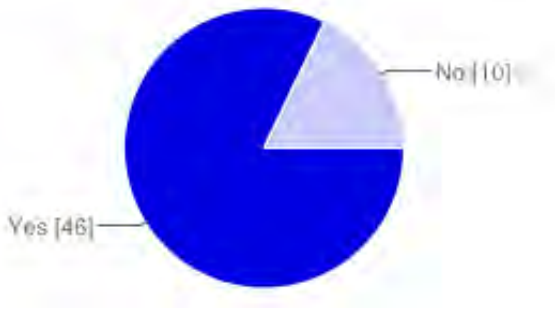
the workshop was a very satisfactory conclusion to the program

The only reason why the "interest question" is 3 is that I already was very interested in the material

There were several speakers from o ...

Additional Activities

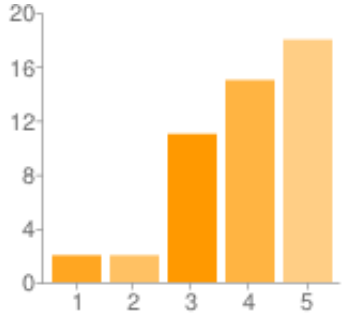
Did you attend the reception?



Yes	46	82%
No	10	18%

If you did attend the reception, did it help to solidify the contacts you made in the workshop?

1 -	Not at all	2	4%
2		2	4%
3		11	20%



4		15	27%
5 -	Very much	18	32%

Please provide any comments on the reception

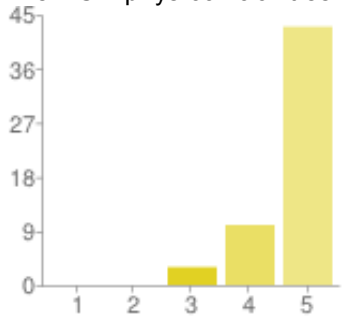
The catered food was of very poor quality. It was great, thank you! It seemed to me that there was more food at the reception for the workshop earlier in the semester, or at least that the food ran ou ...

Venue

I found the MSRI staff helpful

1 -	Not at all	0	0%
2		0	0%
3		9	16%
4		7	13%
5 -	Very	40	71%

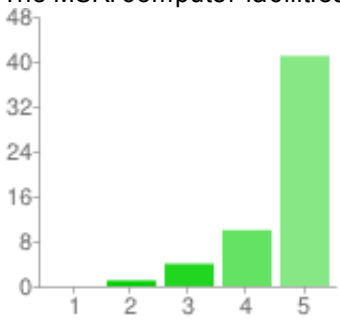
The MSRI physical facilities were conducive for such a workshop



1 -	Not at all	0	0%
2		0	0%
3		3	5%
4		10	18%
5 -	Very	43	77%

Not at all Very

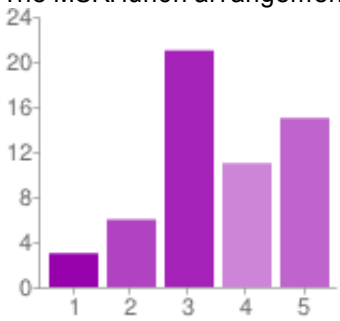
The MSRI computer facilities were adequate for such a workshop



Not at all Very

1 -	Not at all	0	0%
2		1	2%
3		4	7%
4		10	18%
5 -	Very	41	73%

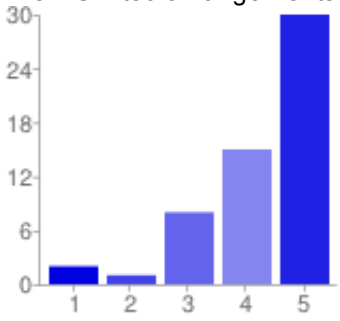
The MSRI lunch arrangements were satisfactory



Not at all Very

1 -	Not at all	3	5%
2		6	11%
3		21	38%
4		11	20%
5 -	Very	15	27%

The MSRI tea arrangements were satisfactory



Not at all Very

1 -	Not at all	2	4%
2		1	2%
3		8	14%
4		15	27%
5 -	Very	30	54%

Additional comments on the venue

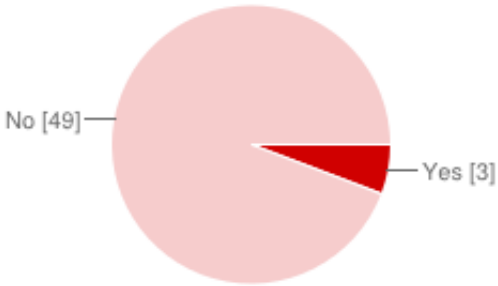
The catered lunches were even worse than the catered reception. The lunch organization is not so good. And in the main auditorium there are a lot of seats from which one does not see very well the bl ...

MSRI Wireless Network

Did you use MSRI's wireless network?

Yes	50	89%
No	6	11%

Did you experience any difficulties with the network?



Yes	3	5%
No	49	88%

If you did experience difficulties with the network, please explain:

It was pretty slow

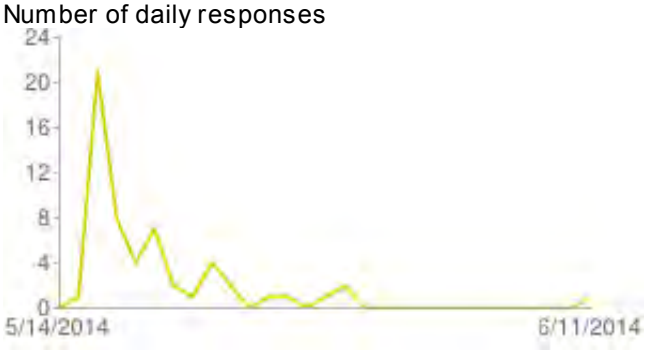
sometimes, . In my case, my labtop said it was accessed to the wireless but I couldn't use the wiress in real. I think, the wireless signal was so weak.

Thank you for completing this survey

We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.

provide more funding You should have an extra bus up and down the hill each day. People are forced to change their plans to try to avoid the busiest two or three buses, It was a very well organised, i ...

Number of daily responses



Model Theory in Geometry and Arithmetic
May 12 - 16, 2014

Additional Survey Responses

Additional comments on your personal assessment

- the workshop was a very satisfactory conclusion to the program
- The only reason why the "interest question" is 3 is that I already was very interested in the material
- There were several speakers from outside model theory whom I had not heard previously, and who gave tremendous talks.
- Powerful talks and time to talk with colleagues--a great workshop!
- The conference offered the opportunity to meet up with people I know who work in my area, as well as make new contacts.
- It was a good experience to meet mathematicians of other branch who have same interests.

Additional comments on the venue

- The catered lunches were even worse than the catered reception.
- The lunch organization is not so good. And in the main auditorium there are a lot of seats from which one does not see very well the blackboard.
- the fact that the building is on the hills facilitate the exchanges between the participants since people have lunch together
- Lunch: The caterer for the first two days of the workshop was very bad (disorganized, overpriced, low quality). The second caterer (Stuffed Inn) was better. Tea: The mango one day was an exciting change, though there was not enough for everyone.
- The lunches were minimal but adequate, but at tea and coffee time there often were people who missed the food and most times the plates and spoons ran out. One time there was a big bowl of diced mango but no plates or spoons for 100 people. The venue can cope with the extra 100 people arriving for the workshop, but the staff need to act to make sure these basic things work right.
- The building needs air conditioning.
- The staff were wonderful and the refreshments were really good.
- There were problems communicating with msri staff by email before the conference. my feeling was that most of the staff work done before the workshop consisted of copy-pasting done in non-timely fashion
- I didn't have call to use the computer facilities or ask anything of the staff, but I only heard good things about them.
- MSRI's remote location makes outside catering difficult, but greater variety of food options would be beneficial.
- It was enough to enjoy the workshops.
- Lunch served at the venue is expensive and not very filling. The tea arrangements wastes a lot of paper cups

We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.

- provide more funding
- You should have an extra bus up and down the hill each day. People are forced to change their plans to try to avoid the busiest two or three buses,
- It was a very well organised, interesting workshop.
- improve communication by email before the workshop
- The workshops and MSRI were all great, nice view, nice place to discuss, nice library. But the wireless was a little unsatisfied.

If you did experience difficulties with the network, please explain:

- It was pretty slow sometimes,
- In my case, my labtop said it was accessed to the wireless but I couldn't use the wiress in real. I think, the wireless signal was so weak.

Please provide any comments on the reception

- The catered food was of very poor quality.
- It was great, thank you!
- It seemed to me that there was more food at the reception for the workshop earlier in the semester, or at least that the food ran out more quickly this time.
- There should have been more, and more varied, food and drink.
- Was a bit on the short side.
- The reception was very appreciated; the only issue may be that the space was perhaps too small for the number of people interacting.
- Local food was great.

Additional comments on the workshop organization

- The organization was fantastic! Thank you!
- the talks were quite good and the schedule was well organized
- There are not so many bus to go to MSRI.
- Thank you
- It ran extremely smoothly -- organization was ideal.
- Good that there were not too many lectures.
- I really liked the longer breaks between talks, as it provided time to chat about/recover from(!) the mathematics of the previous talk.
- Very well organised with nice selection of topics.
- A very well-organized workshop with a consistent and reliable schedule
- This workshops were highly motivated to me!

Connections for Women:
Model Theory and Its Interactions with Number Theory and Arithmetic Geometry

February 10 - 11, 2014

MSRI, Berkeley, CA, USA

Organizers:

Kirsten Eisentraeger (Pennsylvania State University)

Julia Gordon (University of British Columbia)

Deirdre Haskell (McMaster University)

Connections for Women Workshop
Model theory, number theory and arithmetic geometry

Final Report

Organizers

Kirsten Eisenträger, Penn State University
Julia Gordon, University of British Columbia
Deirdre Haskell, McMaster University, chair

Speakers

Senior (50 minute talks)

Maria Carrizosa (Université Lyon 1)
Mei-Chu Chang (University of California)
Zoé Chatzidakis (Centre National de la Recherche Scientifique (CNRS))
Kirsten Eisentraeger (Pennsylvania State University)
Ju-Lee Kim (Massachusetts Institute of Technology)
Rachel Pries (Colorado State University)

Junior (40 minute talks)

Nir Avni (Northwestern University)
Holly Krieger (Massachusetts Institute of Technology)
Jennifer Park (Massachusetts Institute of Technology)
Margaret Thomas (Universität Konstanz)

Description and Goals of the Workshop

The development of model theory has always been influenced by its potential applications. Recent years have seen remarkable flowering of that development, with many exciting applications of model theory in number theory and arithmetic geometry. The MSRI program Model Theory and its Interactions with Number Theory and Arithmetic Geometry began with an Introductory Workshop, followed by the Connections for Women workshop.

Our goal was to highlight the contributions of women in the fields by having them present research talks building on the introductory talks from the week before. We also hoped to encourage connections among women, between junior and senior researchers, and between researchers woking in a wide variety of areas which find common ground through model theory. We focused, in particular, on the contributions of women and underrepresented minority mathematicians, to provide role models for junior researchers and examples for everyone. Many people were able to come to both workshops, partly aided by the coordination between us and the organizers of the Introductory Workshop and the decision to share support of participants.

The topics of the workshop and program were very broad, so our speakers represented a wide array of research areas. We were careful to ensure that each junior speaker was

supported by a senior speaker in the same area, although often their talks were extremely different. The research areas were also represented during the Introductory Workshop, so the speakers could assume the audience had had at least some exposure to the topic.

Presentations

Model theory of fields, algebraic dynamics Zoé Chatzidakis, Holly Krieger

Chatzidakis gave a very beautiful talk, explaining the model theoretic notion called the canonical base property in its context in complex manifolds and differential algebraic varieties. Krieger looked at the problem of when a dynamical system on a complex algebraic variety might exhibit interesting behavior.

Definability in number theory Kirsten Eisenträger, Jennifer Park

Eisenträger reviewed the current state of knowledge of undecidability results, and presented a recent theorem which shows that there are large complementary subrings of number fields K for which Hilbert's tenth problem is undecidable. There was some discussion about whether the divisibility sequences coming from elliptic curves that are used in the proof can be replaced with sequences related to dynamical systems, in particular forward orbits.

Jennifer Park explained the central ideas in her recent proof that the ring of integers in a number field is universally definable. There was some discussions about the implications of this result and whether it was possible to use similar methods to show that the integers are universally definable in number fields as well.

Diophantine geometry Maria Carrizosa, Margaret Thomas

Carrizosa and Thomas both spoke about the general area of finding rational points on varieties. Carrizosa spoke about one approach for tackling the Zilber-Pink conjecture, using ideas that tie it to the Lehmer conjecture. There was some discussion about what is known for heights of algebraic numbers in general number fields, which is the original Lehmer Problem, and about approaches by Dobrowolski to prove this conjecture.

Thomas spoke about recent results on bounding the density of the sets of rational and algebraic points on transcendental sets, using properties of sets definable in o-minimal structures.

Motivic integration in representation theory of p-adic groups Ju-Lee Kim, Nir Avni

Kim spoke about the transfer principle, based on model theory and motivic integration, that allows to transfer statements between local fields of characteristic zero and of finite characteristic, and its applications in harmonic analysis of p-adic groups. In particular, this method lead to the transfer of the Fundamental Lemma of the Langlands Program from finite characteristic to characteristic zero by R. Cluckers, T. Hales and F. Loeser.

The subject of Avni's talk was a question that goes back to Frobenius, about the sequence of dimensions of representations of a family of finite groups obtained by taking $\mathbb{Z}/p^n\mathbb{Z}$-points of an algebraic group. Avni spoke about the generating function for the moments of this sequence, which turns out to be a kind of zeta-function, and the new insights that motivic integration provides into the behaviour of these zeta-functions.

Algebraic combinatorics Mei-Chu Chang

Chang spoke about recent results in counting points in varieties over finite fields. Her results were motivated by a conjecture of Poonen about points on subvarieties of a semiabelian variety which are defined over a finite field.

Arithmetic Geometry Rachel Pries

Pries contrasted the case of characteristic 0 with characteristic p for several different properties of curves. She used Artin-Schreier curves to illustrate approaches to dealing with the more difficult characteristic p case.

Other Activities

Non-strictly-mathematical aspects of the program included a panel discussion and a dinner for the female participants. The panel was on the topic of *Transitions*, with panelists Deirdre Haskell (moderator), Rachel Pries, Christelle Vincent and Carol Wood representing a diversity of age and experience. They spoke to the topic of transitions especially at the graduate student to postdoctoral level, but also to transitioning between different aspects of one's career. Since several people in the audience had just started a postdoc or were graduate students about to start a postdoc in the fall, there were many questions and comments from the audience about how best to use those postdoctoral years to be successful when applying for tenure-track positions. Many people commented on finding the panel interesting and useful, and some of the conversations that were started during the panel were continued during the dinner. The dinner was enjoyed by all, and we found it refreshing to attend a dinner with thirty-five women.

Organizers		
First	**Last**	**Institutions**
Kirsten	Eisentraeger	Pennsylvania State University
Julia	Gordon	University of British Columbia
Deirdre	Haskell	McMaster University

Speakers		
First	**Last**	**Institutions**
Nir	Avni	Northwestern University
Maria	Carrizosa	Universite Lyon 1
Mei-Chu	Chang	University of California
Zoe	Chatzidakis	Centre National de la Recherche Scientifique (CNRS)
Kirsten	Eisentraeger	Pennsylvania State University
Ju-Lee	Kim	Massachusetts Institute of Technology
Holly	Krieger	Massachusetts Institute of Technology
Jennifer	Park	Massachusetts Institute of Technology
Rachel	Pries	Colorado State University
Margaret	Thomas	Universitat Konstanz
Bianca	Viray	Brown University

Connections for Women:
Model Theory and Its Interactions with Number Theory and Arithmetic Geometry

February 10-11, 2014

Schedule

Monday, February 10, 2014			
9:00AM - 9:15AM	Simons Auditorium		Welcome
9:15AM - 10:15AM	Simons Auditorium	Rachel Pries	Galois covers in positive characteristic
10:15AM - 10:45AM	Atrium		Tea
10:45AM - 11:45PM	Simons Auditorium	Kirsten Eisentraeger	Hilbert's Tenth Problem and Mazur's conjectures in large subrings of number fields
11:45AM - 12:30PM	Simons Auditorium	Jennifer Park	A universal first-order formula for the ring of integers inside a number field
12:30PM - 2:00PM	Atrium		Lunch
2:00PM - 3:00PM	Simons Auditorium	Maria Carrizosa	Lehmer problem and applications
3:00PM - 3:30PM	Atrium		Tea
3:30PM - 4:15PM	Simons Auditorium	Margaret Thomas	Counting algebraic points on definable sets
4:15PM - 5:15PM	Simons Auditorium		Panel Discussion
6:30PM - 8:30PM			Dinner at "Taste of Himalayas"

Tuesday, February 11, 2014			
9:00AM - 10:00AM	Simons Auditorium	Ju-Lee Kim	Model theory and harmonic analysis on p-adic groups
10:00AM - 10:30AM	Atrium		Tea
10:30AM - 11:15AM	Simons Auditorium	Nir Avni	Uniformity in representation theory
11:15AM - 12:15PM	Simons Auditorium	Zoé Chatzidakis	Around the Canonical Base Property
12:15PM - 2:15PM	Atrium		Lunch
2:15PM - 3:00PM	Simons Auditorium	Holly Krieger	The geometry of algebraic dynamical systems
3:00PM - 3:30PM	Atrium		Tea
3:30PM - 4:30PM	Simons Auditorium	Mei-Chu Chang	Multiplicative orders on varieties

Participants		
First	**Last**	**Institutions**
Uri	Andrews	University of Wisconsin
Francesca	Balestrieri	University of Oxford
Eliana	Barriga Turriago	Universidad de los Andes
Jennifer	Berg	University of Texas
Julie	Bergner	University of California
Ozlem	Beyarslan	Bogazici University (University of the Bosphorus)
Anton	Bobkov	University of California, Los Angeles
Santiago	Camacho	University of Illinois at Urbana-Champaign
Juan Diego	Caycedo	Albert-Ludwigs-Universitat Freiburg
Artem	Chernikov	Institut de Mathematiques de Jussieu - Paris Rive Gauche
Derya	Ciray	Universitat Konstanz
Georges	Comte	Universite de Savoie (Chambery)
Gabriel	Conant	University of Illinois
Annalisa	Conversano	Massey University
Gregory	Cousins	University of Notre Dame
Reid	Dale	University of Washington
Paola	D'Aquino	Seconda Universita di Napoli
Francoise	Delon	Centre National de la Recherche Scientifique
Antoine	Ducros	Universite Paris VI
Taylor	Dupuy	University of California, Los Angeles
ESTHER	ELBAZ	Universite de Paris VII (Denis Diderot)
Arthur	Forey	Ecole Normale Superieure
James	Freitag	University of California, Berkeley
Natalia	Garcia	Queen's University
Alia	Hamieh	Queen's University
Gwyneth	Harrison-Shermoen	UC Berkeley Math Faculty
Nadja	Hempel	Universite Claude-Bernard (Lyon I)
Martin	Hils	Universite de Paris VII (Denis Diderot)
Meng-Che	Ho	University of Wisconsin
Franziska	Jahnke	Westfalische Wilhelms-Universitat Munster
Alena	Jassova	University of Liverpool
Seongmin	Jeong	Yonsei University
Mary	Karker	Wesleyan University
Charlotte	Kestner	University of Central Lancashire
Hirotaka	Kikyo	Kobe University
Alex	Kruckman	University of California, Berkeley
Therese	Landry	San Francisco State University
Eva	Leenknegt	Purdue University
Francois	Loeser	Universite de Paris VI (Pierre et Marie Curie)
Yun	Lu	Kutztown University of PA
Maryanthe	Malliaris	University of Chicago
Jana	Marikova	Western Illinois University
David	Marker	University of Illinois
Florent	Martin	Universite de Lille I (Sciences et Techniques de Lille Flandres Artois)
Jean-Francois	MARTIN	Ecole Normale Superieure
Niki Myrto	Mavraki	University of British Columbia
Samaria	Montenegro-Guzman	Universite de Paris VII (Denis Diderot)
Victoria	Noquez	University of Illinois

Paige	North	University of Cambridge
Marina	Papkovich	Polotsk State University
Rehana	Patel	Olin College of Engineering
Kripalini	Pillai	Cochin University of Science and Technology
Francoise	Point	Universite de Mons
Nathalie	Regnault	Universite Libre de Bruxelles
Silvain	Rideau	Ecole Normale Superieure
Harry	Schmidt	Universitat Basel
Dr. Abha	Singhal	University of Rajasthan
Suresh	Srinivasamurthy	Kansas State University
Sergei	Starchenko	University of Notre Dame
Caroline	Terry	University of Illinois at Chicago
Ha	Tran	Universita degli Studi di Roma "Tor Vergata"
Christelle	Vincent	Stanford University
Somayeh	Vojdani	University of Notre Dame
Paul	Vojta	University of California, Berkeley
Michael	Wan	University of California, Berkeley
Carol	Wood	Wesleyan University

Officially Registered Participant Information

Participants		68

Gender		68
Male	39.71%	27
Female	60.29%	41
Declined to state	0.00%	0

Ethnicity*		68
White	63.24%	43
Asian	16.18%	11
Hispanic	5.88%	4
Pacific Islander	0.00%	0
Black	0.00%	0
Native American	0.00%	0
Mixed	2.94%	2
Declined to state	11.76%	8

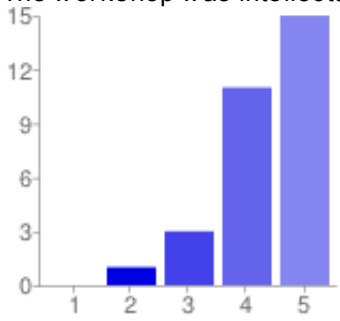
* ethnicity specifications are not exclusive

30 responses

Summary See complete responses

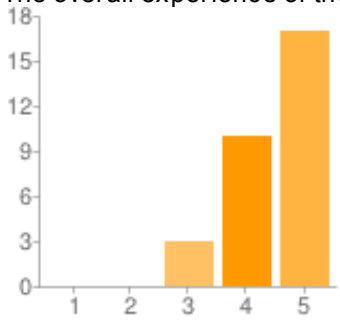
Workshop assessment

The workshop was intellectually stimulating



1 -	Not at all	0	0%
2		1	3%
3		3	10%
4		11	37%
5 -	Very	15	50%

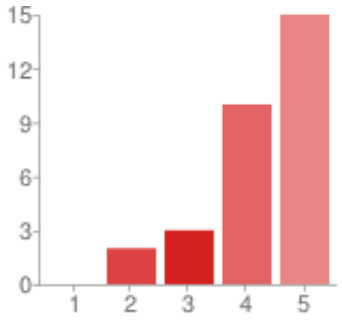
The overall experience of the workshop was worthwhile



1 -	Not at all	0	0%
2		0	0%
3		3	10%
4		10	33%
5 -	Very	17	57%

The time between lectures was adequate for discussion

1 -	Not al all	0	0%
2		2	7%
3		3	10%
4		10	33%
5 -	Very	15	50%



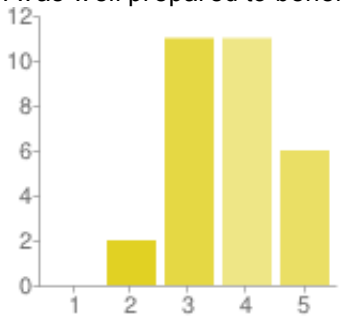
Not al all Very

Additional comments on the workshop organization

fabulous coming after the intro workshop it was good to see areas of application of model theory Excellent Compared to last week conference, I felt there could have been more unity in the subjects. May ...

Personal assessment

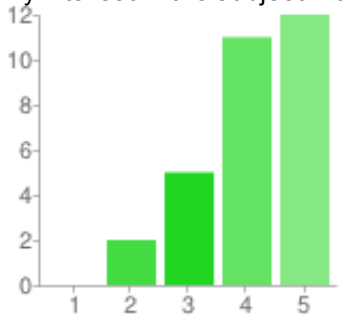
I was well prepared to benefit from the lectures



Not at all Very

1 -	Not at all	0	0%
2		2	7%
3		11	37%
4		11	37%
5 -	Very	6	20%

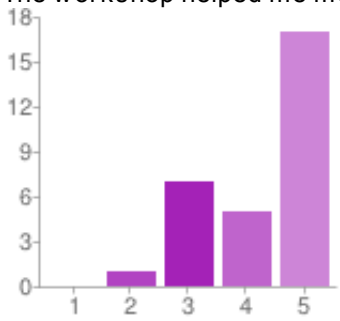
My interest in the subject matter was increased by the workshop



1 -	Niot at all	0	0%
2		2	7%
3		5	17%
4		11	37%
5 -	Very	12	40%

Niot at all Very

The workshop helped me meet people with similar scientific interests



Not at all Very Much

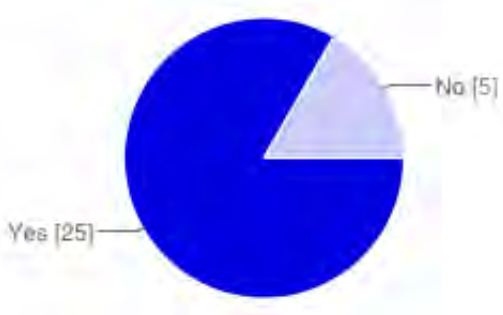
1 -	Not at all	0	0%
2		1	3%
3		7	23%
4		5	17%
5 -	Very Much	17	57%

Additional comments on your personal assessment

The subject material was broad and it did not seem easy to make scientific connections between the model theory and the number theory (and model theorists and number theorists). This workshop was muc ...

Additional Activities

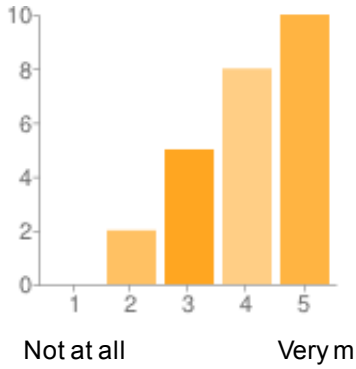
Did you attend the panel discussion?



Yes	25	83%
No	5	17%

If you did attend the panel discussion, did you find it worthwhile?

1 -	Not at all	0	0%
2		2	7%
3		5	17%



4		8	27%
5 -	Very much	10	33%

What other subjects should be addressed in future panel discussions?

Contributions between mathematicians The emphasis was on north amercican women mathematical experience; it could have been more balanced with other continents. Also the fact that these women did math ...

Did you attend the dinner?

Yes	22	73%
No	8	27%

If you did attend the dinner, did it help to solidify the contacts you made in the workshop?

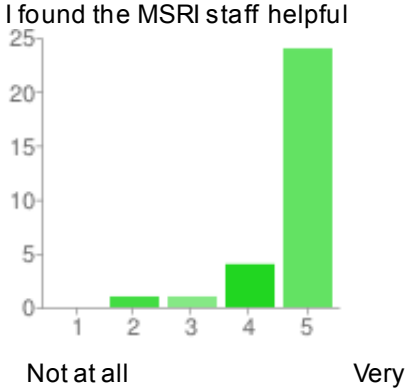
1 -	Not at all	2	7%
2		0	0%
3		3	10%
4		7	23%
5 -	Very much	11	37%

Please provide any comments on the dinner

too little food for so many Excellent Food was not the best... The "only women" dinner was unnecessary. Excellent the atmosphere was convivial The restaurant was very average and not well equipped to han ...

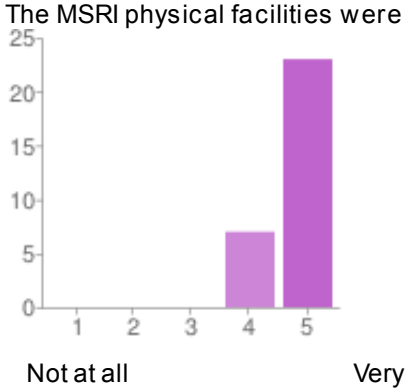
Venue

I found the MSRI staff helpful



1 -	Not at all	0	0%
2		1	3%
3		1	3%
4		4	13%
5 -	Very	24	80%

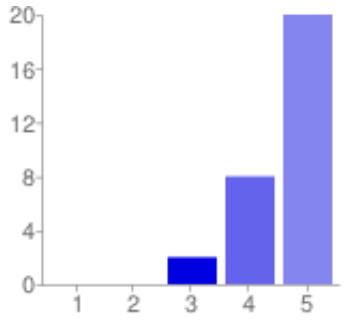
The MSRI physical facilities were conducive for such a workshop



1 -	Not at all	0	0%
2		0	0%
3		0	0%
4		7	23%
5 -	Very	23	77%

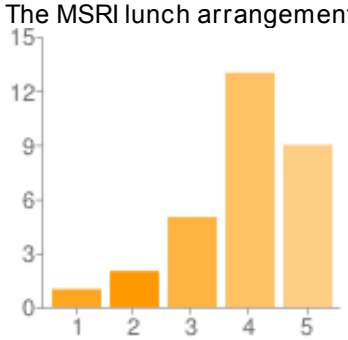
The MSRI computer facilities were adequate for such a workshop

1 -	Not at all	0	0%
2		0	0%
3		2	7%
4		8	27%
5 -	Very	20	67%



Not at all Very

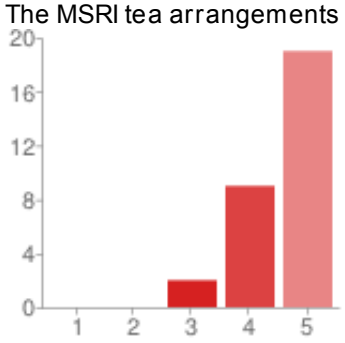
The MSRI lunch arrangements were satisfactory



Not at all Very

1 -	Not at all	1	3%
2		2	7%
3		5	17%
4		13	43%
5 -	Very	9	30%

The MSRI tea arrangements were satisfactory



Not at all Very

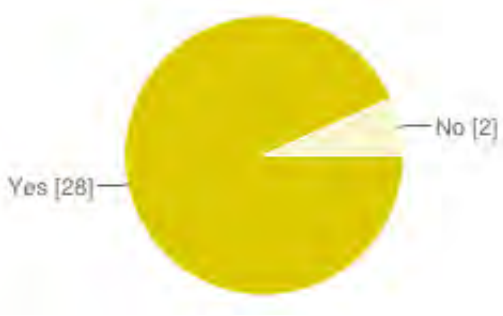
1 -	Not at all	0	0%
2		0	0%
3		2	7%
4		9	30%
5 -	Very	19	63%

Additional comments on the venue

Heating was a problem. The lunch caterers are not very good. Thanks a lot not enough vegetarian sandwiches It is a pleasure to be at MSRI.

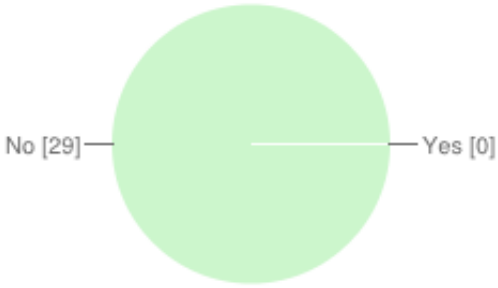
MSRI Wireless Network

Did you use MSRI's wireless network?



Yes	28	93%
No	2	7%

Did you experience any difficulties with the network?



Yes	0	0%
No	29	97%

If you did experience difficulties with the network, 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.

Number of daily responses


20
16
12
8
4
0
2/11/2014
2/18/2014

Connections for Women: Model Theory and Its Interactions with Number Theory and Arithmetic Geometry
February 10 - 11, 2014

Additional Survey Responses

Additional comments on your personal assessment

- The subject material was broad and it did not seem easy to make scientific connections between the model theory and the number theory (and model theorists and number theorists).
- This workshop was much more heavily focused on number theory and arithmetic geometry than model theory (in contrast with the previous week, which focused more on model theory). As a "pure" model theorist, I didn't get as much out of the talks.
- Excellent
- I did know some of the subjects but some talks were a bit too technical for me.

Additional comments on the venue

- Heating was a problem.
- The lunch caterers are not very good.
- Thanks a lot
- not enough vegetarian sandwiches
- It is a pleasure to be at MSRI.

We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.

- none

If you did experience difficulties with the network, please explain:

- none

What other subjects should be addressed in future panel discussions?

- Contributions between mathematicians
- The emphasis was on north amercican women mathematical experience; it could have been more balanced with other continents. Also the fact that these women did mathematics and something else wasn't clear from the discussion.
- Funding for young researchers

Please provide any comments on the dinner

- too little food for so many
- Excellent
- Food was not the best...
- The "only women" dinner was unnecessary.
- Excellent
- the atmosphere was convivial
- The restaurant was very average and not well equipped to handle the crowd
- It is offensive that the one male speaker was not invited to the diner.

Additional comments on the workshop organization

- Fabulous
- coming after the intro workshop it was good to see areas of application of model theory
- Excellent
- Compared to last week conference, I felt there could have been more unity in the subjects. Maybe it would have been better to extract the talks wich could have fitted with last week conference and inserted within last week schedule.
- It was a bit tiring to have two workshops back to back, though this had obvious advantages for shorter term visitors.
- It would be much better if the workshop were held on the weekend before after the introductory workshop. It is very difficult for anyone to get away for a week and a half at the beginning of the semester.

Introductory Workshop: Model Theory, Arithmetic Geometry and Number Theory

February 3 - 7, 2014

MSRI, Berkeley, CA, USA

Organizers:

Elisabeth Bouscaren (Centre National de la Recherche Scientifique)

Antoine Chambert-Loir (Université Paris-Sud (Orsay))

Rahim Moosa (University of Waterloo)

FINAL REPORT ON THE MSRI INTRODUCTORY WORKSHOP *MODEL THEORY, ARITHMETIC GEOMETRY, AND NUMBER THEORY*

Organisers

Elisabeth Bouscaren (CNRS – Université Paris-Sud, Orsay)
Antoine Chambert-Loir (Université Paris-Sud, Orsay)
Rahim Moosa (University of Waterloo), Lead

1. Goals, Structure, and Outcomes of the Workshop

The last model theory program at MSRI, *Model theory of Fields*, was in the spring of 1998. A central focus then was the spectacular applications of model theory to diophantine geometry stemming from Hrushovski's work on the function field Mordell-Lang Conjecture in all characteristics. The current program, *Model Theory, Arithmetic Geometry, and Number Theory* reflects a new round of striking applications of model theory to algebraic and analytic geometry, number theory, and additive combinatorics. The sheer breadth of these recent applications poses a significant challenge to the program: how to bring together in a meaningful way so diverse a group of participating mathematicians. It was natural that the Introductory Workshop should take up this challenge, and the central goal of the Workshop was to expose the participants quickly, but thoroughly, to the ideas, techniques, and problems at the heart of these recent applications.

The Workshop's structure reflected this goal. It was centered around three series of tutorials, each one addressing a particularly fruitful area of current model theoretic applications: diophantine geometry, Berkovich spaces, and combinatorics. The goal of these tutorials was to describe the motivating problems in the subject, explain in depth the nature of the recent accomplishments, and give some idea of how these results were achieved. In order to maximise the benefit the audience would derive from these tutorials, we included a fourth pre-tutorial introducing the techniques of model theory. To these tutorials we also attached several complementary research talks on current work and future directions.

A key aspect of our strategy was to have the main tutorial talks given by people who were known to have deeply penetrated the area, but were not necessarilly themselves directly responsible for the recent developments that they were exposing. The idea was that the speaker should be a little bit of an outsider so as to better empathise with the program participants being tutored.

By all accounts the Workshop was a resounding success. There was an unusual amount of cross-referencing between the tutorials, and the reappearance of the same themes in various guises contributed to a well-rounded and deeper understanding. The talks were of a very high quality, and an impressive amount of effort was put into speaking to mathematicians from the "other side". The introductory workshop has contributed significantly to the breadth and depth of the conversations and collaborations that have since been carried on within the program.

2. Presentations

2.1. **Introduction to Model Theory.** Speaker: Pierre Simon (CNRS)

This was the pre-tutorial aimed at those not familiar with the methods of model theory. It was three hours long and focused on techniques that were then employed by the other tutorials. The topics included pseudofinite structures, stability, NIP, and measures. A highlight was that there were no logic prerequisites whatsoever, and yet Simon covered some very sophisticated ideas from model theory.

2.2. **Diophantine Geometry.** Speakers:

Ekaterina Amerik (Higher School of Economics)
Antoine Chambert-Loir (Université Paris-Sud, Orsay)
Alice Medvedev (City College, CUNY)
Ya'acov Peterzil (University of Haifa)
Anand Pillay (University of Notre Dame)
Margaret Thomas (Universität Konstanz)

These tutorials were split into two sub-themes. Chambert-Loir gave a three hour series of talks motivating and explaining the various diophantine theorems and conjectures that are at the center of the semester program. These include Mordell-Lang, Manin-Mumford, André-Oort, and Pink-Zilber. The other speakers, amounting to another seven hours, explored the various ways that model theory intervenes in these problems. Pillay spoke about how stability theoretic techniques apply, and Thomas and Peterzil focused on the role of o-minimality via the Pila-Wilkie theorem. Amerik and Medvedev gave research talks on the application of model-theoretic techniques to algebraic dynamics.

2.3. **Berkovich Spaces.** Speakers:

Deirdre Haskell (McMaster University)
Martin Hils (Université Paris Diderot – Paris VII)

This was a very focused tutorial of four hours duration on the model theoretic constructions behind the recent topological tameness results of Hrushovski and Loeser for the Berkovich analytification of algebraic varieties over complete non-archimidean absolute valued fields. Haskell introduced the model theory of algebraically closed valued fields, which is the structure in which Hrushovski and Loeser work, and Hils gave a very detailed explanation of the construction of the model-theoretic manifestation of the Berkovich space.

2.4. **Combinatorics.** Speakers:

Ehud Hrushovski (Hebrew University)
Terence Tao (University of California, Los Angeles)
Lou van den Dries (University of Illinois at Urbana-Champaign)

This theme began with Hrushovski's talk on the relations between model theory, combinatorics, and locally compact groups, that underlies the recent application of his work by Breuillard-Green-Tao determining the structure of approximate subgroups. The ideas that Hrushovski discussed were then worked out in detail by Van den Dries in a three hour tutorial. Tao continued the theme of model theory and combinatorics, especially the role played by ultraproducts and pseodofinite structures, in a talk on his recent Algebraic Regularity Lemma.

Organizers		
First	**Last**	**Institutions**
Elisabeth	Bouscaren	Universite Paris-Sud (Orsay)
Antoine	Chambert-Loir	Universite de Paris XI (Paris-Sud)
Rahim	Moosa	University of Waterloo

Speakers		
First	**Last**	**Institutions**
Ekaterina	Amerik	Higher School of Economics
Antoine	Chambert-Loir	Universite de Paris XI (Paris-Sud)
Deirdre	Haskell	McMaster University
Martin	Hils	Universite de Paris VII (Denis Diderot)
Alice	Medvedev	City College, CUNY
Ya'acov	Peterzil	University of Haifa
Anand	Pillay	University of Notre Dame
Pierre	Simon	Centre national de la recherche scientifique (CNRS)
Terence	Tao	University of California, Los Angeles
Margaret	Thomas	Universitat Konstanz
Lou	van den Dries	University of Illinois at Urbana-Champaign

Introductory Workshop:
Model Theory, Arithmetic Geometry and Number Theory

February 3 - 7, 2014

Schedule

Monday, February 3, 2014			
9:15 AM - 9:30 AM	Simons Auditorium		Welcome
9:30 AM - 10:30 AM	Simons Auditorium	Antoine Chambert-Loir	Specialities for non-specialists
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00 PM	Simons Auditorium	Pierre Simon	An Introduction to Stability-Theoretic Techniques
12:00 PM - 2:00 PM	Atrium		Lunch
2:00 PM - 3:00 PM	Simons Auditorium	Deirdre Haskell	A model-theorist's view of algebraically closed valued fields
3:00 PM - 4:00 PM	Atrium		Tea
4:00 PM - 5:00 PM	**Evans Hall**	**Ehud Hrushovski**	**MSRI/Evans Lecture: Talk Title**

Note: Special Charter buses will leave MSRI at 3:10 and 3:40 for Evans Hall

Tuesday, February 4, 2014			
9:30 AM - 10:30 AM	Simons Auditorium	Antoine Chambert-Loir	Specialities for non-specialists
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00 PM	Simons Auditorium	Pierre Simon	An Introduction to Stability-Theoretic Techniques
12:00 PM - 1:30 PM	Atrium		Lunch
1:30 PM- 2:00 PM	Simons Auditorium	Ekaterina Amerik	Some applications of Hrushovski's theorem about the Frobenius map to algebraic dynamics
2:30 PM - 3:30 PM	Simons Auditorium	Martin Hils	A Model Theoretic Approach to Berkovich Spaces
3:30 PM - 4:00 PM	Atrium		Tea
4:00 PM - 5:00 PM	Simons Auditorium	Lou van den Dries	Model theory and multiplicative combinatorics
5:00 PM - 7:00 PM	Atrium		Reception

Note: Special Charter buses will leave MSRI at 6:30 and 7:00 for Evans Hall

Wednesday,February 5, 2014			
9:30 AM - 10:30 AM	Simons Auditorium	Antoine Chambert-Loir	Specialities for non-specialists
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00 PM	Simons Auditorium	Pierre Simon	An Introduction to Stability-Theoretic Techniques
12:00 PM - 1:00 PM	Simons Auditorium	Margaret Thomas	The Pila-Wilkie

Thursday, February 6, 2014			
9:30 AM - 10:30 AM	Simons Auditorium	Martin Hils	A Model Theoretic Approach to Berkovich Spaces
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00 PM	Simons Auditorium	Anand Pillay	Stability theory and Diophantine geometry
12:00 PM - 1:30 PM	Atrium		Lunch
1:30 PM- 2:30 PM	Simons Auditorium	Ya'acov Peterzil	O-Minimal Ingredients in Proofs of Arithmetical Conjectures Such as Manin-Mumford and Andre-Oort
2:30 PM - 3:30 PM	Simons Auditorium	Lou van den Dries	Model theory and multiplicative combinatorics
3:30 PM - 4:00 PM	Atrium		Tea
4:00 PM - 5:00 PM	Simons Auditorium	Terence Tao	A regularity lemma for definable sets over finite fields, and expanding polynomials

Friday, February 7, 2014			
9:30 AM - 10:30 AM	Simons Auditorium	Martin Hils	A Model Theoretic Approach to Berkovich Spaces
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00 PM	Simons Auditorium	Anand Pillay	Stability theory and Diophantine geometry
12:00 PM- 1:30 PM	Atrium		Lunch
1:30 PM- 2:30 PM	Simons Auditorium	Ya'acov Peterzil	O-Minimal Ingredients in Proofs of Arithmetical Conjectures Such as Manin-Mumford and Andre-Oort
2:30 PM - 3:30 PM	Simons Auditorium	Alice Medvedev	Algebraic Dynamics and the Model Theory of Difference Fields
3:30 PM - 4:00 PM	Atrium		Tea
4:00 PM - 5:00 PM	Simons Auditorium	Lou van den Dries	Model theory and multiplicative combinatorics

Participants		
First	**Last**	**Institutions**
Nate	Ackerman	Harvard University
Emrah	Akyar	Anadolu (Anatolia) University
Manuel	Alves	CUNY, Graduate Center
Uri	Andrews	University of Wisconsin
Will	Anscombe	University of Leeds
Matthias	Aschenbrenner	University of California, Los Angeles
Vahagn	Aslanyan	University of Oxford
Matti	Astrand	University of Pennsylvania
John	Baldwin	University of Illinois
Francesca	Balestrieri	University of Oxford
Eliana	Barriga Turriago	Universidad de los Andes
Fabrizio	Barroero	Scuola Normale Superiore
Franck	Benoist	Universite Paris-Sud (Orsay)
Jennifer	Berg	University of Texas
Ozlem	Beyarslan	Bogazici University (University of the Bosphorus)
Arindam	Biswas	Universite Paris-Sud (Orsay)
Anton	Bobkov	University of California, Los Angeles
Will	Boney	Carnegie-Mellon University
Santiago	Camacho	University of Illinois at Urbana-Champaign
Antonio de Jesus	Campos Rodriguez	Universiteit Leiden
Laura	Capuano	Scuola Normale Superiore
Josh	Carmichael	Bucks County Community College
Maria	Carrizosa	Universite Lyon 1
Erin	Caulfield	University of Illinois at Urbana-Champaign
Juan Diego	Caycedo	Albert-Ludwigs-Universitat Freiburg
Jorge	Cely	University of Pittsburgh
Mei-Chu	Chang	University of California
Zoe	Chatzidakis	Centre National de la Recherche Scientifique (CNRS)
Artem	Chernikov	Institut de Mathematiques de Jussieu - Paris Rive Gauche
Sunil	Chetty	College of St Benedict and St John's University
Dohoon	choi	Korea aerospace university
youn-seo	choi	Korea Institute for Advanced Study
Derya	Ciray	Universitat Konstanz
William	Cocke	Brigham Young University
Georges	Comte	Universite de Savoie (Chambery)
Gabriel	Conant	University of Illinois
Annalisa	Conversano	Massey University
David	Corwin	Massachusetts Institute of Technology
Gregory	Cousins	University of Notre Dame
Reid	Dale	University of Washington
Paola	D'Aquino	Seconda Universita di Napoli
Christopher	Daw	University College London
Juan	de Vicente	Autonomous University of Madrid
Francoise	Delon	Centre National de la Recherche Scientifique
Benjamin	DRUART	Universite Claude-Bernard (Lyon I)
Antoine	Ducros	Universite Paris VI
Taylor	Dupuy	University of California, Los Angeles
Clifton	Ealy	Western Illinois University

Kirsten	Eisentraeger	Pennsylvania State University
ESTHER	ELBAZ	Universite de Paris VII (Denis Diderot)
Pantelis	Eleftheriou	Universitat Konstanz
bernadette	Faye	AIMS Senegal
Arthur	Forey	Ecole Normale Superieure
Brett	Frankel	University of Pennsylvania
James	Freitag	University of California, Berkeley
Ziyang	GAO	Universite Paris-Sud (Orsay)
Natalia	Garcia	Queen's University
Dario	Garcia	Universidad de los Andes
Allen	Gehret	University of Illinois at Urbana-Champaign
Danielle	GONDARD-COZETTE	Universite de Paris VI (Pierre et Marie Curie)
Heidi	Goodson	University of Minnesota Twin Cities
Vincent	Guingona	University of Notre Dame
Joseph	Gunther	CUNY, Graduate Center
Priya	Gupta	Purvanchal University
Adam	Gutter	Carnegie Mellon University
Ali	Hakami	Jazan University
Tigran	Hakobyan	University of Illinois at Urbana-Champaign
Yatir	Halevi	Hebrew University
Gwyneth	Harrison-Shermoen	UC Berkeley Math Faculty
Michael	Haskel	University of Notre Dame
Aloysius	Helminck	North Carolina State University
Nadja	Hempel	Universite Claude-Bernard (Lyon I)
C Ward	Henson	University of Illinois at Urbana-Champaign
Cameron	Hill	Wesleyan University
Meng-Che	Ho	University of Wisconsin
Bo-Hae	Im	Chung-Ang University
Franziska	Jahnke	Westfalische Wilhelms-Universitat Munster
ANUJ	JAKHAR	Indian Institute of Science Education and Research Mohali
Tiago	Jardim da Fonseca	Universite Paris-Sud (Orsay)
Alena	Jassova	University of Liverpool
Seongmin	Jeong	Yonsei University
Ruizhang	Jin	University of Waterloo
Moshe	Kamensky	Hebrew University
Itay	Kaplan	Hebrew University
Charlotte	Kestner	University of Central Lancashire
adel	khalfallah	King Fahd University of Petroleum and Minerals
Mohamed	Khalifa	Central European University
Mohsen	Khani	Albert-Ludwigs-Universitat Freiburg
Hirotaka	Kikyo	Kobe University
SunYoung	Kim	Yonsei University
Joonhee	Kim	Yonsei University
Byunghan	Kim	Yonsei University
Alexander	Knop	Steklov Mathematical Institute, St. Petersburg
Holly	Krieger	Massachusetts Institute of Technology
Alex	Kruckman	University of California, Berkeley
Therese	Landry	San Francisco State University
Michael	Larsen	Indiana University
Wan	Lee	Yonsei University

JUNGUK	LEE	Yonsei University
Eva	Leenknegt	Purdue University
Omar	Leon Sanchez	McMaster University
Francois	Loeser	Universite de Paris VI (Pierre et Marie Curie)
Amena	Mahmoud	Cairo University
Ali	Mahmoud	Cairo University
Mohammad	Mahmoud	Cairo University
Edson	Makuluni	University of Wisconsin
Maryanthe	Malliaris	University of Chicago
Guillermo	Mantilla-Soler	Ecole Polytechnique Federale de Lausanne (EPFL)
David	Marker	University of Illinois
Florent	Martin	Universite de Lille I (Sciences et Techniques de Lille Flandres Artois)
Jean-Francois	MARTIN	Ecole Normale Superieure
Jean-Cyrille	Massicot	Universite de Lyon 1
Niki Myrto	Mavraki	University of British Columbia
Barry	Mazur	Harvard University
Emmanuel	Mensah	University of L'Aquila
Timothy	Mercure	University of Maryland
Daniel	Meyer	Ohio State University
Samaria	Montenegro-Guzman	Universite de Paris VII (Denis Diderot)
Rahim	Moosa	University of Waterloo
Joel	Nagloo	University of Leeds
Iwuchukwu	Ndukwem	university of Nigeria Nsukka
Dong Quan	Nguyen	University of British Columbia
Johannes	Nicaise	Katholieke Universiteit Leuven
Victoria	Noquez	University of Illinois
Paige	North	University of Cambridge
Trent	Ohl	Ohio State University
Alf	Onshuus	Universidad de los Andes
Koushik	Pal	University of Saskatchewan
Marina	Papkovich	Polotsk State University
Donghoon	Park	Yonsei University
Rehana	Patel	Olin College of Engineering
Sam	Payne	Yale University
Francoise	Point	Universite de Mons
PRASANTA	RAY	International Institute of Information and Technology, Bhubaneswar
Prasanta	Ray	IIIT, Bhubaneswar
Nathalie	Regnault	Universite Libre de Bruxelles
Nathan	Rehfuss	University of Illinois at Urbana-Champaign
Alex	Rennet	University of Toronto
Silvain	Rideau	Ecole Normale Superieure
Emily	Riehl	Harvard University
mohan	rudravarapu	GOVERNMENT POLYTECHNIC
Carlos	Ruiz Guido	Universite Paris-Sud (Orsay)
Harry	Schmidt	Universitat Basel
Philip	Scowcroft	Wesleyan University
Alisa	Sedunova	Ecole Normale Superieure
Mehmet Haluk	Sengun	University of Warwick
Shahed	Sharif	CSU San Marcos
William	Simmons	University of California, Los Angeles

Michael	Singer	North Carolina State University
Bismark	Singh	University of Texas
Filip	Sladek	University of Oxford
Saronsad	Sokantika	Chulalongkorn University
Luis	Sordo Vieira	University of Kentucky
Suresh	Srinivasamurthy	Kansas State University
Sergei	Starchenko	University of Notre Dame
Kristian	Strommen	University of Oxford
Caroline	Terry	University of Illinois at Chicago
Athipat	Thamrongthanyalak	Chulalongkorn University
Vladimir	Tonchev	Michigan Technological University
Adam	Topaz	University of California, Berkeley
Minh	Tran	University of Illinois at Urbana-Champaign
Marcus	Tressl	University of Manchester
Maciej	Ulas	Jagiellonian University
Somayeh	Vojdani	University of Notre Dame
Paul	Vojta	University of California, Berkeley
erik	walsberg	University of California, Los Angeles
Gary	Walsh	University of Ottawa
Michael	Wan	University of California, Berkeley
Carol	Wood	Wesleyan University
Jie	Xia	Columbia University
Myungjun	Yu	University of California, Irvine
Jon	Ziegler	Unknown School
Julian	Ziegler Hunts	none
Hong	Zong	Princeton University

Officially Registered Participant Information

Participants		129

Gender		129
Male	70.54%	91
Female	27.91%	36
Declined to state	1.55%	2

Ethnicity*		129
White	51.16%	66
Asian	19.38%	25
Hispanic	8.53%	11
Pacific Islander	0.00%	0
Black	3.10%	4
Native American	0.00%	0
Mixed	4.65%	6
Declined to state	13.18%	17

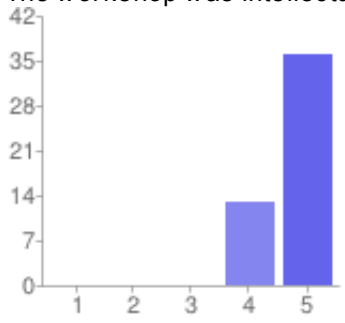
* ethnicity specifications are not exclusive

49 responses

Summary See complete responses

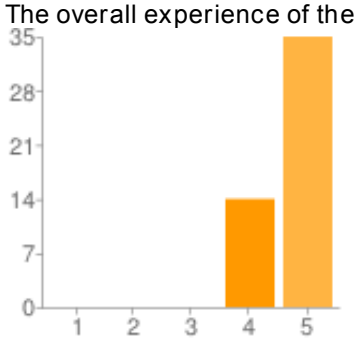
Workshop assessment

The workshop was intellectually stimulating



1 -	Not at all	0	0%
2		0	0%
3		0	0%
4		13	27%
5 -	Very	36	73%

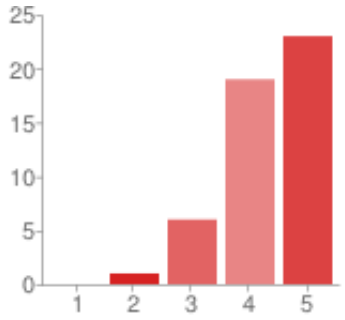
The overall experience of the workshop was worthwhile



1 -	Not at all	0	0%
2		0	0%
3		0	0%
4		14	29%
5 -	Very	35	71%

The time between lectures was adequate for discussion

1 -	Not al all	0	0%
2		1	2%
3		6	12%
4		19	39%
5 -	Very	23	47%



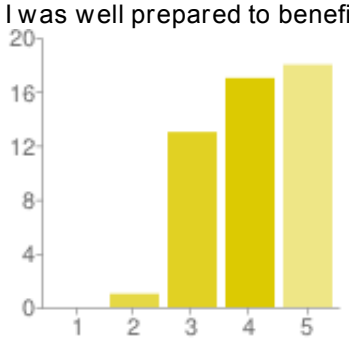
Not al all Very

Additional comments on the workshop organization

Excellent; everything was very smooth. if we can download the slide files, it would be also helpful as much as video files. Excellent I would have also asked the people who did actually proved the res ...

Personal assessment

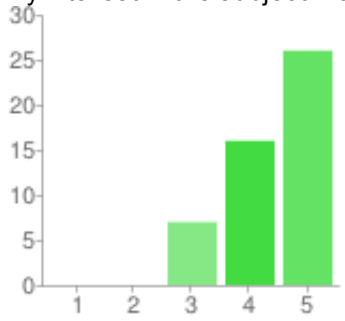
I was well prepared to benefit from the lectures



Not at all Very

1 -	Not at all	0	0%
2		1	2%
3		13	27%
4		17	35%
5 -	Very	18	37%

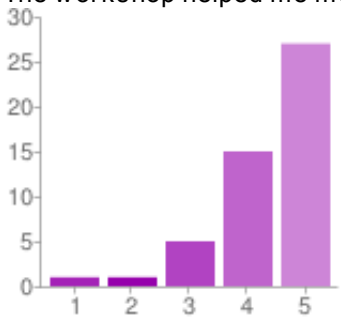
My interest in the subject matter was increased by the workshop



1 -	Niot at all	0	0%
2		0	0%
3		7	14%
4		16	33%
5 -	Very	26	53%

Niot at all Very

The workshop helped me meet people with similar scientific interests



Not at all Very Much

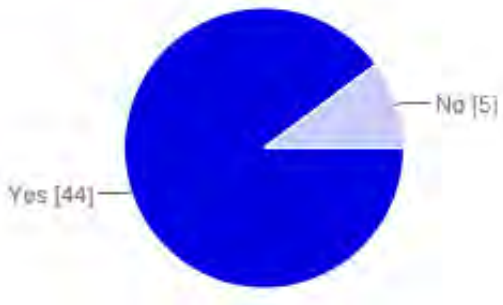
1 -	Not at all	1	2%
2		1	2%
3		5	10%
4		15	31%
5 -	Very Much	27	55%

Additional comments on your personal assessment

Excellent I had attended lectures on these subjects and I found sometimes that it was beth too easy and rather difficult to follow very nice programme, very well designed. The level of the lectures wa ...

Additional Activities

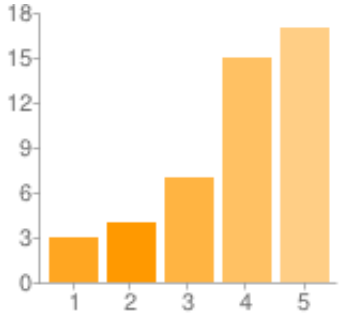
Did you attend the reception?



Yes	44	90%
No	5	10%

If you did attend the reception, did it help to solidify the contacts you made in the workshop?

1 -	Not at all	3	6%
2		4	8%
3		7	14%



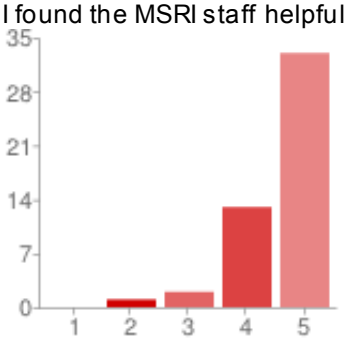
4		15	31%
5 -	Very much	17	35%

Please provide any comments on the reception

At the reception, I have not been pursuing the aim of solidifying contacts, that's all :) Excellent it was friendly There were so many people in the little space that discussion was hard. I talked to p ...

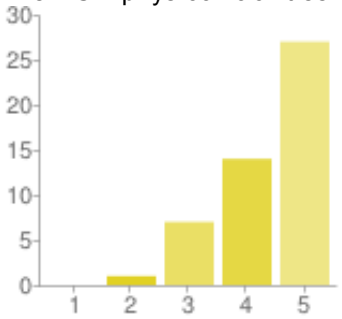
Venue

I found the MSRI staff helpful



1 -	Not at all	0	0%
2		1	2%
3		2	4%
4		13	27%
5 -	Very	33	67%

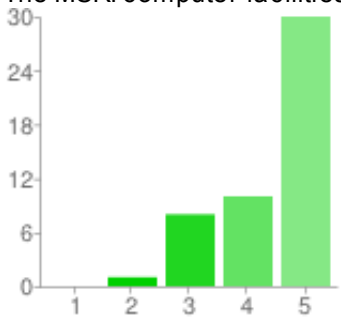
The MSRI physical facilities were conducive for such a workshop



1 -	Not at all	0	0%
2		1	2%
3		7	14%
4		14	29%
5 -	Very	27	55%

Not at all Very

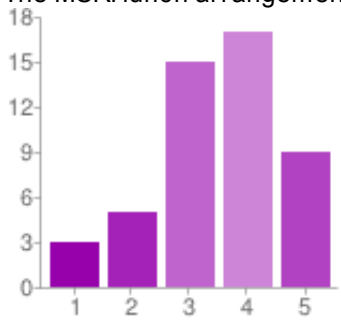
The MSRI computer facilities were adequate for such a workshop



Not at all Very

1 -	Not at all	0	0%
2		1	2%
3		8	16%
4		10	20%
5 -	Very	30	61%

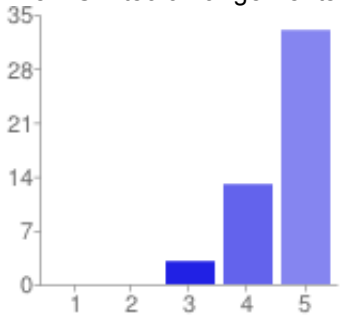
The MSRI lunch arrangements were satisfactory



Not at all Very

1 -	Not at all	3	6%
2		5	10%
3		15	31%
4		17	35%
5 -	Very	9	18%

The MSRI tea arrangements were satisfactory



Not at all Very

1 -	Not at all	0	0%
2		0	0%
3		3	6%
4		13	27%
5 -	Very	33	67%

Additional comments on the venue

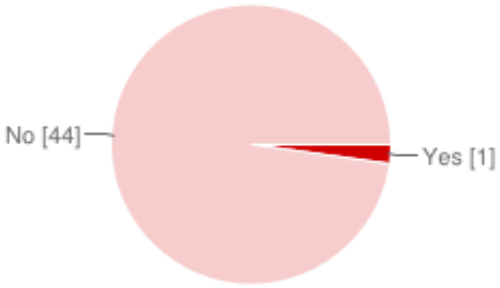
1) The auditorium (Simons) is very nice. But there is a real problem when sitting on one of the side parts in the room. It is very difficult to read what is written on a blackboard in this case. The ...

MSRI Wireless Network

Did you use MSRI's wireless network?

Yes	45	92%
No	4	8%

Did you experience any difficulties with the network?



Yes	1	2%
No	44	90%

If you did experience difficulties with the network, please explain:

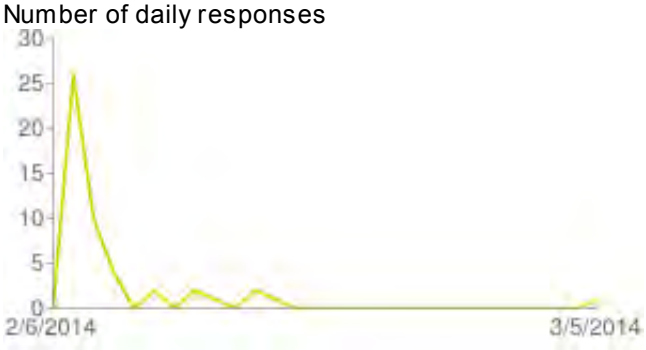
The laptop wireless was fine. I never managed to login in room 2o5 to print. The machines did not accept the id's and passwords suggested. I did print from the library

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 nice to have a kind of visitor's room (shared office) for people who are not members but come for somewhat longer than the workshop, in order to benefit from the discussions with members I e ...

Number of daily responses



Introductory Workshop:
Model Theory, Arithmetic Geometry and Number Theory
February 3 - 7, 2014

Additional Survey Responses

Additional comments on your personal assessment

- Excellent
- I had attended lectures on these subjects and I found sometimes that it was beth too easy and rather difficult to follow
- very nice programme, very well designed.
- The level of the lectures was perfect for me: I could follow the lectures if I paid good attention, but it wasn't easy and I learned a ton. In the later afternoon talks I was often so exhausted that it was hard to follow with enough attention.

Additional comments on the venue

- 1) The auditorium (Simons) is very nice. But there is a real problem when sitting on one of the side parts in the room. It is very difficult to read what is written on a blackboard in this case. There were many people at the workshop, so it was necessary to reserve a good seat before a talk iof one wanted to actually see everything.
- Excellent
- tea is very nice with always fruits provided
- conference room: hard to view the blackboard from the sides; low quality, long queue at lunch; color problems with the beamer presentations
- The auditorium is very problematic. One cannot see well from the sides, the beamer projector does not work well (the colors are not right) and the aucustic is quite bad.
- screen of projection trembling, sound not very goodvery
- I think the arrangement of the tables for tea, etc could be improved to avoid unnecessarily long queues.
- it is not suitable for large numbers of participants.
- The Simons auditorium has a strange design. On the right side, the morning daylight reflects from the blackboard and it is hard to read. The seats in the back rows in the middle are blocked by the desks in the front. In the front rows there could be many more good seats if they were more dense. There is a constant supply of fresh coffee on every floor.
- I did not find the staff particularly friendly, and I also found that the suggested accomodation was vey expensive, most conferences I have been to in this situation try to pair people together to share rooms to reduce the costs. This would have been very helpful.

We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.

- would be nice to have a kind of visitor's room (shared office) for people who are not members but come for somewhat longer than the workshop, in order to benefit from the discussions with members
- I enjoyed this workshop!!

- I found that when one is sitting on the sides that one cannot see very well and I did not like to reserve a seat in the middle

If you did experience difficulties with the network, please explain:

- The laptop wireless was fine. I never managed to login in room 205 to print. The machines did not accept the id's and passwords suggested. I did print from the library

Please provide any comments on the reception

- At the reception, I have not been pursuing the aim of solidifying contacts, that's all :)
- Excellent
- it was friendly
- There were so many people in the little space that discussion was hard. I talked to people more at other times. The food was great!
- I feel a sit down meal allows more time to have meaningful conversations

Additional comments on the workshop organization

- Excellent; everything was very smooth.
- if we can download the slide files, it would be also helpful as much as video files.
- Excellent
- I would have also asked the people who did actually proved the results to interact more--I felt a bit frustating at times--since they were also attending the talks
- Very good
- Perhaps too many talks per day...
- It would have been convenient to have extra shuttles scheduled for the end of the day.

Reimagining the Foundations of Algebraic Topology

April 7 - 11, 2014

MSRI, Berkeley, CA, USA

Organizers:

Vigleik Angeltveit (Australian National University)

Mark Behrens (Massachusetts Institute of Technology)

Julie Bergner (University of California)

Andrew Blumberg (University of Texas)*

1. Workshop description

The topical workshop, "Reimagining the foundations of algebraic topology", occurred towards the end of the MSRI semester, and provided a reinvigorating infusion of new ideas and energy into the program. Building on the background provided by the Introductory Workshop, the topical workshop provided a view of work at the frontier in algebraic topology.

Algebraic topology derives its strength and effectiveness from a deep interplay of algebraic and geometric methods, using algebraic tools to make tractable problems in geometry and geometric insights to inform algebraic constructions. In the last decade, there has been a flurry of work rebuilding and reinvigorating the foundations of the subject based on insights and ideas coming from higher category theory.

This workshop featured lectures (described below) by a diverse collection of researchers, with talks centered around the use of recent innovations in higher category theory to reimagine the basic tools and constructions in algebraic topology. In particular, many of the talks described the interplay between these higher and ∞-categorical techniques with classical algebraic topology.

The workshop was extremely well-attended, and reactions were very positive; the talks provided a broad and exciting sense of new developments in the field.

2. Lectures

The workshop consisted of eighteen research lectures, loosely thematically organized. The overall quality of the talks given was very high, and we were particularly pleased by the interactions and collaborations that were sparked by the lectures. Full videos and careful notes for all of the lectures are available at `http://www.msri.org/workshops/689`, but we provide here a short description of each talk.

Monday: field theories and geometry

David Ben-Zvi: Algebraic geometry and topological field theories

Ben-Zvi explained joint work with Nadler, Neitzke, and Nevins on understanding supersymmetric gauge theories from the perspective of topological field theories. Much of the talk emphasized the connection to the modern geometric perspective on representation theory in terms of homotopical categories of representations.

David Ayala: Poincare/Koszul duality

Ayala described recent work with Francis and Tanaka that studies Poincare duality in the setting of factorization (co)homology. The main theorem connects factorization homology with coefficients in an E_n algebra to factorization cohomology in the Koszul dual coalgebra. The method of proof required investigation of stratified spaces and certain categories of manifolds, as well as the study of the connection between Goodwillie calculus and embedding calculus.

John Francis: Poincare/Koszul duality and formal moduli

In a continuation of the previous talk, Francis described an interpretation of his work with Ayala on Poincare duality for factorization homology in terms of formal moduli problems. This work provided a setting for completion phenomena that arise in studying duality in Hochschild homology and has applications to describing the correct duality of topological field theories.

Kirsten Wickelgren: Sullivan's conjecture and applications to arithmetic

Wickelgren described her recent progress on Grothendieck's anabelian conjectures. These are central and difficult conjectures in equivariant algebraic geometry. A very nice aspect of the talk was that it motivated the algebraic geometry for a topological audience by making a precise analogy to the (affirmed) Sullivan conjecture.

Tuesday: higher category theory

Emily Riehl: The formal theory of adjunctions, monads, algebras, and descent

Riehl described her on-going work with Verity that uses the 2-category of quasi-categories to give new proofs of foundational results about adjunctions and monadic algebras in the ∞-categorical setting. These new proofs are comparatively easy and reflect classical proofs of these results in ordinary category theory.

Hugo Bacard: co-Segal algebras and Deligne's conjecture

Bacard described his approach to obtaining multiplicative structures on derived endomorphism algebras (the generalized Deligne's conjecture) using model structures on co-Segal objects in suitable model categories.

Andre Joyal: What is an elementary higher topos?

Joyal presented a conjectural description of an elementary higher topos in the context of higher category theory. His talk included a completely homotopy-theoretic interpretation of homotopy type theory, as part of the motivation for his definition.

Angelica Osorno: Modeling stable 2-types

Osorno described her joint work with Gurski and Johnson that obtains a categorical model for stable 2-types, inspired by the classical work of Thomason on modeling connective spectra via symmetric monoidal categories (and the K-theory functor). They construct a suitable K-theory functor that applies to Picard bicategories.

Wednesday

Thomas Nikolaus: Aspects of differential cohomology

Nikolaus presented work on a higher categorical construction of differential cohomology. Traditionally, differential cohomology theories are constructed in a very direct geometric fashion which can obscure formal properties. Nikolaus explained how this new perspective allowed for a natural decomposition, an elegant theory of integration, and straightforward construction of twistings.

Christopher Schommer-Pries: The unicity of the homotopy theory of higher categories

Schommer-Pries presented his joint work with Barwick that establishes that any two theories of (∞, n) categories satisfying a small collection of reasonable axioms coincide up to a well-understood automorphism.

Thursday: derived algebraic geometry

Clark Barwick: Redshift and higher categories

Barwick explained a conjectural approach to proving the redshift conjecture in algebraic K-theory (which roughly speaking states that algebraic K-theory increases chromatic filtration) in terms of a higher-categorical algebraic K-theory and attendant operations arising from a theory of homotopical plethories.

Michael Hill: Derived equivariant algebraic geometry

Motivated by the observation that certain phenomena in the calculational study of topological modular forms suggests some kind of underlying equivariant algebraic geometry, Hill outlined questions and some speculative answers about the foundations of derived equivariant algebraic topology. In the equivariant setting, even basic questions about the meaning of commutative ring and the correct definition of the Zariski topology have subtle answers and admit many possible choices.

Vesna Stojanoska: Duality, algebro-homotopically

Stojanoska talked about work aimed at understanding Brown-Comenetz duality in spectra arising from chromatic homotopy theory through the lens of derived algebraic geometry. She focused on her work on self-duality for topological modular forms.

Charles Rezk: Calculations in multiplicative stable homotopy theory at height 2

Rezk explained how the theory of power operations in Morava E-theory and their explicit description can be used to make calculations, focusing on examples coming from the Bousfield-Kuhn functor and from twisted E-theory.

Friday: orientations

Michael Mandell: E_n genera

Mandell described recent work with Chadwick in which they showed that any maps from certain Thom spectra (notably MU and MSO) to an even E_2 ring spectrum can be refined to an E_2 map. Such multiplicative refinements of genera have played an important role work on elliptic cohomology, for example.

Goncalo Tabuada: Motives vs. noncommutative motives

Tabuada explained the connection between his program for studying Kontsevich-style noncommutative motives and classical commutative motives. Most notably, he explained the connections between the standard conjectures on both sides, focusing on cases where the noncommutative setting might be an easier place to work.

David Gepner: Thom spectra and twisted Umkehr maps

Gepner described his joint work with Ando and Blumberg that explained how the ∞-categorical perspective on the Thom spectrum functor and parametrized homotopy theory can be used to provide an elegant construction of twisted Umkehr maps.

Andre Henriques: A $K(\mathbb{Z}, 4)$ in nature

Henriques described a byproduct of his work on von Neumann algebras in the context of topological field theories, which is a natural construction of a geometric model of a $K(\mathbb{Z}, 4)$.

Organizers		
First	**Last**	**Institutions**
Vigleik	Angeltveit	Australian National University
Mark	Behrens	Massachusetts Institute of Technology
Julie	Bergner	University of California
Andrew	Blumberg	University of Texas *Lead Organizer

Speakers		
First	**Last**	**Institutions**
David	Ayala	Montana State University
Hugo	Bacard	University of Western Ontario
Clark	Barwick	Massachusetts Institute of Technology
David	Ben-Zvi	University of Texas
John	Francis	Northwestern University
David	Gepner	Purdue University
Andre	Henriques	Rijksuniversiteit te Utrecht
Michael	Hill	University of Virginia
Andre	Joyal	University of Quebec
Michael	Mandell	Indiana University
Ieke	Moerdijk	Radboud University Nijmegen
Thomas	Nikolaus	Universitat Regensburg
Angelica	Osorno	Reed College
Charles	Rezk	University of Illinois at Urbana-Champaign
Emily	Riehl	Harvard University
Christopher	Schommer-Pries	Max-Planck-Institut fur Mathematik
Vesna	Stojanoska	Massachusetts Institute of Technology
Goncalo	Tabuada	Massachusetts Institute of Technology
Kirsten	Wickelgren	Georgia Institute of Technology

Reimagining the Foundations of Algebraic Topology

April 7 - 11, 2014

Schedule

Monday, April 7, 2014			
9:15 AM - 9:30 AM	Simons Auditorium		Welcome
9:30 AM - 10:30 AM	Simons Auditorium	David Ben-Zvi	Algebraic geometry of topological field theories
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00 PM	Simons Auditorium	David Ayala	Poincare'/Koszul duality and formal moduli
12:00 PM - 2:00 PM	Atrium		Lunch
2:00 PM - 3:00 PM	Simons Auditorium	John Francis	Poincaré/Koszul duality
3:00 PM - 3:30 PM	Atrium		Tea
4:10 PM - 5:00 PM	60 Evans Hall, UC Berkeley	Kirsten Wickelgren	Sullivan's conjecture and applications to arithmetic

Tuesday, April 8, 2014			
9:30 AM - 10:30 AM	Simons Auditorium	Emily Riehl	The formal theory of adjunctions, monads, algebras, and descent
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00	Simons Auditorium	Hugo Bacard	co-Segal algebras and Deligne's conjecture
12:00PM- 2:00 PM	Atrium		Lunch
2:00PM - 3:00 PM	Simons Auditorium	Andre Joyal	What is an elementary higher topos?
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:30 PM	Simons Auditorium	Angelica Osorno	Modeling stable 2-types
4:30 PM - 6:20 PM	Atrium		Reception

Wednesday, April 9, 2014			
9:30 AM - 10:30 AM	Simons Auditorium	Thomas Nikolaus	Aspects of differential cohomology
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00 PM	Simons Auditorium	Chris Schommer-Pries	The unicity of the homotopy theory of higher categories

Thursday, April 10, 2014			
9:30 AM - 10:30 AM	Simons Auditorium	Clark Barwick	Redshift and higher categories
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00 PM	Simons Auditorium	Michael Hill	Derived Equivariant Algebraic Geometry
12:00 PM - 2:00 PM	Atrium		Lunch
2:00 PM - 3:00 PM	Simons Auditorium	Vesna Stojanoska	Duality, algebro-homotopically
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:30 PM	Simons Auditorium	Charles Rezk	Calculations in multiplicative stable homotopy theory at height 2

Friday, April 11, 2014			
9:30 AM - 10:30 AM	Simons Auditorium	Mike Mandell	Nilpotence of the algebraic K-theory of the sphere spectrum
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00 PM	Simons Auditorium	Goncalo Tabuada	Voevodsky's mixed motives versus Kontsevich's noncommutative mixed motives
12:00 PM - 2:00 PM	Atrium		Lunch
2:00 PM - 3:00 PM	Simons Auditorium	David Gepner	Thom spectra and twisted umkehr maps
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:30 PM	Simons Auditorium	Andre Henriques	A K(Z,4) in nature

Participants		
First	**Last**	**Institutions**
Elie	Alhajjar	George Mason University
Nerses	Aramyan	University of Illinois at Urbana-Champaign
Manuel	Araujo	University of Oxford
Nils	Baas	NTNU
Andrew	Baker	University of Glasgow
Lauren	Bandklayder	Northwestern University
Matthew	Barber	University of California
Tarje	Bargheer	Australian National University
Tobias	Barthel	Harvard University
Yakov	Berchenko-Kogan	Massachusetts Institute of Technology
Irina	Bobkova	Northwestern University
Anna Marie	Bohmann	Northwestern University
Peter	Bonventre	University of Virginia
Eric	Bunch	Kansas State University
Jonathan	Campbell	University of Texas
David	Carchedi	Max Planck Institute for Mathematics
Andrea	Cesaro	Universite de Lille I (Sciences et Techniques de Lille Flandres Artois)
Safia	Chettih	University of Oregon
Michael	Ching	Amherst College
Ralph	Cohen	Stanford University
Lee	Cohn	University of Texas
Reid	Dale	University of Washington
Ivo	Dell'Ambrogio	Universite de Lille I (Sciences et Techniques de Lille Flandres Artois)
Bjorn	Dundas	University of Bergen
William	Dwyer	University of Notre Dame
Thomas	Fiore	University of Michigan
Daniel	Flores	Instituto de Ciencias Nucleares
John	Foley	University of Copenhagen
Ernest	Fontes	University of Texas
Soren	Galatius	Stanford University
Teena	Gerhardt	Michigan State University
Paul	Goerss	Northwestern University
Chris	Gomes	University of Illinois at Chicago
Ilya	Grigoriev	University of Chicago
Jesper	Grodal	University of Copenhagen
Meng	Guo	Harvard University
Nick	Gurski	University of Sheffield
Joe	Hannon	Boston University
John	Harper	Ohio State University
Rune	Haugseng	Max-Planck-Institut fur Mathematik
Kathryn	Hess	Ecole Polytechnique Federale de Lausanne (EPFL)
Lars	Hesselholt	Nagoya University
Justin	Hilburn	University of Oregon
Zhen	Huan	University of Illinois at Urbana-Champaign
John	Huerta	Instituto Superior Tecnico
Niles	Johnson	Ohio State University
Brenda	Johnson	Union College
Magdalena	Kedziorek	University of Sheffield

Jonathan	Kirby	University of East Anglia
Inbar	Klang	Stanford University
Stephan	Klaus	Math. Forschungsinstitut Oberwolfach
Benjamin	Knudsen	Northwestern University
Valentin	Krasontovitsch	University of Bergen
Nicholas	Kuhn	University of Virginia
Alexander	Kupers	Stanford University
Kathryn	Lesh	Union College
Ayelet	Lindenstrauss	Indiana University
Cary	Malkiewich	Stanford University
Maryanthe	Malliaris	University of Chicago
Lennart	Meier	University of Virginia
Peter	Nelson	University of Illinois at Urbana-Champaign
Justin	Noel	University of Regensburg
Kyle	Ormsby	MIT / Reed College
Matthew	Pancia	University of Texas
Simona	Paoli	University of Leicester
Irakli	Patchkoria	University of Copenhagen
David	Pengelley	New Mexico State University
Mark	Penney	University of Oxford
Eric	Peterson	University of California, Berkeley
Dorette	Pronk	Dalhousie University
Hoel	Queffelec	Universite de Paris VII (Denis Diderot)
Sune	Reeh	University of Copenhagen
Birgit	Richter	Universitat Hamburg
Aaron	Royer	University of Texas
Hal	Sadofsky	University of Oregon
Brooke	Shipley	University of Illinois at Chicago
Charmaine	Sia	Harvard University
Yalin	Sinan	Centre Universitaire de Luxembourg
Scott	Slinker	University of Virginia
Marc	Stephan	Ecole Polytechnique Federale de Lausanne (EPFL)
Danny	Stevenson	University of Adelaide
Yuri	Sulyma	University of Texas
Thomas	Sutton	University of Sheffield
Karol	Szumilo	Rheinische Friedrich-Wilhelms-Universitat Bonn
Markus	Szymik	University of Copenhagen
Felicia	Tabing	University of California, Santa Cruz
Hiro	Tanaka	Harvard University
Sean	Tilson	Royal Institute of Technology (KTH)
Adam	Topaz	University of California, Berkeley
Philip	Tynan	Harvard University
Massimiliano	Ungheretti	University of Copenhagen
Ashish	Upadhyay	Indian Institute of Technology Patna
Gabriel	Valenzuela	Wesleyan University
Nathalie	Wahl	University of Copenhagen
Guozhen	Wang	Massachusetts Institute of Technology
Thomas	Wasserman	University of Oxford
Jacob	West	University of California
David	White	Wesleyan University

Dylan	Wilson	Northwestern University
W Stephen	Wilson	Johns Hopkins University
Aliaksandra	Yarosh	University of Pittsburgh
Sarah	Yeakel	University of Illinois at Urbana-Champaign
Justin	Young	Ecole Polytechnique Federale de Lausanne (EPFL)

Officially Registered Participant Information

Participants		126

Gender		126
Male	76.19%	96
Female	22.22%	28
Declined to state	1.59%	2

Ethnicity*		126
White	76.98%	97
Asian	4.76%	6
Hispanic	3.17%	4
Pacific Islander	0.00%	0
Black	0.79%	1
Native American	0.00%	0
Mixed	2.38%	3
Declined to state	11.90%	15

* ethnicity specifications are not exclusive

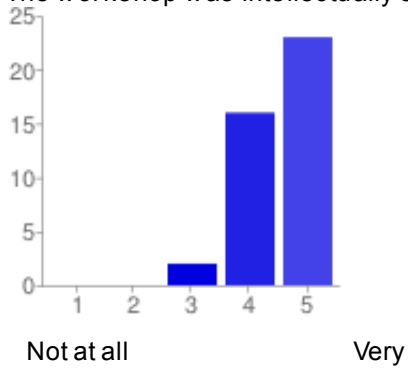
41 responses

41 responses / 126 participants = 33% response rate

Summary See complete responses

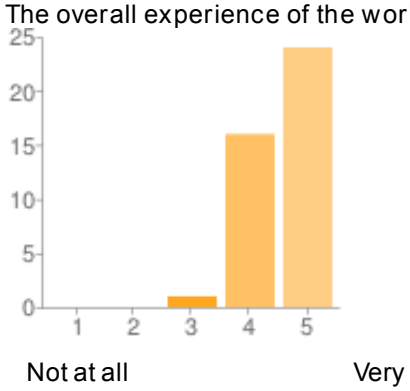
Workshop assessment

The workshop was intellectually stimulating



1 -	Not at all	0	0%
2		0	0%
3		2	5%
4		16	39%
5 -	Very	23	56%

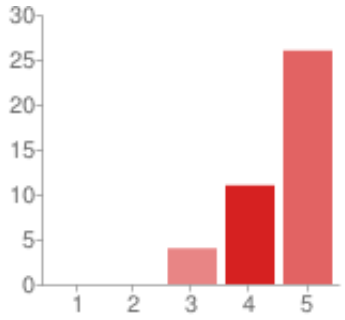
The overall experience of the workshop was worthwhile



1 -	Not at all	0	0%
2		0	0%
3		1	2%
4		16	39%
5 -	Very	24	59%

The time between lectures was adequate for discussion

1 -	Not al all	0	0%
2		0	0%
3		4	10%
4		11	27%
5 -	Very	26	63%



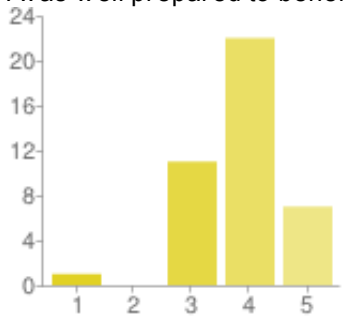
Not al all Very

Additional comments on the workshop organization

As a middle aged mathematician, the demographics of the speakers seemed aimed at perpuating the stereotype that mathematicians over 40 should be put out to pasture. One more grumble: having one le ...

Personal assessment

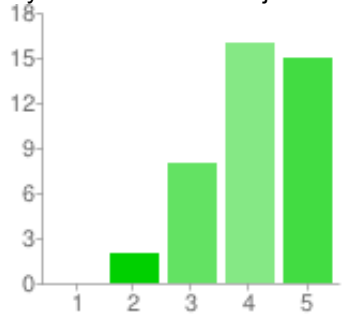
I was well prepared to benefit from the lectures



Not at all Very

1 -	Not at all	1	2%
2		0	0%
3		11	27%
4		22	54%
5 -	Very	7	17%

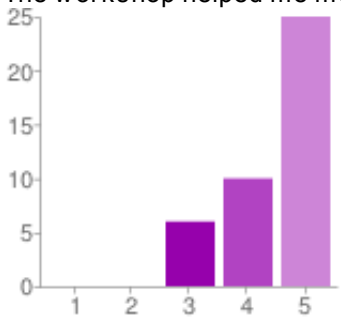
My interest in the subject matter was increased by the workshop



1 -	Niot at all	0	0%
2		2	5%
3		8	20%
4		16	39%
5 -	Very	15	37%

Niot at all Very

The workshop helped me meet people with similar scientific interests



Not at all Very Much

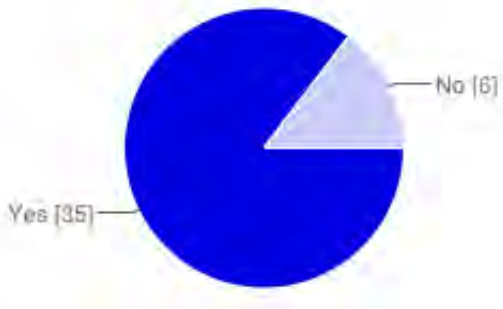
1 -	Not at all	0	0%
2		0	0%
3		6	15%
4		10	24%
5 -	Very Much	25	61%

Additional comments on your personal assessment

It was a good chance to meet some young folks I hadn't met before. For me it was a great experience to finally find someone who did something that inspires me this much. I decided on what direction t ...

Additional Activities

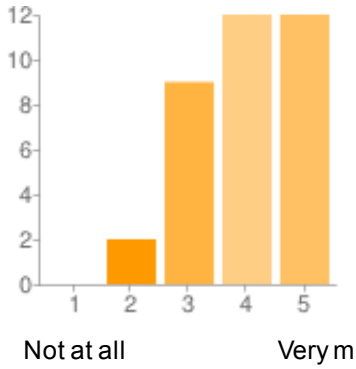
Did you attend the reception?



Yes	35	85%
No	6	15%

If you did attend the reception, did it help to solidify the contacts you made in the workshop?

1 -	Not at all	0	0%
2		2	5%
3		9	22%



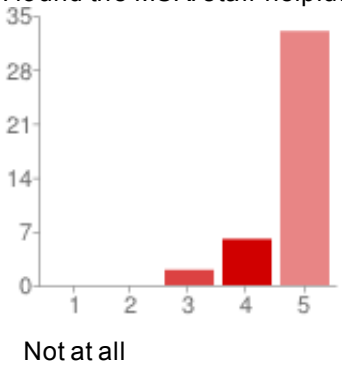
4		12	29%
5 -	Very much	12	29%

Please provide any comments on the reception

very nice and useful the reception allows for lots of time to interact and get to talk about things more concretely It was a good time for me to introduce myself to the more senior people in the field ...

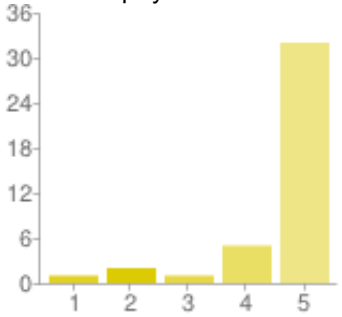
Venue

I found the MSRI staff helpful



1 -	Not at all	0	0%
2		0	0%
3		2	5%
4		6	15%
5 -	Very	33	80%

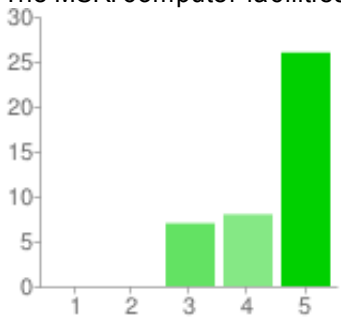
The MSRI physical facilities were conducive for such a workshop



1 -	Not at all	1	2%
2		2	5%
3		1	2%
4		5	12%
5 -	Very	32	78%

Not at all Very

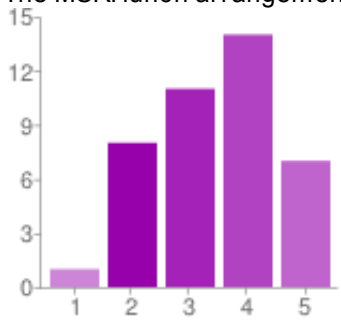
The MSRI computer facilities were adequate for such a workshop



Not at all Very

1 -	Not at all	0	0%
2		0	0%
3		7	17%
4		8	20%
5 -	Very	26	63%

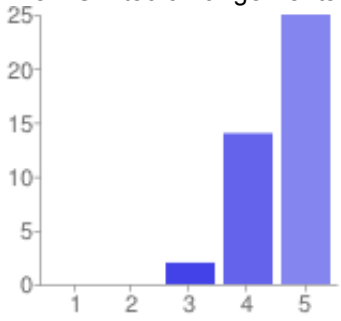
The MSRI lunch arrangements were satisfactory



Not at all Very

1 -	Not at all	1	2%
2		8	20%
3		11	27%
4		14	34%
5 -	Very	7	17%

The MSRI tea arrangements were satisfactory



Not at all Very

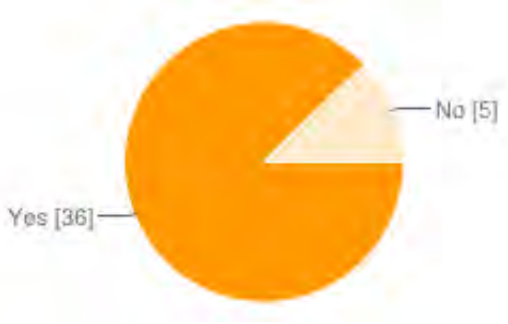
1 -	Not at all	0	0%
2		0	0%
3		2	5%
4		14	34%
5 -	Very	25	61%

Additional comments on the venue

the lecture hall was too cold Of the morning snack options, bagels and cream cheese are highly preferable. I spoke with a number of participants who were disappointed in the highly processed and sug ...

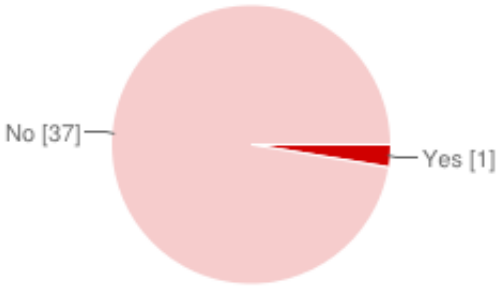
MSRI Wireless Network

Did you use MSRI's wireless network?



Yes	36	88%
No	5	12%

Did you experience any difficulties with the network?



Yes	1	2%
No	37	90%

If you did experience difficulties with the network, please explain:

facetime quality

varied

Thank you. Invaluable.

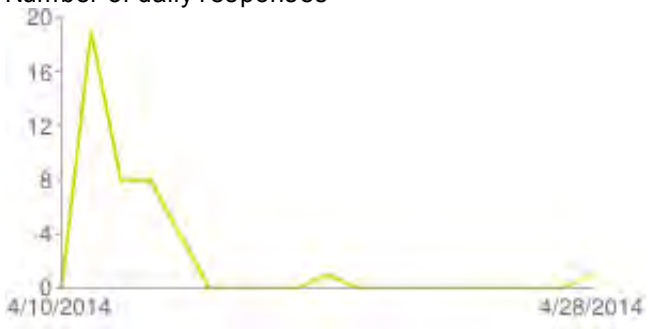
Thank you for completing this survey

We welcome any additional comments or suggestions you may have to improve the overall experience for

future participants.

I have been here for the program. The building is great, the staff are friendly and well organized. The main lecture room is poor. I think MSRI is one of the few places were such a conference coul ...

Number of daily responses



Reimagining the Foundations of Algebraic Topology
April 7 - 11, 2014

Additional Survey Responses

Additional comments on your personal assessment

- It was a good chance to meet some young folks I hadn't met before.
- For me it was a great experience to finally find someone who did something that inspires me this much. I decided on what direction to undertake for my doctorate studies because of the workshop.
- The level of the talks was a bit too high: very little background was presented in most of the talks. This workshop was more like a conference than a workshop. Considering the large number of grad students, I would have expected some "minicourse" lectures. Perhaps the typeset notes will include some additional introduction by the speakers.
- The talks were over my head but I enjoyed meeting and talking to the other participants.

Additional comments on the venue

- the lecture hall was too cold
- Of the morning snack options, bagels and cream cheese are highly preferable. I spoke with a number of participants who were disappointed in the highly processed and sugary plastic-wrapped pastries.
- The main lecture hall is appalling bad. The angles from the side seats make most of them unusable. This dim light makes it hard to see from most of the central seats too. For most talks I had to just guess what we being written. (Yes 6 boards are nice.)
- perhaps more variety in lunch would be nice
- The auditorium is too cold!
- The lecture room was often far too cold because of excessive air conditioning.Theside seating was not good for viewing the blackboards.
- Absolutely amazing and inspiring.
- Tea could have somewhat healthier, fewer sweets, options. General drinks could include hot chocolate, for those who don't drink coffee/caffeine tea. Thanks.

We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.

- I have been here for the program. The building is great, the staff are friendly and well organized. The main lecture room is poor.
- I think MSRI is one of the few places were such a conference could've been held. It's an exciting and motivating place to be around other expects and I hope this place keeps growing and receiving the necessary support from the government and the universities involved.
- Wonderful environment. Love the outside blackboard and plants.

If you did experience difficulties with the network, please explain:

- facetime quality varied
- Thank you. Invaluable.

Please provide any comments on the reception

- very nice and useful
- the reception allows for lots of time to interact and get to talk about things more concretely
- It was a good time for me to introduce myself to the more senior people in the field.

Additional comments on the workshop organization

- As a middle aged mathematician, the demographics of the speakers seemed aimed at perpuating the stereotype that mathematicians over 40 should be put out to pasture. One more grumble: having one lecture down at UC was impractical to get to, if one had come to MSRI in the morning by car: the case for roughly a dozen people.
- not enough reimagining as announced,varying quality of speakers
- excellent administrators
- It would be nice if there was at least one additional shuttle in the morning.
- Loved the bagels and the brownie bites.
- Excellent! The time between talks was very necessary for discussions.

Connections for Women: Mathematical General Relativity

September 3 to 4, 2013

MSRI, Berkeley, CA, USA

Organizers:

Beverly Berger (None)

Lydia Bieri* (University of Michigan)

Iva Stavrov (Lewis and Clark College)

MSRI - MATHEMATICAL GENERAL RELATIVITY. CONNECTIONS FOR WOMEN.

Organization and Goals

The "Connections for Women" workshop for the program "Mathematical General Relativity" was held September 3 and 4, 2013, at the MSRI, Berkeley CA. The **organizing committee** consisted of Beverly Berger, Lydia Bieri (University of Michigan (Lead Organizer)), Iva Stavrov (Lewis & Clark College).

The **main goals** of this workshop were achieved successfully:

1. To disseminate results and enhance research in active areas of the field of Mathematical General Relativity (GR).
2. To allow students and postdocs to interact with the established researchers in the field.
3. To create contacts between women researchers in the field.
4. To inaugurate and facilitate interactions as well as collaborations between different communities in GR, in particular between the mathematical on the one side and the numerical/physical community on the other side.

The organizing committee of the Connections for Women selected plenary speakers to reflect both the more analytic as well as the more physical and numerical approach to solve problems in Mathematical GR. The selection of the speakers reflects the wide variety of this research field and covers aspects of Mathematical GR including active areas, but not limited to, the following: geometric analysis, pde analysis, geometric flows, physical aspects of two-body problem in GR, numerical simulations of binary black hole mergers and radiation, etc.

Speakers, Participants, Program and Scientific Achievements

For the detailed schedule see the extra xlsx file. The workshop featured 11 talks in total. In addition, there was held a women in math panel as well as an extra discussion to bring closer together the communities of mathematical GR and physical/numerical GR. After each talk there was time for discussions. (See schedule). In fact, the discussions were very active and supported very much the main goals of the program. Moreover, the schedule of the workshop was laid out in such a way that mathematical interaction in a more social frame was encouraged. Among these were a dinner on the first day, common lunches and tea breaks.

Talks and Scientific Achievements

Of the 11 talks 5 lasted one-hour and 6 lasted 30 minutes. The choice of the speakers reflects various levels of diversity. The organizing committee made a point to invite as speakers well-established professors who are leading figures in their fields as well as junior researchers. The latter included postdocs and finishing Ph.D. students. The **one-hour talks** were delivered by Shabnam Beheshti, Rutgers University, Manuela Campanelli, Rochester Institute of Technology, Lan-Hsuan Huang, Connecticut, Deirdre Shoemaker, Georgia Tech, Qian Wang, Oxford. The **30-minutes talks** were held by Tanja Bode, Georgia Tech, Carla Cederbaum, Duke and University of Tübingen, Germany, Chen-Yun Lin, Connecticut, Kristen Moore, University of Potsdam, Germany, Jocelyn Read, California State U Fullerton, Anna Sakovich, KTH, Stockholm, Sweden.

The topics covered in the talks combine various fields in pure mathematics (see above) with astrophysics, applications and experiments. In GR the Einstein equations describe the laws of the Universe in the large (cosmology) as well as in the local regions (such as galaxies). Among the latter we find many more isolated gravitating systems like clusters of stars, clusters of galaxies, or extreme objects like black holes. They are mathematically described as asymptotically flat spacetimes (Lorentzian manifolds). Thus, solutions of the Einstein equations that decay towards flat Minkowski spacetime at infinity. Asymptotically Euclidean manifolds in 4 and 3 dimensions play a crucial role in GR. Since the landmark work by Demetrios Christodoulou and Sergiu Klainerman proving nonlinear global stability of Minkowski space, much insight has been gained into asymptotically flat systems. They have become the focus of study in order to understand gravitational waves, which are believed to be detected in the near future. Among the sources of this radiation we find supernovae, mergers of black holes and neutron stars. This decade will witness observations for which gravitational waves are the messengers that deliver information in exquisite detail about astrophysical phenomena. The Einstein equations are solved for the metric under physical assumptions. The main challenge lies in solving geometric

hyperbolic pde with interesting structures. The Einstein equations splitting into constraint equations on an initial hypersurface and evolution equations are a large pool of hyperbolic, parabolic and elliptic problems. In the recent past, much progress has been made in all directions. Confined to a spacelike, 3-dimensional hypersurface of the 4-dimensional Lorentzian spacetime, many questions from Riemannian geometry occur. Often the answers are given by geometric flows. Moreover, they are of main importance to understand (and find) quasi-local and global concepts of energy, mass and momentum.

Speakers and audience representing the different cultures of mathematicians and physicists working in GR found themselves often surprised, even amused by traditions of the other groups. For instance, the fact that most of the pure mathematicians used the blackboard and most of the numerical mathematicians and physicists used their laptop to give a talk. A remark by a numerical mathematician on a pure mathematician's talk was: 'This is great. I can follow the math, because it is developed slowly on the blackboard.'

In 1993, Robert Bartnik introduced a quasi-spherical construction of metrics of prescribed scalar curvature on 3-manifolds. This quasi-spherical ansatz has a background foliation with round metrics and converts the problem into a semi-linear parabolic equation. It is also known by work of Richard Hamilton and Ben Chow that the evolution under the Ricci flow of an arbitrary initial metric g_0 on S^2, suitably normalized, exists for all time and converges to the round metric. In her talk, Lin described a construction of metrics of prescribed scalar curvature using solutions to the Ricci flow. Considering background foliations given by Ricci flow solutions, she obtained a parabolic equation similar to Bartnik's. She discussed conditions on the scalar curvature that guarantees the solvability of the parabolic equation, and thus the existence of asymptotically flat 3-metrics with a prescribed inner boundary. Huang explained her recent results together with Damin Wu studying hypersurfaces with non-negative scalar curvature. They proved that a closed hypersurface with nonnegative scalar curvature must be weakly mean convex. In general, vanishing scalar curvature causes analytical difficulties because the scalar curvature operator may not be elliptic. Huang and collaborator tackled the problem by studying the level sets of a height function, which is motivated by GR. They further extended their proof to unbounded hypersurfaces which are asymptotically flat at infinity and obtain applications in the positive mass theorem and the Penrose inequality. Moore introduced new geometric evolution equations for hypersurfaces in asymptotically flat Riemannian manifolds, and discussed a natural application of these null mean curvature flows to locating marginally outer trapped surfaces (MOTS). They play the role of quasi-local black hole boundaries in GR. Whereas asymptotically Euclidean manifolds have been investigated intensively, manifolds which are asymptotically hyperbolic are a relatively new field in mathematical GR. Sakovich presented a review on the notion of mass for asymptotically hyperbolic manifolds, and discussed the respective positive mass conjecture and Penrose conjecture. She addressed the nearly equality case of the positive mass theorem, discussing results on how to establish closeness to the hyperbolic metric for small mass. Parts of her new results are joint with Mattias Dahl and Romain Gicquaud. Questions for static spacetimes were raised in Cederbaum's presentation on the geometry of such manifolds in GR. She introduced the notion of geometrostatics: Consider a 4-dimensional Lorentzian manifold with timelike Killing field and hypersurface-orthogonality. She discussed metrics of the form $ds^2 = -N^2c^2dt^2 + g$ with N lapse function and g induced metric on the hypersurface, where $N \to 1$ and $g_{ij} \to \delta_{ij}$ as $r \to \infty$. Moreover, the Einstein vacuum equations are satisfied outside a compact set. These manifolds are automatically Schwarzschildean. She addressed quasi-local definitions of mass and center of mass as well as Newtonian limits. Latest results in pde theory for waves were discussed by Wang who presented her proof of sharp local well-posedness of quasilinear wave equations by a vector field method approach. The $H^{2+\epsilon}$ local-well posedness was established by Smith and Tataru through the construction of a parametrix using wave packet. Based on the commuting vector field approach, this type of results have been established by Klainerman and Rodnianski for $(3+1)$ Einstein vacuum equations, by taking advantage of $Ric = 0$. Wang found a way to obtain a bounded Morawetz type energy. She combines this with a new approach by Dafermos and Rodnianski on this energy, which allows her to obtain the sharp result. Beheshti presented new results providing a framework for analyzing axially symmetric harmonic maps on $\mathbb{R}^3$ with symmetric target spaces. Drawing on results from analysis to Lie theory to geometry, she gave a complete and rigorous proof that, all such maps are completely integrable. She further demonstrated that new solutions to the harmonic map equations can be generated from a given seed solution. This unifies the integrability of theories including chiral field models, Yang-Mills and Einstein electrovacuum equations in the general context of harmonic maps. She addressed generating N-solitonic harmonic maps into a non-compact Grassmann manifold. She demonstrated a special case by deriving Kerr and Kerr-Newman solutions from the Minkowski initial seed for the Einstein vacuum and Einstein- Maxwell cases, respectively. Further, Beheshti indicated the possibility of using this analysis to control the resulting N-black hole configurations in this setting. Extreme events in the Universe are the mergers of binary

black holes. Thereby mass and momenta are radiated away as gravitational waves. These are fluctuations in the spacetime curvature traveling at the speed of light. These phenomena have been studied intensively via numerical methods. There have been groundbreaking numerical, but also analytic and geometric-analytic results in the recent years. Numerical simulations exist for the various cases of binary black hole mergers and their waves. Campanelli explained results by her and collaborators (Bowen, Lousto, Noble, Yunes, Zlochower, Zilhao, Krolik, Yunes, Mundim, Nakano) on binary black hole mergers, gravitational radiation, kicks and gas dynamics. Their numerical methods are based on a strongly hyperbolic $3+1$ formulation. Their solutions of the Einstein equations allow to study waveforms. These encode information on parameters like black hole masses, spins, orbital parameters and more. They are essential on assisting gravitational wave detectors to predict what to expect and for physical information extraction. Numerical simulations have shown that under well-understood circumstances the final black hole in a binary merger may be ejected out of the galaxy. This is due to recoil. Campanelli and collaborators computed procedure, size and probability for these extreme events. Shoemaker presented models that predict gravitational wave signals from likely sources, in particular binary black hole and binary neutron star mergers. Modeling sources of gravitational radiation requires solving the Einstein equations of GR. She uses numerical models to predict gravitational waves from binary collisions. Gravitational radiation is decomposed into spherical harmonics and the different sources show characteristic patterns. This is one pivotal step in ushering in the new era of gravitational-wave astronomy. Often the production of gravitational waves comes together with the radiation of electromagnetic fields. This happens for instance during the merger of neutron stars or supermassive black holes, carrying additional information of the environment in which the source is embedded. Bode explained how they use techniques from numerical relativity for the coupled Einstein equations with matter fields to study the dynamical spacetimes of non-vacuum binary mergers in fully nonlinear GR with matter probing the most dynamic strong regime of the system. She discussed the current understanding of anticipated electromagnetic counterparts from astrophysical environments probing the highly dynamic spacetime surrounding these strong gravitational wave sources. Read talked about neutron stars and their mergers. These are highly dense objects which can only be fully described within GR by coupling the Einstein equations to fluid equations. Observed data exhibits huge noise. Analysis of source data and noise is important to distinguish them in future experiments. They solve the nonlinear equations numerically.

Participants

There were 46 participants (men and women) who officially registered and attended the workshop. In addition, there were people from the GR program who attended some of the lectures but did not register. The organizers encouraged especially young researchers in the field and students to participate. There was a great mixture of well-established professors in leading positions, tenured and tenure-track faculty, postdocs, Ph.D students and even a few motivated undergraduates. To reach out in particular to students and postdocs the organizers enlisted the help of the invited speakers as liasons to advertise this opportunity among their colleagues and students.

Women in Math Panel

On September 3, 2014, after the last talk of the day, there was held a women in math panel discussion. The organizers together with MSRI made a point in having a very diverse panel representing women in mathematical GR and related fields. We invited senior and junior professors in mathematics and in applied mathematics/astrophysics, one postdoc and one student to serve on the panel. The panelists were: Andrea Bertozzi (University of California, Los Angeles), Manuela Campanelli (Rochester Institute of Technology), Carla Cederbaum (Tübingen University), Alexi Hoeft (Virginia Commonwealth University), Christina Sormani (CUNY, Graduate Center), Iva Stavrov (Lewis and Clark College).

The panel discussion was very well attended with more than 20 people. Among the people present were Helene Barcelo (MSRI), Greg Galloway (Miami, organizer MSRI program), James Isenberg (Oregon, lead organizer MSRI program). The students and postdocs in the audience were very curious about career possibilities. The panelists gave a very broad overview of various career paths in GR on different continents, in particular the USA and Europe. GR is represented in pure mathematics departments, applied mathematics, as well as in physics and astrophysics. It is well possible as a mathematician to obtain a position in a theoretical physics group, or for someone coming from physics with main focus on mathematical GR to work in a mathematics department. Whereas these are topics equally important for women and men, there were specific concerns about the roles of women researchers in the field. Have their careers been much different from the ones of their male colleagues? If yes, why? How did the women cope with difficult situations?

The panelists and many female researchers in the audience shared their paths into mathematical GR and academia. We heard many interesting life and work stories. Their was a main consent that the situation for women in math in particular in the USA has improved a lot over the years, but that there is still work to do. MSRI and institutions like AMS or NSF have played a crucial role in supporting the pioneers in the field and have been essential to these improvements. The many achieved women researchers on the panel and in the audience gave very positive, motivating and inspiring role models for the junior participants.

Another concern of the non-tenured audience was: How to publish? How to get tenured? During the discussion, it was felt a certain fear of the 'publish or perish' mentality, that some of the people believed had grown in the recent past in mathematics. Questions like the following were discussed: Should one publish the best quality possible or the largest number of papers possible? Among the postdocs and Ph.D. students who were applying for jobs there were many intimidated by the (generally believed) tough job market and how their work would be judged (quality versus quantity). One of the organizers (Bieri) was even told after the panel in private discussions with some of the Ph.D. students, that they felt they might be better off looking for a job in finance than in academia. The organizers together with the representatives of MSRI and the achieved researchers on the panel and in the audience who have served on editorial boards and have had many other leading positions, encouraged the junior researchers to believe in themselves and to continue what they think is the right path for them.

It was observed that most women who shared their career story with the audience were married to either a mathematician or physicist. This led to the question of another 'two-body-problem' than discussed in some of the talks before. Namely, on how an academic career works out with relationship and family. Most of the women researchers with family found it difficult to live in different places for a while, and some expressed problems to keep up with research and teaching when their children were small. However, it is common in many (most?) universities in the USA to grant maternal and paternal leaves for their faculty.

The panel was very well received by everyone. And some of the discussions continued during the dinner afterwards.

Plenary Discussion to Foster Exchange and Collaboration between Mathematical and Numerical/Physical GR

The organizers together with James Isenberg (Oregon, lead organizer main program) led a plenary discussion to foster exchange and collaboration between mathematical and numerical/physical GR.

Even though we all work on the same topic, GR, it may sometimes seem as if we spoke different languages. In the large community of GR, collaborations between pure mathematics and applied mathematics/physics is rare. Why collaborate, if it is already difficult to talk in the same language? Because we can learn a great deal from each other. Both communities were asked: What are problems that you would like the other group to help you with? And what are results that you achieved that you want the other group to know? It turned out that there was a great overlap of common problems, and also that some questions may be answered by the other group or in collaboration beyond the 'borders'. One issue in GR is how to define center of mass. Both communities showed special interest in that topic. In various fields, including two-body problem and quasi-local mass, there were common interests and partial answers.

It was very important to 'break the ice' and start talking to each other with the option to launch collaborations. The discussion was very well received.

Websites Created as Platforms for More Exchange

Two websites were created by the organizers and Carla Cederbaum. MSRI and in particular Helene Barcelo made it possible to use the MSRI website even after the program ended. The websites are hosted by MSRI.

The websites are linked through the MSRI website. They are:

Connections for Women in Mathematical General Relativity Wiki

Connections between Mathematical and Physical General Relativity Wiki

Concluding Remarks

The workshop was a great success and we wish to thank MSRI for having hosted it. All the goals were achieved. Top research was discussed and seeds for new collaborations were planted. Exchange across various groups in the field was enhanced. Minorities and junior people were especially encouraged to participate. The workshop profited from the knowledgable faculty, staff and the frame provided at MSRI. We thank Helene Barcelo, David Eisenbud and MSRI for the great collaboration.

Organizers		
First Name	**Last Name**	**Institution**
Beverly	Berger	None
Lydia	Bieri*	University of Michigan
Iva	Stavrov	Lewis and Clark College

Speakers		
First Name	**Last Name**	**Institution**
Shabnam	Beheshti	Rutgers University
Tanja	Bode	Eberhard-Karls-Universitat Tubingen
Manuela	Campanelli	Rochester Institute of Technology
Carla	Cederbaum	Tubingen University
Alexi	Hoeft	Virginia Commonwealth University
Lan-Hsuan	Huang	University of Connecticut
Chen-Yun	Lin	University of Connecticut
Kristen	Moore	Potsdam University
Jocelyn	Read	California State University
Anna	Sakovich	Linkoping University
Deirdre	Shoemaker	Georgia Institute of Technology
Christina	Sormani	CUNY, Graduate Center
Iva	Stavrov	Lewis and Clark College
Qian	Wang	University of Oxford

Connections for Women: Mathematical General Relativity

September 3 - 4, 2013

Schedule

Tuesday, September 3, 2013			
8:40AM - 9:00AM	Simons Auditorium		Welcome
9:00AM - 10:00AM	Simons Auditorium	Lan-Hsuan Huang	Hypersurfaces with non-negative scalar curvature
10:15AM - 10:45AM	Atrium		Tea
10:45AM - 11:45PM	Simons Auditorium	Manuela Campanelli	Binary black holes in strong field gravity, gravitational waves and electromagnetic signatures from their accretion disks
12:00PM - 12:30PM	Simons Auditorium	Rafaela Carla Cederbaum	Geometrostatics: The Geometry of Static Spacetimes in General Relativity
12:45PM - 2:15PM	Atrium		Lunch
2:15PM - 3:15PM	Simons Auditorium	Qian Wang	A vector field approach for sharp local well-posedness of quasiliner wave equations
3:30PM - 4:00PM	Atrium		Tea
4:00PM - 4:30PM	Simons Auditorium	Chen-Yun Lin	On Hamilton's Ricci flow and Bartnik's construction of metrics of prescribed scalar curvature
4:45PM - 5:15PM	Simons Auditorium	Jocelyn Read	From perturbation to observation: measuring the response of neutron stars
5:30PM - 6:15PM	Commons Room		Panel Discussion
7:00PM - 9:00PM			Dinner at Taste of the Himalayas

Wednesday, September 4, 2013			
9:00AM - 10:00AM	Simons Auditorium	Shabnam Beheshti	Integrability meets Control Theory: Harmonic Maps in General Relativity
10:15AM - 10:45AM	Atrium		Tea
10:45AM - 11:45PM	Simons Auditorium	Deirdre Shoemaker	The Hunt for Gravitational Waves and Black Holes
12:00PM - 12:30PM	Simons Auditorium	Tanja Bode	Lighting up Binary Supermassive Black Holes: Probing the Dynamical Spacetimes of Mergers
12:45PM - 2:15PM	Atrium		Lunch
2:15PM - 2:45PM	Simons Auditorium	Anna Sakovich	On the mass of asymptotically hyperbolic manifolds
3:00PM - 3:30PM	Simons Auditorium	Kristen Moore	Marginally outer trapped surfaces and "null" mean curvature flows
3:45PM - 5:00PM	Atrium		Tea and Discussions

Participants		
First Name	**Last Name**	**Institution**
Shabnam	Beheshti	Rutgers University
Beverly	Berger	None
Lydia	Bieri	University of Michigan
Tanja	Bode	Eberhard-Karls-Universitat Tubingen
Manuela	Campanelli	Rochester Institute of Technology
Carla	Cederbaum	Tubingen University
Piotr	Chrusciel	Universitat Wien
Julien	Cortier	Institut des Hautes Etudes Scientifiques (IHES)
Justin	Corvino	Lafayette College
Anda	Degeratu	Albert-Ludwigs-Universitat Freiburg
James	Dilts	University of Oregon
Semyon	Dyatlov	Massachusetts Institute of Technology
Raisa	Galimova	ETH Zurich
Greg	Galloway	University of Miami
Alexi	Hoeft	Virginia Commonwealth University
Lan-Hsuan	Huang	University of Connecticut
James	Isenberg	University of Oregon
Aruna	Kesavan	Pennsylvania State University
Robert	Korsan	Carnegie Mellon University
Sajjad	Lakzian	Universitat Bonn
Dan	Lee	Queens College, CUNY
Philippe	LeFloch	Universite Pierre et Marie Curie
Chen-Yun	Lin	University of Connecticut
Marc	Mars	University of Salamanca
Davi	Maximo	Stanford University
Kristen	Moore	Potsdam University
Todd	Oliynyk	Monash University
Raquel	Perales Aguilar	SUNY
Jocelyn	Read	California State University
Hans	Ringstrom	Royal Institute of Technology (KTH)
Anna	Sakovich	Linkoping University
Volker	Schlue	University of Toronto
Chen	Shibing	University of Toronto
Deirdre	Shoemaker	Georgia Institute of Technology
Christina	Sormani	CUNY, Graduate Center
Suresh	Srinivasamurthy	Kansas State University
Iva	Stavrov	Lewis and Clark College
Carlos	Vega	University of Miami
Qian	Wang	University of Oxford
Willie	Wong	Ecole Polytechnique Federale de Lausanne
Haotian	Wu	MSRI - Mathematical Sciences Research Institute
Ling	Xiao	Johns Hopkins University
Jinxin	Xue	University of Chicago

Shuangjian	Zhang	University of Toronto
Xin	Zhou	Massachusetts Institute of Technology

Officially Registered Participant Information

Participants		45

Gender		45
Male	51.11%	23
Female	44.44%	20
Declined to state	4.44%	2

Ethnicity*		45
White	64.44%	29
Asian	24.44%	11
Hispanic	4.44%	2
Pacific Islander	0.00%	0
Black	0.00%	0
Native American	0.00%	0
Mixed	0.00%	0
Declined to state	6.67%	3

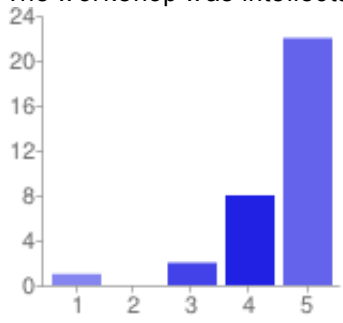
* ethnicity specifications are not exclusive

33 responses

Summary See complete responses

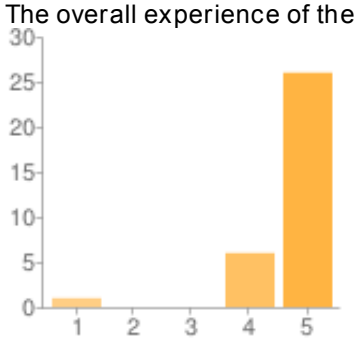
Workshop assessment

The workshop was intellectually stimulating



1 -	Not at all	1	3%
2		0	0%
3		2	6%
4		8	24%
5 -	Very	22	67%

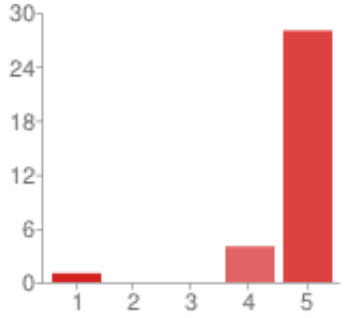
The overall experience of the workshop was worthwhile



1 -	Not at all	1	3%
2		0	0%
3		0	0%
4		6	18%
5 -	Very	26	79%

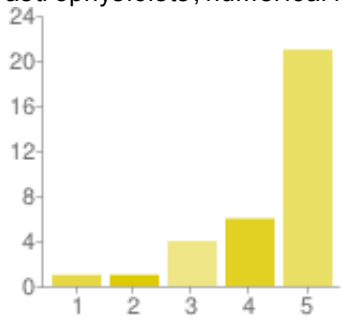
The time between lectures was adequate for discussion

1 -	Not at all	1	3%
2		0	0%
3		0	0%
4		4	12%
5 -	Very	28	85%



Not at all Very

I benefited from the interdisciplinarity of the talks (mathematical relativists, relativistic astrophysicists, numerical relativists).



Not at all Very much

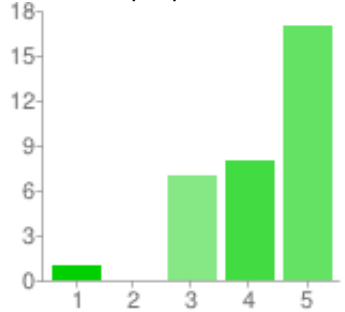
1 -	Not at all	1	3%
2		1	3%
3		4	12%
4		6	18%
5 -	Very much	21	64%

Additional comments on the workshop organization

Great. I feel the men involved in this conference were exceptionally respectful of the women speakers and would do a good job working with the women. This is not always true of women's conference. ...

Personal assessment

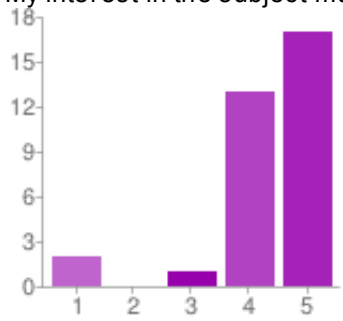
I was well prepared to benefit from the lectures



1 -	Not at all	1	3%
2		0	0%
3		7	21%
4		8	24%
5 -	Very	17	52%

Not at all Very

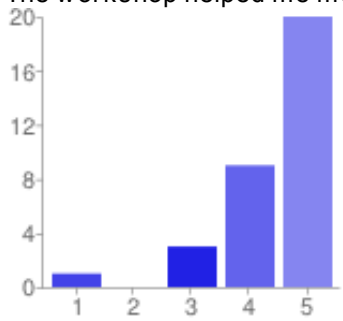
My interest in the subject matter was increased by the workshop



1 -	Not at all	2	6%
2		0	0%
3		1	3%
4		13	39%
5 -	Very	17	52%

Not at all Very

The workshop helped me meet people with similar scientific interests



1 -	Not at all	1	3%
2		0	0%
3		3	9%
4		9	27%
5 -	Very Much	20	61%

Not at all Very Much

The organizers of the workshop are planning to create a website pointing to female relativists (mathematical relativists, relativistic astrophysicists, numerical relativists etc) and providing links to their professional websites or contact information. Please provide your perspective.

very good idea Great. A second website which just points to relativists in general that includes a fair share of women would also be very useful. Often general websites and conferences forget women exist, but if more such websites were sure to include women that would be very helpful. As a male, I don't have much say in the matter, but I think it is a good idea. This would be very helpful for me and hopefully also for my colleauges. This is an excellent idea! I think any webpage which brings together high-quality related pages together in one well-organized page is a valuable resource. Grea ...

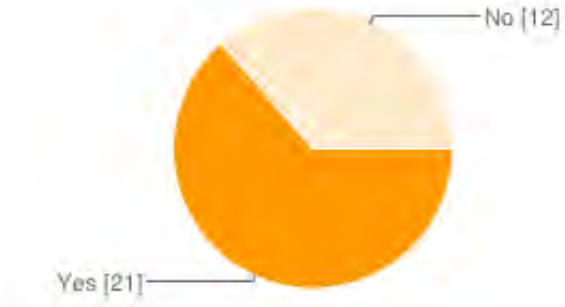
Additional comments on your personal assessment

This meeting was the first opportunity I have had to meet fellow female mathematical relativists. I found it both scientifically and personally inspiring to interact with these

colleagues and look ...

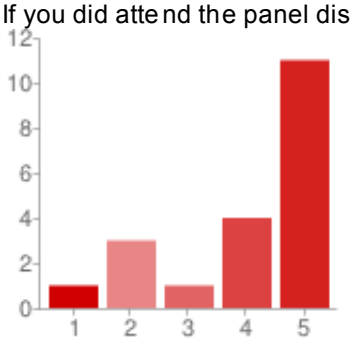
Additional Activities

Did you attend the panel discussion?



Yes	21	64%
No	12	36%

If you did attend the panel discussion, did you find it worthwhile?



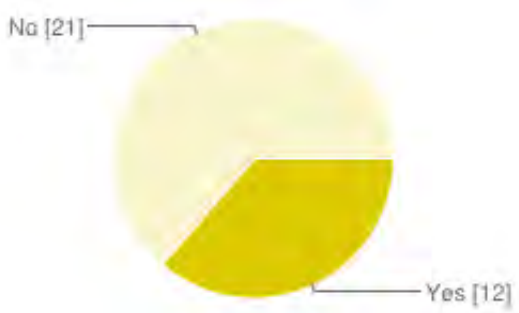
1 -	Not at all	1	3%
2		3	9%
3		1	3%
4		4	12%
5 -	Very much	11	33%

What other subjects should be addressed in future panel discussions?

Strategic directions for the relativity community there should be more time to warm up talk longer about publishing, open access, etc It would be useful to know for whom the panel discussion is direct ...

Did you attend the dinner?

Yes	12	36%
No	21	64%



If you did attend the dinner, did it help to solidify the contacts you made in the workshop?

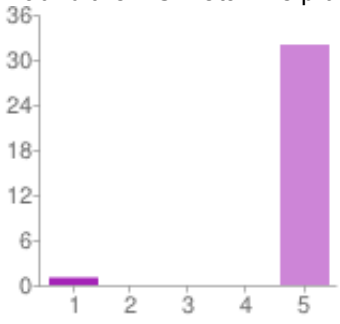
1 -	Not at all	1	3%
2		0	0%
3		1	3%
4		5	15%
5 -	Very much	6	18%

Please provide any comments on the dinner

the restaurant was OKish. The food average. Great. It was a fun followup after the panel so the conversation could continue. I enjoyed the dinner very much and appreciated the opportunity to speak with ...

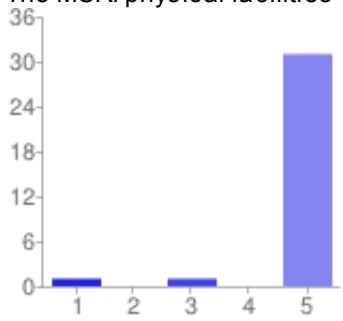
Venue

I found the MSRI staff helpful



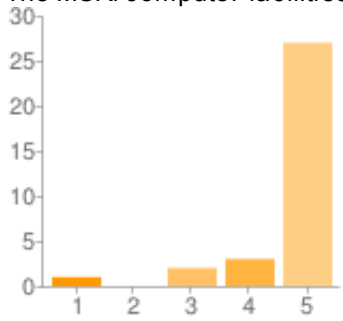
1 -	Not at all	1	3%
2		0	0%
3		0	0%
4		0	0%
5 -	Very	32	97%

The MSRI physical facilities were conducive for such a workshop



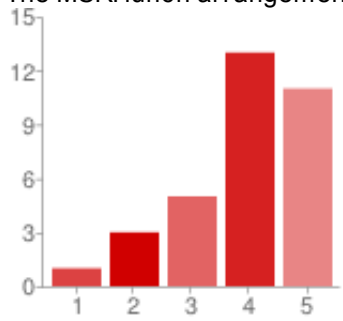
1 -	Not at all	1	3%
2		0	0%
3		1	3%
4		0	0%
5 -	Very	31	94%

The MSRI computer facilities were adequate for such a workshop



1 -	Not at all	1	3%
2		0	0%
3		2	6%
4		3	9%
5 -	Very	27	82%

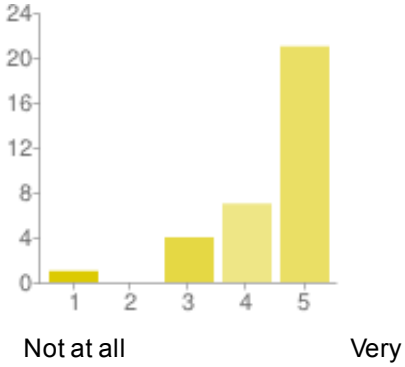
The MSRI lunch arrangements were satisfactory



1 -	Not at all	1	3%
2		3	9%
3		5	15%
4		13	39%
5 -	Very	11	33%

The MSRI tea arrangements were satisfactory

1 -	Not at all	1	3%
2		0	0%
3		4	12%
4		7	21%



5 -	Very	21	64%

Additional comments on the venue

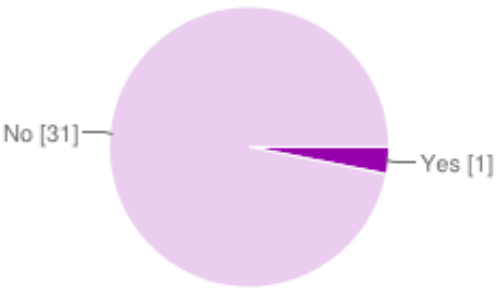
Beautiful tea times and I adore all the fruit options. It would have been useful to know in advance that the lunches required cash payment Was not warned I needed cash to buy lunch.

MSRI Wireless Network

Did you use MSRI's wireless network?

Yes	28	85%
No	5	15%

Did you experience any difficulties with the network?



Yes	1	3%
No	31	94%

If you did experience difficulties with the network, 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.

Thank you to the organizers and the staff. Something needs to be done to get more of the women to stay for the second week. This may require paying for them to bring their children along or to cov ...

Number of daily responses

Connections for Women Workshop: Mathematical General Relativity September 3 - 4, 2013

Additional Survey Responses

Additional comments on your personal assessment

- This meeting was the first opportunity I have had to meet fellow female mathematical relativists. I found it both scientifically and personally inspiring to interact with these colleagues and look forward to our future collaborations! Thank you very much for your efforts.

Additional comments on the venue

- Beautiful tea times and I adore all the fruit options.
- It would have been useful to know in advance that the lunches required cash payment
- Was not warned I needed cash to buy lunch.

We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.

- Thank you to the organizers and the staff.
- Something needs to be done to get more of the women to stay for the second week. This may require paying for them to bring their children along or to cover the costs of babysitting when they are gone.
- It would be nice to somehow have access to the building after hours (for those of us who are only participants and not MSRI members). I would have liked to work in the building outside of the standard opening hours since the facility was so fantastic.
- Excellent conference. THANK YOU!

What other subjects should be addressed in future panel discussions?

- Strategic directions for the relativity community
- there should be more time to warm up
- talk longer about publishing, open access, etc
- It would be useful to know for whom the panel discussion is directed. The challenges facing graduate students vs. tenure-track faculty are too different to be addressed in the same panel, I believe.
- there were not maky students in the audience so there seemed to be a disconnect between the intent of the panel and the audience.

Please provide any comments on the dinner

- the restaurant was OKish. The food average.
- Great.
- It was a fun followup after the panel so the conversation could continue.
- I enjoyed the dinner very much and appreciated the opportunity to speak with some of the participants with whom I had not interacted during the day.

Additional comments on the workshop organization

- Great.
- I feel the men involved in this conference were exceptionally respectful of the women speakers and would do a good job working with the women. This is not always true of women's conference. Often there are men who feel they must explain to women presenters the most basic elements of their field as if they do not understand. One has the sense such men want to coddle women and help them rather than really support them as serious mathematicians. At this conference, perhaps because all relativists cite Choquet-Bruhat and Morawetz, there was a real respect for the women present.
- one of the best workshops I ever attended
- It would be nice to have the triangle rung before each lecture starts to help remind those of us (me!) who would lose track of time during breaks.
- great quality of the different talks
- The workshop was very smoothly run and the MSRI facilities are the ideal place to hold such a meeting. I particularly appreciated the variety of expertise among the participants and interdisciplinary nature of the meeting.
- very much enjoyed

The organizers of the workshop are planning to create a website pointing to female relativists (mathematical relativists, relativistic astrophysicists, numerical relativists etc) and providing links to their professional websites or contact information. Please provide your perspective.

- very good idea.
- Great.
- A second website which just points to relativists in general that includes a fair share of women would also be very useful. Often general websites and conferences forget women exist, but if more such websites were sure to include women that would be very helpful.
- As a male, I don't have much say in the matter, but I think it is a good idea.
- This would be very helpful for me and hopefully also for my colleauges.
- This is an excellent idea! I think any webpage which brings together high-quality related pages together in one well-organized page is a valuable resource.
- Great idea, this might also include physicists (high-energy physics, string theory...) who have interests and make contributions towards relativity.
- It's a good idea.
- Go for it! Great idea!
- I would be extremely interested in the creation of such a site. I intend to keep in touch with as many of the researchers at this meeting as is possible; several of us have already begun conversations for possible future collaborations. Such a website would have my unequivocal support.
- Sounds like a great idea. I think someone will have to be its shepherd, making sure it is kept up to date and keep people interested.
- very important
- I think it's a good idea & look forward to seeing what will come out of it.
- I think this is a very good idea.

Introductory Workshop:
Mathematical General Relativity

September 9 to 13, 2013

MSRI, Berkeley, CA, USA

Organizers:

Justin Corvino* (Lafayette College)

Greg Galloway (University of Miami)

Hans Ringström (Royal Institute of Technology (KTH)

Final Report

MSRI Introductory Workshop: Mathematical General Relativity

September 9-13, 2013

Organizers:
Justin Corvino (Lafayette College)
Gregory Galloway (University of Miami)
Hans Ringström (KTH)

Overview. Mathematical relativity is a very widely ranging area of mathematical study, spanning differential geometry, elliptic and hyperbolic partial differential equations, and dynamical systems. The introductory workshop served as an overview to overarching themes of the semester-long program on Mathematical General Relativity at MSRI in Fall 2013. As such, the purpose of this workshop was to introduce some of the leading areas of current interest associated with problems in cosmology, the theory of black holes, and the geometry and physics of the Cauchy problem (initial data constraints and evolution) for the Einstein equations.

By design, the intended audience of the introductory workshop included graduate students, postdocs, and non-experts. In order to make accessible to a wide audience some of the major and topics of the semester program, including areas of current research interest, the speakers were asked to include introductory material as part of their talks, and several speakers were invited to give two lectures to introduce their topics. There were a total of seventeen talks given by eleven different speakers as part of the workshop; one of these talks was an invited Evans Lecture on the first afternoon of the workshop. We generally had two talks each in the morning and afternoon sessions; Wednesday afternoon was left free, and Friday afternoon we had only one talk. There was a reception following the talks on Tuesday afternoon.

Interaction between this workshop and the Connections for Women Workshop which was held the week before the introductory workshop was facilitated in concert with the organizers of the Connections workshop, in particular with Lydia Bieri (Michigan) and Iva Stavrov (Lewis & Clark College). In fact we coordinated funding (in discussions with MSRI administration) to assist a number of participants from the Connections workshop to be able to stay for the Introductory workshop. We note that the organizers focused on reserving as much of the budget to fund participants as possible: all but two of the speakers for the Introductory workshop were drawn from participants of the program, and thus most of the speakers were already funded by the program budget.

Description of the Lectures. The organizers strived to have representation from a broad range of topics in the field, presented by a range of lecturers at various stages in their careers. We also stressed to the speakers that the introduction to their fields should form a substantial component of their talks, and they by-and-large delivered. We list below the lecturers, in order of appearance.

Daniel Pollack (University of Washington).
Lecture 1: *Spacetime Geometry: A Setting for General Relativity.*
Lecture 2: *The Einstein Field Equations: A PDE Perspective.*
Dan accepted our invitation to give the two opening introductory lectures for the workshop. A large part of the meeting revolved around aspects of the Cauchy problem for Einstein's equations. Daniel Pollack's lectures served the purpose of introducing this problem to a general mathematical audience. He discussed the underlying Lorentzian geometry, the types of hypersurfaces on which it is natural to specify initial data, the constraint equations (which the initial data have to satisfy) and the issue of solving Einstein's equations by means of gauge source functions.

David Maxwell (University of Alaska, Fairbanks).
Two lectures: *The conformal method of constructing Cauchy data for the Einstein equations.*
David gave two lectures in which he introduced the conformal method for solving the constraints, discussing not only the classical results, but linking to current problems in the field. In particular, some activity in the semester-long program will most likely involve study of the far-from-CMC case of the conformal method, which is far from well understood, and David explained some known results and open questions.

Greg Galloway (University of Miami).
MSRI Evans Lecture: *On the Topology of Black Holes and Beyond.*
Greg gave the opening MSRI Evans lecture for the semester, in Evans Hall on the first day of the workshop. He presented both classic and recent results on black hole topology in four and higher space-time dimensions, and in particular described the motivating Principle of Topological Censorship, which roughly asserts that the topology of the region outside of all black holes (and white holes) should be simple.

Pieter Blue (University of Edinburgh).
Lecture 1: *Introduction to decay of fields outside black holes.*
Lecture 2: *Further topics in decay of fields outside black holes.*
Pieter gave two lectures on wave and field equations on black hole space-times, weaving into his talks an introduction to the problem of the stability of the Kerr space-time, When modeling an isolated system, whether it be a star, a galaxy or a black hole, the so-called Kerr spacetimes are of central importance, largely due to the uniqueness properties of this family. In particular, Kerr is expected to be the end state of gravitational collapse to a black hole. Proving stability of Kerr is therefore a problem of fundamental importance in the field. Pieter explained the importance of the Kerr family and described the current work carried out with the aim of proving stability. In particular, he discussed how to prove decay of solutions to the wave equations (as well as other field equations) on a Kerr background.

Mihalis Dafermos (University of Cambridge, UK and Princeton)
Two lectures: *The cosmic censorship conjectures.*
Mihalis introduced and carefully framed problems of cosmic censorship in his two lectures. The weak and strong cosmic censorship conjectures are fundamental problems in the subject of mathematical general relativity, relating to the formation of black holes and the issue

of determinism. Mihalis discussed the historical background of these conjectures, phrased them carefully, and provided a detailed discussion in the spherically symmetric setting. In particular, he described examples of solutions in spherical symmetry where the singularity has no spacelike component.

Richard M. Schoen (Stanford University)
Constructing localized solutions of the Einstein constraint equations.
Rick discussed constructions of solutions to the Einstein constraint equations by gluing methods, including a new result which is joint with his Ph.D. student Alessandro Carlotto. This new result answers an old question, by producing asymptotically flat solutions to the Einstein constraint equations which are identical to Euclidean geometry on a half-space. Applications include construction of N-body initial data of a type distinct from that of Chruściel-Corvino-Isenberg.

Lydia Bieri (University of Michigan)
Lecture 1: *Null hypersurfaces in Lorentzian spacetimes.*
Lecture 2: *Gravitational radiation: a geometric-analytic approach.*
Lydia gave two lectures on the asymptotic structure of space-times. In the first lecture she presented an introduction to the framework of null hypersurfaces, and in the second lecture, she discussed geometric analysis problems which tie in to the physical problem of detecting gravitational waves, manifested at future null infinity, for which the analysis presented in the first lecture is utilized.

Mu-Tao Wang (Columbia University)
Two lectures: *Quasi-local mass in general relativity.*
Mu-Tao gave two lectures on notions of quasi-local mass, introducing many interesting geometric notions and results, and tying in to the problem of assigning a notion of energy-momentum and angular momentum to an extended body (region) in general relativity, a notion which takes into account not only matter fields present, but also gravitational energy-momenta.

Lan-Hsuan Huang (University of Connecticut)
Density Theorems for the Einstein Constraint Equations.
Lan gave one lecture discussing various dense subsets of the space of asymptotically flat solutions to the Einstein constraint equations, with some interesting applications. In particular her talks highlighted the nature of the center of mass and angular momentum of isolated systems. We note that she also gave an hour-long lecture in the Connections workshop.

Marc Mars (Salamanca, Spain)
An introduction to the Penrose inequality conjecture.
Marc gave one lecture on the status of the Penrose inequality. He nicely weaved in the physical motivation for the conjecture with the geometric analysis formulations of the inequality. The inequality relates the total energy content in a space-time to that which is thought to be contributed by black holes. While certain cases are settled, there are a number of open problems in formulating and proving Penrose-type inequalities, and Marc outlined many of

these, tying into the initial data and space-time pictures.

Hans Ringström (KTH)
Cosmology
An overview of the subject of cosmology was given in the the final lecture of the program, by Hans Ringström. After a brief background from physics, some of the main questions were phrased. The subjects that then followed were: a general conjecture concerning the future asymptotics of cosmological vacuum solutions (relating the Einstein evolution to geometrization); cosmological models with accelerated expansion; and the problem of constructing large classes of singularities with prescribed asymptotics.

On the participants. The participants included graduate students and postdocs, both from Berkeley and from farther afield, and many young researchers. As mentioned above, effort was made to fund participants from the Connections for Women Workshop, and a number of participants were able to stay for the Introductory Workshop. The lectures seemed to be fairly well attended right up through the finale.

We note here that a number of participants noted that there seemed to be just the right number of talks, leaving adequate time for discussion at coffee breaks, lunch and tea times between the talks. The only complaint we heard was that some folks were not entirely satisfied with the catering for lunches. Of course, with the ample time allotted for lunch breaks (two hours), participants could certainly make their way down to campus and back up the hill for the afternoon session.

The Venue. MSRI is a magical place for mathematics. The administration is wonderful to work with, from the budget to the library to the coffee breaks. We hope participants availed themselves of the time between talks to peruse the fantastic library facilities.

The budget seemed kind of tight to the organizers. In order to address a broad range of topics in the field, we needed more than a few lecturers, but as we wanted to stretch the funds as far as possible (leaving as much as possible for participant funding), we sought to choose lecturers mostly supported by the semester program budget. Having said this, we note that the administration made it work, even as late requests for funding arrived. In particular, we note close collaboration with Hélène Barcelo and Christine Marshall, both of whom are superb sources of support and advice.

The only social event schedule for the workshop was the Tuesday reception. The organizers felt strongly about having another event to thank the lecturers for their efforts. We decided to have a reception for the speakers, and Greg and his wife Michelle graciously offered to host it at the house at which they were staying in Berkeley. It was a great success!

Conclusion. The organizers feel that the workshop was indeed a success. The lecturers made great efforts to keep their presentations introductory and suitable for a wide audience, while still broaching topics, results and conjectures of interest to experts; even experts stated some appreciation for seeing some of the introductory material presented in this format. Many of the lectures engendered follow up discussions, which will no doubt continue during the program.

Organizers		
First Name	**Last Name**	**Institution**
Justin	Corvino	Lafayette College
Greg	Galloway	University of Miami
Hans	Ringstrom	Royal Institute of Technology (KTH)

Speakers		
First Name	**Last Name**	**Institution**
Lydia	Bieri	University of Michigan
Pieter	Blue	University of Edinburgh
Mihalis	Dafermos	Princeton University
Greg	Galloway	University of Miami
Lan-Hsuan	Huang	University of Connecticut
Marc	Mars	University of Salamanca
David	Maxwell	University of Alaska Fairbanks
Daniel	Pollack	University of Washington
Hans	Ringstrom	Royal Institute of Technology (KTH)
Richard	Schoen	Stanford University
Mu-Tao	Wang	Columbia University

Introductory Workshop: Mathematical General Relativity

September 9 - 13, 2013

Schedule

Monday, September 9, 2013			
9:15AM - 9:30AM	Simons Auditorium		Welcome
9:30AM - 10:30AM	Simons Auditorium	Daniel Pollack	Spacetime Geometry: A Setting for General Relativity
10:30AM - 11:00AM	Atrium		Tea
11:00AM - 12:00PM	Simons Auditorium	Daniel Pollack	The Einstein Field Equations: A PDE Perspective
12:00PM - 2:00PM	Atrium		Lunch
2:00PM - 3:00PM	Simons Auditorium	David Maxwell	The conformal method of constructing Cauchy data for the Einstein equations
3:00PM - 3:30PM	Atrium		Tea
4:10PM - 5:00PM	UC Berkeley 60 Evans Hall	Greg Galloway	MSRI Evans Talk: On the topology of black holes and beyond

Tuesday, September 10, 2013			
9:30AM - 10:30AM	Simons Auditorium	Pieter Blue	Introduction to decay of fields outside black holes.
10:30AM - 11:00AM	Atrium		Tea
11:00AM - 12:00PM	Simons Auditorium	David Maxwell	The conformal method of constructing Cauchy data for the Einstein equations
12:00PM - 2:00PM	Atrium		Lunch
2:00PM - 3:00PM	Simons Auditorium	Mihalis Dafermos	The cosmic censorship conjectures
3:00PM - 3:30PM	Atrium		Tea
3:30PM - 4:30PM	Simons Auditorium	Richard Schoen	Constructing localized solutions of the Einstein constraint equations
4:30PM - 6:20PM	Atrium		Reception

Wednesday, September 11, 2013			
9:30AM - 10:30AM	Simons Auditorium	Pieter Blue	Further topics in decay of fields outside black holes.
10:30AM - 11:00AM	Atrium		Tea
11:00AM - 12:00PM	Simons Auditorium	Mihalis Dafermos	The cosmic censorship conjectures

Thursday, September 12, 2013			
9:30AM - 10:30AM	Simons Auditorium	Mu-Tao Wang	Quasi-local mass in general relativity
10:30AM - 11:00AM	Atrium		Tea
11:00AM - 12:00PM	Simons Auditorium	Lydia Bieri	Null hypersurfaces in Lorentzian spacetimes
12:00PM - 2:00PM	Atrium		Lunch
2:00PM - 3:00PM	Simons Auditorium	Lan-Hsuan Huang	Density Theorems for the Einstein Constraint Equations
3:00PM - 3:30PM	Atrium		Tea
3:30PM - 4:30PM	Simons Auditorium	Marc Mars	An introduction to the Penrose inequality conjecture

Friday, September 13, 2013			
9:30AM - 10:30AM	Simons Auditorium	Mu-Tao Wang	Quasi-local mass in general relativity
10:30AM - 11:00AM	Atrium		Tea
11:00AM - 12:00PM	Simons Auditorium	Lydia Bieri	Gravitational radiation - a geometric-analytic approach
12:00PM - 2:00PM			Lunch
2:00PM - 3:00PM	Simons Auditorium	Hans Ringstroem	Cosmology
3:00PM - 3:30PM	Atrium		Tea

Participants		
First Name	**Last Name**	**Institution**
Ioannis	Angelopoulos	University of Toronto
Malva	Asaad	University of Connecticut
Dean	Baskin	Northwestern University
Shabnam	Beheshti	Rutgers University
ALI	BEHZADAN	University of California, San Diego
Beverly	Berger	None
Udayan	Bhaduri	University of Calcutta
Lydia	Bieri	University of Michigan
Pieter	Blue	University of Edinburgh
Yann	Brenier	Ecole Polytechnique
Alessandro	Carlotto	Stanford University
Marcos	Cavalcante	Universidade Federal de Alagoas - UFAL
Carla	Cederbaum	Tubingen University
Otis	Chodosh	Stanford University
Piotr	Chrusciel	Universitat Wien
Damon	Civin	Cambridge University
Julien	Cortier	Institut des Hautes Etudes Scientifiques (IHES)
Justin	Corvino	Lafayette College
Mihalis	Dafermos	Princeton University
Anda	Degeratu	Albert-Ludwigs-Universitat Freiburg
James	Dilts	University of Oregon
Alexis	Drouot	Universite de Grenoble I (Joseph Fourier)
Semyon	Dyatlov	Massachusetts Institute of Technology
Raisa	Galimova	ETH Zurich
Greg	Galloway	University of Miami
Henrique	Gomes	University of California, Davis
Nishanth	Gudapati	Max Planck Institute fur Gravitationsphysik, AEI
Nick	Haber	Stanford University
Dylan	Helliwell	Seattle University
Alexi	Hoeft	Virginia Commonwealth University
Lan-Hsuan	Huang	University of Connecticut
Guillaume	Idelon-Riton	Universite de Grenoble I (Joseph Fourier)
James	Isenberg	University of Oregon
Fabio	Iunes Sanches	Oakland University
Casey	Jao	University of California, Los Angeles
Seongtag	Kim	Inha University
Young-Heon	Kim	University of British Columbia
Robert	Korsan	Carnegie Mellon University
Jyothi	Krishnan	UC berkeley
Eugene	Kur	University of California, Berkeley
Sajjad	Lakzian	Universitat Bonn
Mathew	Langford	Australian National University
Jeremy	Leach	Stanford University

Dan	Lee	Queens College, CUNY
Philippe	LeFloch	Universite Pierre et Marie Curie
Zhiwu	Lin	Georgia Institute of Technology
Josh	Lipsmeyer	University of Tennessee
John	Lott	University of California, Berkeley
Marc	Mars	University of Salamanca
Davi	Maximo	Stanford University
David	Maxwell	University of Alaska Fairbanks
Shuang	Miao	University of Michigan
Kristen	Moore	Potsdam University
Jason	Murphy	University of California, Los Angeles
Raquel	Perales Aguilar	SUNY
Daniel	Pollack	University of Washington
Hans	Ringstrom	Royal Institute of Technology (KTH)
Anna	Sakovich	Linkoping University
Richard	Schoen	Stanford University
Sohrab	Shahshahani	University of Michigan
Christina	Sormani	CUNY, Graduate Center
Suresh	Srinivasamurthy	Kansas State University
CALVIN	TADMON	University of Pretoria
Carlos	Vega	University of Miami
Robert	Wald	University of Chicago
Mu-Tao	Wang	Columbia University
Guofang	Wei	University of California, Santa Barbara
Willie	Wong	Ecole Polytechnique Federale de Lausanne (EPFL)
Haotian	Wu	MSRI - Mathematical Sciences Research Institute
Jinxin	Xue	University of Chicago
Anil	Zenginoglu	California Institute of Technology
Shuangjian	Zhang	University of Toronto
Xin	Zhou	Massachusetts Institute of Technology

Officially Registered Participant Information

Participants		73

Gender		73
Male	75.34%	55
Female	20.55%	15
Declined to state	4.11%	3

Ethnicity*		73
White	58.90%	43
Asian	24.66%	18
Hispanic	4.11%	3
Pacific Islander	0.00%	0
Black	1.37%	1
Native American	0.00%	0
Mixed	2.74%	2
Declined to state	8.22%	6

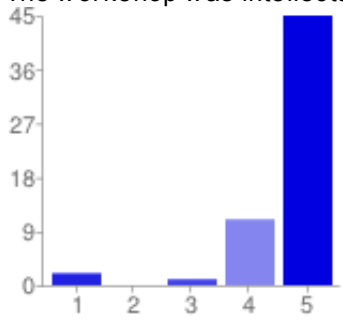
* ethnicity specifications are not exclusive

59 responses

Summary See complete responses

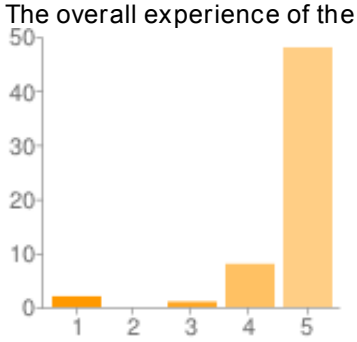
Workshop assessment

The workshop was intellectually stimulating



1 -	Not at all	2	3%
2		0	0%
3		1	2%
4		11	19%
5 -	Very	45	76%

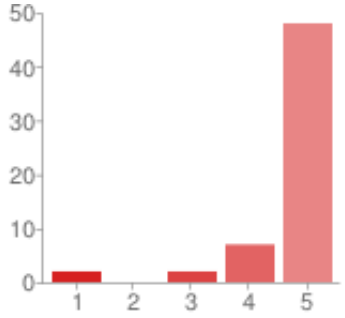
The overall experience of the workshop was worthwhile



1 -	Not at all	2	3%
2		0	0%
3		1	2%
4		8	14%
5 -	Very	48	81%

The time between lectures was adequate for discussion

1 -	Not al all	2	3%
2		0	0%
3		2	3%
4		7	12%
5 -	Very	48	81%



Not al all Very

Additional comments on the workshop organization

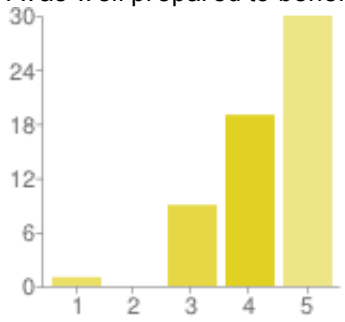
It has been very pleasant experience. The talks are well-organized. The schedule for talks and discussion time is perfect. Very good I especially liked the format chosen with pairs of lectures and t ...

The purpose of the workshop was in part to introduce the field to graduate students and non-specialists. Did the level and nature of the talks help to achieve this goal?"

Yes, it was helpful to have many speakers give two talks. Yes, the level was excellent. I think so, as far as I can tell. Yes. Yes. Yes Yes, I think the organization was very well done. Considering the audience and the subject matter, it was especially nice that the organisers asked Dan Pollack to give a series of two very introductory lectures that outlined much of the basic, necessary materials for understanding the rest of the workshop. I am an expert and a speaker, so maybe not the right person to ask. I do believe that most speakers tried hard to make their talks accessible to a general mat ...

Personal assessment

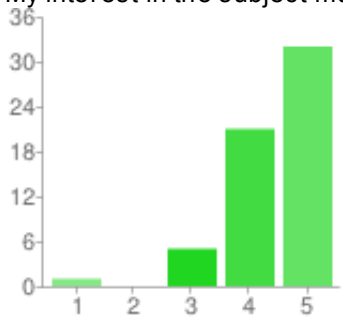
I was well prepared to benefit from the lectures



Not at all Very

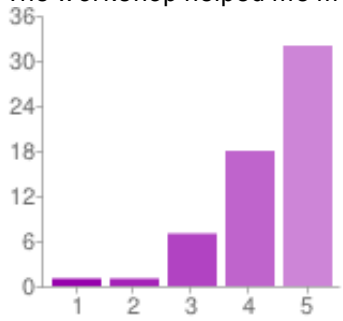
1 -	Not at all	1	2%
2		0	0%
3		9	15%
4		19	32%
5 -	Very	30	51%

My interest in the subject matter was increased by the workshop



1 -	Niot at all	1	2%
2		0	0%
3		5	8%
4		21	36%
5 -	Very	32	54%

The workshop helped me meet people with similar scientific interests



1 -	Not at all	1	2%
2		1	2%
3		7	12%
4		18	31%
5 -	Very Much	32	54%

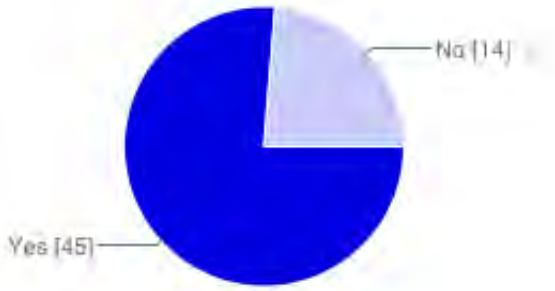
Additional comments on your personal assessment

Excellent talks This workshop motivated me to work on several problems which I had previously abandoned, largely thanks to the lectures. I have also made several contacts with whom I plan to collabo ...

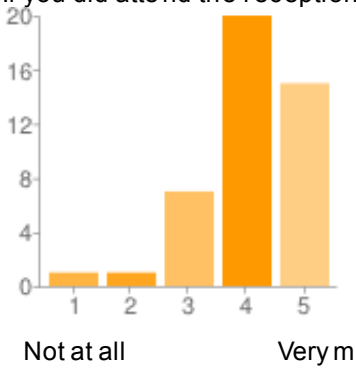
Additional Activities

Did you attend the reception?

Yes	45	76%
No	14	24%



If you did attend the reception, did it help to solidify the contacts you made in the workshop?



1 -	Not at all	1	2%
2		1	2%
3		7	12%
4		20	34%
5 -	Very much	15	25%

Please provide any comments on the reception

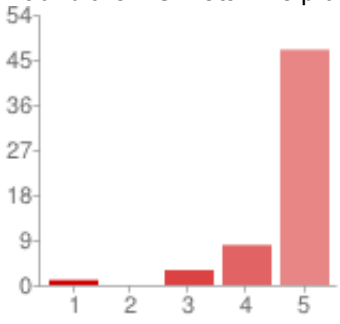
The reception was very pleasant and I did enjoy both the company and the food!

The reception was well organized.

excellent

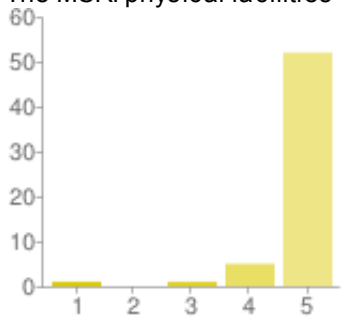
Venue

I found the MSRI staff helpful



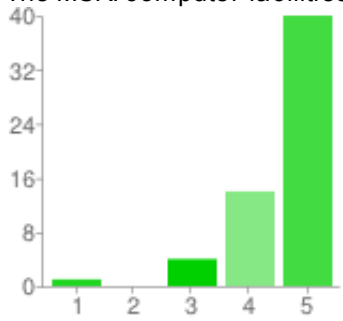
1 -	Not at all	1	2%
2		0	0%
3		3	5%
4		8	14%
5 -	Very	47	80%

The MSRI physical facilities were conducive for such a workshop



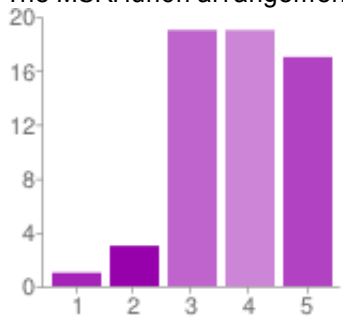
1 -	Not at all	1	2%
2		0	0%
3		1	2%
4		5	8%
5 -	Very	52	88%

The MSRI computer facilities were adequate for such a workshop



1 -	Not at all	1	2%
2		0	0%
3		4	7%
4		14	24%
5 -	Very	40	68%

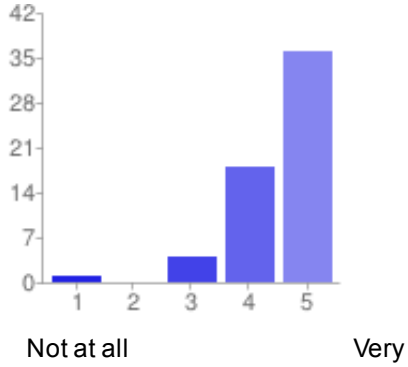
The MSRI lunch arrangements were satisfactory



1 -	Not at all	1	2%
2		3	5%
3		19	32%
4		19	32%
5 -	Very	17	29%

The MSRI tea arrangements were satisfactory

1 -	Not at all	1	2%
2		0	0%
3		4	7%
4		18	31%



5 -	Very	36	61%

Additional comments on the venue

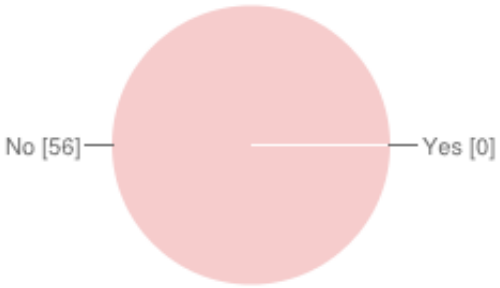
orange or apple juice would be welcome The bagels were the best It would, of course, be nice if the lecture hall were not so cold, but it was a problem easily fixed. Beautiful building! There is really ...

MSRI Wireless Network

Did you use MSRI's wireless network?

Yes	53	90%
No	6	10%

Did you experience any difficulties with the network?



Yes	0	0%
No	56	95%

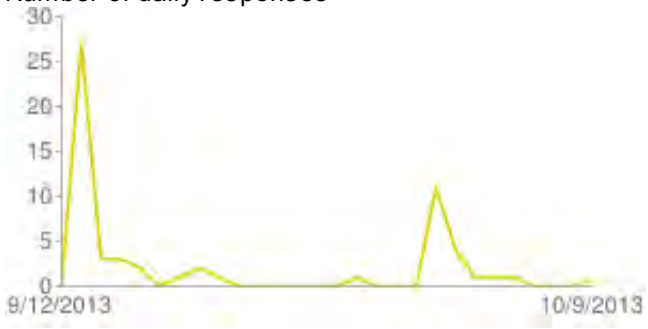
If you did experience difficulties with the network, please explain:

Thank you for completing this survey

We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.

Thanks a lot! Thanks! Thank you very much for an EXCELLENT conference. I participated fully in every day of the programme and feel that I have benefitted greatly for the visit, both mathematically an ...

Number of daily responses



Introductory Workshop:
Mathematical General Relativity
September 9 - 13, 2013

Additional Survey Responses

Additional comments on your personal assessment

- Excellent talks
- This workshop motivated me to work on several problems which I had previously abandoned, largely thanks to the lectures. I have also made several contacts with whom I plan to collaborate and this has rekindled my interest in several difficult problems!
- The long lunch breaks and tea times were very helpful for meeting the other participants & members at MSRI
- I was a speaker at the workshop. I am already very interested in the subject of the workshop, so I could not honestly say that the workshop greatly increased my interest from its already high level.

Additional comments on the venue

- orange or apple juice would be welcome
- The bagels were the best
- It would, of course, be nice if the lecture hall were not so cold, but it was a problem easily fixed.
- Beautiful building!
- There is really too much air conditioning in the lecture hall, which became at some point quite uncomfortable Considering the reasonnable outside temperatures of the week, it would have been easy to cool down the hall by opening the doors instead. Despite a notice to the staff, it continued to be excessively cold, expecially for people sitting near an air inlet... maybe there is some difficulty concerning the regulation of it? Thanks a lot for trying to fix it anyway.
- the temperature was inadequately cold
- The MSRI facilities are a model for others.
- less sweet would be better
- food is not so good
- It would be more interesting to offer free lunch to participants.
- Man, that hill...

We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.

- Thanks a lot!
- Thanks!
- Thank you very much for an EXCELLENT conference. I participated fully in every day of the programme and feel that I have benefitted greatly for the visit, both mathematically and professionally. Thank you.
- It would be nice to have someone consistently ring the triangle one minute before each talk starts in case participants have lost track of time during breaks
- Thanks a lot for the overall wonderful conditions provided to participants !

- According to me, the procedure of reimbursment is not effective. Please consider paying perdiem to participants on a daily basis upon their arrival at MSRI. It would also be more efficient to reimburse airticket costs once the participants arrive at MSRI. Participants who arrive in California for the first time would like to be picked up at the airports, and visit a touristic site in the golden state.
- It was a very nice workshop, with many important researchers in the subject.

Please provide any comments on the reception

- The reception was very pleasant and I did enjoy both the company and the food!
- The reception was well organized.
- Excellent

Additional comments on the workshop organization

- It has been very pleasant experience. The talks are well-organized. The schedule for talks and discussion time is perfect.
- Very good
- I especially liked the format chosen with pairs of lectures and time in between for tea and discussion. It was perfect!
- Excellent
- Very comfortable schedule, not over-filled
- Jacari and the other members of the admin team were amazing! Everything ran smoothly and efficiently.
- great talks

The purpose of the workshop was in part to introduce the field to graduate students and non-specialists. Did the level and nature of the talks help to achieve this goal?

- Yes, it was helpful to have many speakers give two talks.
- Yes, the level was excellent.
- I think so, as far as I can tell.
- Yes.
- Yes.
- Yes.
- Yes, I think the organization was very well done. Considering the audience and the subject matter, it was especially nice that the organisers asked Dan Pollack to give a series of two very introductory lectures that outlined much of the basic, necessary materials for understanding the rest of the workshop.
- I am an expert and a speaker, so maybe not the right person to ask. I do believe that most speakers tried hard to make their talks accessible to a general mathematical audience and I heard good comments from non-experts.
- Some talks were more technical than others. The talks of Dafermos, for instance, were excellent towards this end.
- This workshop helps a lot. It is the best workshop I have ever attended that achieve the goal successfully.
- I am a researcher with long experience in the field so I am not sure that I have an unbiased opinion, but I believe it did
- Yes, I think it was perfect.

- Yes, although the talks were at a higher level than I was expecting. It would have been nice if someone talked about where the Einstein equations come from!!
- Yes
- Yes, I am a PhD candidate in Mechanical Engineering at UC Berkeley. My background is in mathematical Continuum Mechanics and I was able to follow the speaker very well.
- I think so, but I am a specialist!
- The talks had an introductory level very appropriate for students and non-specialists, and at the same time they managed to advance sufficiently to give an idea of current research being conducted in the field. Also the selection of topics by the organizers was very balanced, and covered many of the aspects of mathematical general relativity.
- Yes
- Yes
- Some talk were maybe a little bit too hard for that. But otherwise it was awesome.
- Yes
- Yes.
- Yes. I thought the level of the talks was very appropriate. It was a very beneficial conference. I am a graduate student who is new to the field. I feel like I received a very good flavor of ongoing research, as well as a broad base in which to build.
- Yes. I enjoyed hearing about a variety of subject.
- This was the first conference I have attended where exhaustion (and frustration) did not set in from day after day of packed unintelligible lecture sessions. The speakers were clearly briefed on the goals of the workshop and most everybody did a wonderful job of following the suggestion. The two-lecture format was also very nice and kept the topics moving. As a nonspecialist, I managed to find points of commonality with other researchers, both during their talks and over discussions.

  A word on some speakers in particular:

  1. The overview talks by Pollack were a master class in clear lectures and using beamer effectively.
  2. Wang's lectures were beautifully executed and I only wish he had time to finish his third topic.
- Some of the talks were a bit too technical, but it was a very good selection of topics giving an overview of the area.
- About two thirds of the talks were actually introductory, but many other talks consisted of more specialized research, perhaps more accessible to experts in the area.
- No. I believe in order to understand most of the talks, one needed to know a great deal about general relativity and Lorentzian geometry. For some reason that I can never understand, most of the speakers thought that the only thing that they need to do to make their talk introductory is to state the definition of spacetime and asymptotically flat manifolds at the beginning of their talk and nothing more. As an example, it is highly improbable that a non-specialist knows a lot about Penrose diagrams. So it does not make sense to start your talk with explaining a well known basic fact about spacetime (= so you are assuming the audience is not necessarily familiar with the basic notions) and then use the Penrose diagrams throughout your talk without properly explaining what they are. I strongly believe the only two talks that were appropriate for a non-specialist were the talks given by Professor Pollack.

- I am a physics graduate student, and the talks were a bit difficult to follow mostly because the physics was on the easy side, while the math was a bit difficult to understand.
- yes, pretty well for mathematicians. Not sure for physicists or engineers
- In some sense yes
- Maybe some of the talks were a bit technical for this purpose, but the first half of most talks were quite accessible
- All the speakers did very well in introducing the fundamental mathematical concepts and tools in General Relativity, and showing the way to the most advanced research topics !
- Yes. I would say that it was ideal for post-docs and PhD students.
- Yes
- Yes, I do not have a strong GR background and I thought the level of talks were very appropriate for me.
- Yes. As a non-specialist, I found the talks enjoyable and informative. I have a much clearer picture of "the lay of the land" than I did when I arrived.
- Yes
- I believe so.
- Yes. I am 3 years into the study of this field and found the talks very easy to follow. I think that someone with a decent background in Riemannian Geometry and/or physics background would have gained a lot from the talks and appreciated the virtues of mathematical relativity.
- Most were at the right level. Some lacked the appropriate introductory material.
- Yes
- Yes. There are several introductory lectures which can give the graduate students and non-specialists enough background knowledges.
- yes. absolutely!
- Yes, very much.
- yes, good mixture of introduction and research.
- I would day that 85 percent of them were suitable for grad students and non specialists.
- Yes, I suppose so.
- Yes, almost.
- Perfectly well.
- I am a (senior) specialist, so it would be hard for me to judge.
- No. Almost all lectures were designed for specialists.
- yes.
- Yes - they were pitched at exactly the right level.
- Yes
- to some extent.
- Yes, the level of the talks were generally excellent.
- The level of talks was diverse. The introductory talks were a highlight for me, but certainly also gained something from the more technical talks.
- Yes. I learned many interesting things in the field of Mathematical General Relativity.

Initial Data and Evolution Problems in General Relativity

November 18 to 22, 2013

MSRI, Berkeley, CA, USA

Organizers:

Piotr Chrusciel (Universität Wien)

Igor Rodnianski (Massachusetts Institute of Technology)

Report on the workshop Initial Data and Evolution Problems in General Relativity

MSRI, Berkeley, November 18-22, 2013

The workshop took place at the MSRI from August 18 to December 20, 2014, as part of the semester-long program "Mathematical General Relativity". The program is concerned with all mathematical aspects of general relativity, and the workshop was designed as a focus point of the program.

The aim of the workshop was to review recent developments in the study of both the properties of initial data for Einstein's equations and the Einstein evolution problem, and to inspire new directions of research. Cosmic censorship, the formation and stability of black holes, and the construction of solutions of the Einstein constraint equations were some of the main topics for the workshop.

Eighteen lectures were held during five days by leading researchers in the field. The workshop was well attended, with 84 participants signing the attendance list. Eight lecturers were long-term participants of the program. The level of the lectures was excellent to exceptional. As Igor Rodnianski could not attend due to health reasons, this report has been written by Piotr Chruściel.

One of the highlights was the lecture by Gustav Holzegel, who outlined his recent proof with Mihalis Dafermos and Igor Rodnianski of the dynamical linearization stability of the Schwarzschild metric. The result was a well kept secret, announced at the MSRI for the first time. To put things in proper context, it should be kept in mind that one of the main efforts in the current studies of mathematical general relativity is the search for a proof of dynamical stability of the Kerr family of metrics. The lectures by Aretakis, Dafermos, Holzegel, Klainerman and Tataru were directly or indirectly related to that question. The strategy to understand dynamical stability has been to obtain first a detailed understanding of the global behaviour of the scalar wave equation on black hole space-times. The second anticipated step was to carry this over to linearized Maxwell and Einstein fields on black hole space-times. The hope is that the estimates obtained in the second step will be precise enough to allow a successful completion of the third step, namely a global control of the full non-linear problem.

The first step above has been solved by Dafermos and Rodnianski a few

years ago, in a series of papers culminating decades of work of many mathematicians and physicists. The second step for the Maxwell field has been recently carried-out by Andersson and Blue. The Holzegel et al. solution of the second step for the linearized Einstein equations, presented in the workshop, had to face many new challenges. One of the key problems is the lack of decoupling of the Bianchi equations and the rotation-coefficients equations, within a formidable system of equations. Holzegel explained how an observation of Chandrasekhar can be used to obtain a decoupled master equation to which the techniques developed in the study of the scalar wave equations on black hole backgrounds apply. The control, so obtained, of the relevant combination of fields can be used to establish sharp decay estimates for all the remaining fields at hand. The result is expected to be a key ingredient for a future proof of nonlinear stability of Kerr black holes.

A second absolute highlight of the workshop was the lecture by Schoen on his construction, with Carlotti, of a class of asymptotically flat initial data, already known as the Carlotti-Schoen initial data To understand the issues involved one needs to recall that the Einstein equations split into a system of constraint equations which have to be satisfied by the initial data, and a system of evolution equations. The constraint equations form a non-linear system of geometric PDEs, and the lectures by Corvino, Gicquaud, Lee, Maier, Sakovich and Schoen were devoted to the construction and understanding of the properties of solutions of those equations.

The Carlotti-Schoen initial data arise through a version of the gluing construction invented some ten years ago by Corvino and Schoen. In his lecture Schoen explained how the technique can be applied to localize asymptotically flat initial data sets within solid cones. The resulting initial data have the striking property that the metric is flat outside of a solid cone, coinciding with the original metric in a slightly narrower one. This is a strong field effect of general relativity: indeed, in Newtonian theory an asymptotically flat gravitating system will possess an m/r tail of the gravitational field in all directions. This will therefore also be the case for gravitating relativistic system with small masses and velocities. It is fair to say that no researcher in general relativity imagined that the Carlotti-Schoen initial data could exist. Indeed, the construction can be thought of as a version of anti-gravity: using the Carlotti-Schoen method, one can put together a number of self-gravitating systems in a new configuration where the space-time separating the original systems is flat, no gravitational interactions being felt outside of the cones in which gravity is localized.

Yet another highlight of the conference was the description by Ringström of his discovery of unstable dynamical behaviour of $U(1) \times U(1)$ symmet-

ric vacuum cosmologies in the expanding direction, again a result first announced and described at the workshop.

As already mentioned, our hope was that the workshop will play an inspiring role for future research. This is illustrated by the fascinating new problems that arose from the workshop's lectures: what other geometries allow Carlotti-Schoen constructions? what is the equivalent of Chandrasekhar's master equation for Kerr black holes? does Ringström behavioural instability persist when passing to $U(1)$-symmetry? how to obtain a good mathematical understanding of the global behaviour observed by Bizoń in his numerical simulations of wave equations? can one strengthen Lee's lower bound on the mass aspect function to a bound on the mass? and many others.

We wish to take this opportunity to thank the MSRI and its staff for giving us the possibility to organize the workshop, providing the funding and the facilities, and helping with the organization.

Organizers		
First	**Last**	**Institution**
Piotr	Chrusciel	Universitat Wien
Igor	Rodnianski	Massachusetts Institute of Technology

Speakers		
First	**Last**	**Institution**
Stefanos	Aretakis	Princeton University
Piotr	Bizon	Jagiellonian University
Justin	Corvino	Lafayette College
Mihalis	Dafermos	Princeton University
Romain	Gicquaud	Universite de Tours (Francois Rabelais)
Gustav	Holzegel	Imperial College, London
Lan-Hsuan	Huang	University of Connecticut
Sergiu	Klainerman	Princeton University
Dan	Lee	Queens College, CUNY
Jonathan	Luk	University of Pennsylvania
Rafe	Mazzeo	Stanford University
Caleb	Meier	University of California, San Diego
Hans	Ringstrom	Royal Institute of Technology (KTH)
Anna	Sakovich	Linkoping University
Richard	Schoen	Stanford University
Jeremie	Szeftel	Universite Paris VI
Daniel	Tataru	University of California, Berkeley
Anil	Zenginoglu	California Institute of Technology

Evolution Problems in General Relativity

November 18 - 22, 2013

Schedule

Monday, November 18, 2013			
9:15 AM - 9:30 AM	Simons Auditorium		Welcome
9:30 AM - 10:30 AM	Simons Auditorium	Piotr Bizon	Simple nonlinear waves on curved manifolds
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00	Simons Auditorium	Hans Ringström	Stability and instability of spatially homogeneous solutions in the T^2 symmetric setting
12:00 - 1:15 PM	Atrium		Lunch
1:15 PM - 2:15 PM	Simons Auditorium	Stefanos Aretakis	Conservation laws for the wave equation and applications
2:20 PM - 3:15 PM	Simons Auditorium	Lan-Hsuan Huang	Asymptotically Flat Graphs with Small Mass
3:15 PM - 3:45 PM	Atrium		Tea
4:10 PM - 5:00 PM	MSRI/Evans Hall	Cedric Villani	On an information-theoretical interpolation inequality

Tuesday, November 19, 2013			
9:30 AM - 10:30 AM	Simons Auditorium	Sergiu Klainerman	The formation of Trapped Surfaces
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00	Simons Auditorium	Anil Zenginoglu	Hyperboloidal Evolution and Applications
12:00 - 2:00 PM	Atrium		Lunch
2:00 PM - 3:00 PM	Simons Auditorium	Jeremie Szeftel	The resolution of the bounded L2 curvature conjecture in general relativity
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:30 PM	Simons Auditorium	Mihalis Dafermos	TBA
4:30 PM - 6:20 PM	Atrium		Reception

Wednesday, November 20, 2013			
9:30 AM - 10:30 AM	Simons Auditorium	Richard Schoen	Approximating general data by optimally flat data
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00	Simons Auditorium	Romain Gicquaud	Constraint equations on compact manifolds with boundary (Join work with Emmanuel Humbert and Ngo Quoc Anh

Thursday, November 21, 2013			
9:30 AM - 10:30 AM	Simons Auditorium	Rafe Mazzeo	The Nahm pole boundary conditions for the KW equations
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00	Simons Auditorium	Anna Sakovich	A Jang equation approach to the positive mass theorem for asymptotically hyperbolic manifolds
12:00 - 2:00 PM	Atrium		Lunch
2:00 PM - 3:00 PM	Simons Auditorium	Daniel Tataru	Decay of scalar and electromagnetic waves on black hole backgrounds
3:00 PM - 4:00 PM	Simons Auditorium		Poster Session
3:00 PM - 4:00 PM	Atrium		Tea
4:00 PM - 5:00 PM	Simons Auditorium	Caleb Meier	Applications of Bifurcation Analysis to the Einstein Constraint Equations

Friday, November 22, 2013			
9:30 AM - 10:30 AM	Simons Auditorium	Dan Lee	The Penrose inequality for asymptotically locally hyperbolic spaces with nonpositive mass
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00 PM	Simons Auditorium	Justin Corvino	Density and deformation theorems for the Einstein constraint equations.
12:00 PM- 2:00 PM	Atrium		Lunch
2:00 PM- 3:00 PM	Simons Auditorium	Gustav Holzegel	TBA
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:30 PM	Simons Auditorium	Jonathan Luk	Weak null singularities in general relativity

Participants		
First	**Last**	**Institution**
Amir	Aazami	Kavli Institute for the Physics and Mathematics of the Universe (IPMU)
Guglielmo	Albanese	Universita degli Studi di Milano
Xinliang	An	Princeton University
Ioannis	Angelopoulos	University of Toronto
Ivan	Arraut Guerrero	Osaka University
Thomas	Backdahl	University of Edinburgh
Anita	Bagora	Jaipur National University,Jaipur
Patenou	Baptiste	University of Dschang, Cameroon
Ilyas	Bayramov	University of California, Berkeley
Marius	Beceanu	UC Berkeley Math Faculty
Shabnam	Beheshti	Rutgers University
Beverly	Berger	None
Florian	Beyer	University of Otago
Vinay	Bhardwaj	Intel Corporation
Lydia	Bieri	University of Michigan
Pieter	Blue	University of Edinburgh
mandela	butu	Institut Superieure des Techniques Appliquees
Alessandro	Carlotto	Stanford University
Carla	Cederbaum	Tubingen University
Po-Ning	Chen	Columbia University
Otis	Chodosh	Stanford University
Tony	Chu	Canadian Institute for Theoretical Astrophysics
Damon	Civin	Cambridge University
Joao	Costa	University of Lisbon
Hristu	Culetu	Ovidius University
Viktor Gabor	Czinner	Universidade do Minho
Ashkbiz	Danehkar	Macquarie University
KUDINGA KABILA NKANI	DEBORAH	UNIVERSITE PEDAGOGIQUE NATIONALE
James	Dilts	University of Oregon
MARCELO	DISCONZI	Vanderbilt University
Alexis	Drouot	Universite de Grenoble I (Joseph Fourier)
Semyon	Dyatlov	Massachusetts Institute of Technology
Maksym	Eingorn	North Carolina Central University
David	Fajman	Universitat Wien
Arthur	Fischer	University of California, Santa Cruz
Grigorios	Fournodavlos	University of Toronto
Joerg	Frauendiener	University of Otago
Helmut	Friedrich	Max-Planck-Institut fuer Gravitationsphysik
Dejan	Gajic	University of Cambridge
Greg	Galloway	University of Miami
Luz	Garcia Penaloza	Universidad Nacional de Colombia
David	Garfinkle	Oakland University
Karsten	Gimre	Columbia University
Henrique	Gomes	University of California, Davis
Viktor	Grigoryan	Occidental College
Giovanny	Guanga	National Polytechnic University
Nishanth	Gudapati	Max Planck Institute fur Gravitationsphysik, Albert-Einstein-Institut
Nick	Haber	Stanford University
Dietrich	Hafner	Universite de Grenoble I (Joseph Fourier)
Ould-Lahoucine	Hassan Khaled	University of Setif
Dylan	Helliwell	Seattle University
MBIYE KAKESE	HERVE	UNIVERSITE PEDAGOGIQUE NATIONALE
Iasonas	Hitzazis	University of Patras
Michael	Holst	University of California

Cecile	Huneau	Ecole Normale Superieure
Oksana	Iarygina	Kyiv Taras Shevchenko University
James	Isenberg	University of Oregon
Daniel	Jackson	Monash University
Moulik	Kalluplam Balasubramanian	Rutgers University
Arvind	Kant Sagar	NONE
Aditya	Chauhan	NONE
Nicolaos	Kapouleas	Brown University
Joseph	Keir	University of Cambridge
Suhail	Khan	Abdul Wali Khan University
Young-Heon	Kim	University of British Columbia
pinar	kirezli	namik kemal university
David	Kofron	Charles University in Prague
Robert	Korsan	Carnegie Mellon University
Eugene	Kur	University of California, Berkeley
Sajjad	Lakzian	Universitat Bonn
Mathew	Langford	Australian National University
Andrew	Lawrie	University of California, Berkeley
Jeremy	Leach	Stanford University
KUO-WEI	LEE	Monash University
Philippe	LeFloch	Universite Pierre et Marie Curie
Martin Man-chun	Li	Massachusetts Institute of Technology
Woei Chet	Lim	University of Waikato
Grace	Liu	University of California, Berkeley
John	Lott	University of California, Berkeley
Jonathan	Luk	Massachusetts Institute of Technology
David	Maxwell	University of Alaska Fairbanks
Sepide	Mazloomzade	Shahid Beheshti University
Stephen	McCormick	Monash University
kirk	Morgan	University of the West Indies
Georgios	Moschidis	Princeton University
Sourabh	Nampalliwar	University of Texas, Brownsville
Saad	Nasr	Faculty of science Alexandria University Egypt
Christopher	Nerz	Eberhard-Karls-Universitat Tubingen
Ernesto-Miguel	Nungesser Y Luengo	Trinity College
SANJAY	OLI	Vishveshwarya Institute of Engineering & Technology, Ghaziabad
Jesus	Oliver	University of California, San Diego
Tim-Torben	Paetz	Universitat Wien
SHANKAR	PATHAK	Department of Physics, Lucknow University
Eak	paudel	Tribhuvan University
Raquel	Perales Aguilar	SUNY
Daniel	Pollack	University of Washington
Katharina	Radermacher	Royal Institute of Technology (KTH)
Moritz	Reintjes	Instituto Nacional de Matematica Pura e Aplicada
Oscar	Reula	Universidad Nacional de Cordoba
Jan	Sbierski	University of Cambridge
David	Schinkel	Friedrich-Schiller-Universitat
Volker	Schlue	University of Toronto
Josef	Schmidt	Faculty of Nuclear Sciences and Physical Engineering
Sohrab	Shahshahani	University of Michigan
Yakov	Shlapentokh-Rothman	Massachusetts Institute of Technology
Jacques	Smulevici	Universite Paris-Sud (Orsay)
Christina	Sormani	CUNY, Graduate Center
Suresh	Srinivasamurthy	Kansas State University
CALVIN	TADMON	University of Pretoria
Martin	Taylor	Cambridge Centre for Analysis
Christopher	Tiee	University of California

Shreyas	Tikare	University of North Carolina
Mihai	Tohaneanu	Johns Hopkins University
Konstantina	Trivisa	University of Maryland
Sergiu	Vacaru	Alexandru Ioan Cuza University at Iasi, UAIC, Romania
Carlos	Vega	University of Miami
Monica	Visan	University of California, Los Angeles
Branislav	Vlahovic	North Carolina Central University
Tuo	Wang	Vienna University of Technology
Weinan	Wang	University of Kansas
Xuecheng	Wang	Princeton University
Ye-Kai	Wang	Columbia University
Yi	Wang	Stanford University
Jeffrey	Winicour	University of Pittsburgh
Haotian	Wu	MSRI - Mathematical Sciences Research Institute
Jinxin	Xue	University of Chicago
Aijun	Ye	University of Maryland, Baltimore County
kwasi	zakari	crystal mediplus enterprise
Shuangjian	Zhang	University of Toronto
wei	zhou	CCNY-CUNY
Xin	Zhou	Massachusetts Institute of Technology
Aaron	Zimmerman	Canadian Institute for Theoretical Astrophysics

Officially Registered Participant Information

Participants		112

Gender		112
Male	85.71%	96
Female	10.71%	12
Declined to state	3.57%	4

Ethnicity*		112
White	60.71%	68
Asian	22.32%	25
Hispanic	3.57%	4
Pacific Islander	0.00%	0
Black	2.68%	3
Native American	0.00%	0
Mixed	0.00%	0
Declined to state	10.71%	12

* ethnicity specifications are not exclusive

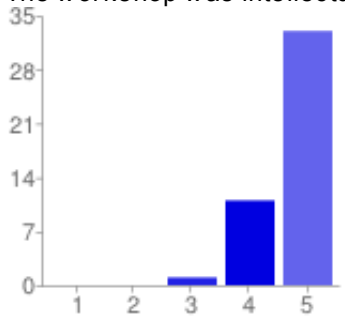
This form will soon be upgraded to the new version of Google Forms. Learn more.

45 responses

Summary See complete responses

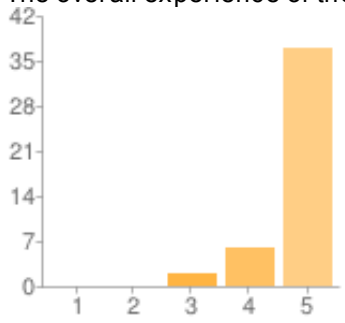
Workshop assessment

The workshop was intellectually stimulating



1 -	Not at all	0	0%
2		0	0%
3		1	2%
4		11	24%
5 -	Very	33	73%

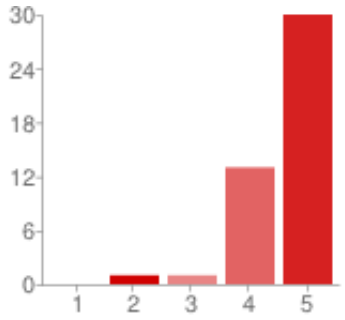
The overall experience of the workshop was worthwhile



1 -	Not at all	0	0%
2		0	0%
3		2	4%
4		6	13%
5 -	Very	37	82%

The time between lectures was adequate for discussion

1 -	Not al all	0	0%
2		1	2%
3		1	2%
4		13	29%
5 -	Very	30	67%



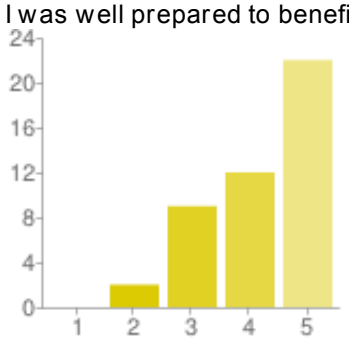
Not al all Very

Additional comments on the workshop organization

Very smoothly organised I learned about the work of various people in direct way which otherwise I hardly could have done. The workshop was extremely useful for me. Perfect. One fewer talk Monday afte ...

Personal assessment

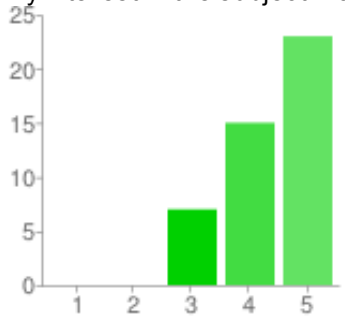
I was well prepared to benefit from the lectures



Not at all Very

1 -	Not at all	0	0%
2		2	4%
3		9	20%
4		12	27%
5 -	Very	22	49%

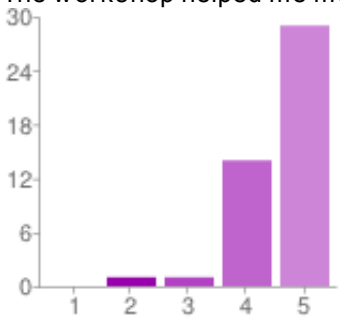
My interest in the subject matter was increased by the workshop



1 -	Niot at all	0	0%
2		0	0%
3		7	16%
4		15	33%
5 -	Very	23	51%

Niot at all Very

The workshop helped me meet people with similar scientific interests



Not at all Very Much

1 -	Not at all	0	0%
2		1	2%
3		1	2%
4		14	31%
5 -	Very Much	29	64%

Additional comments on your personal assessment

Extra women's dinner Monday night provided mentoring opportunities. Great selection of people! My interest in the subject was not increased significantly, since this subject is already my main area o ...

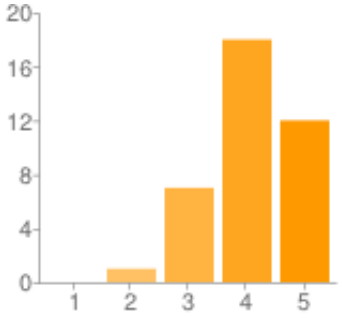
Additional Activities

Did you attend the reception?

Yes	38	84%
No	7	16%

If you did attend the reception, did it help to solidify the contacts you made in the workshop?

1 -	Not at all	0	0%
2		1	2%
3		7	16%



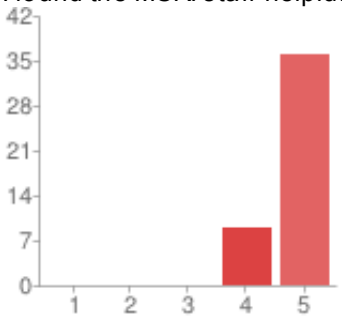
4		18	40%
5 -	Very much	12	27%

Please provide any comments on the reception

I gives the opportunity to talk with people about topics which go beyond some immediate mathematical problems. This givevs a much wider prespective on their activities.

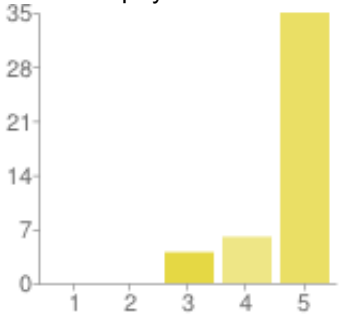
Venue

I found the MSRI staff helpful



1 -	Not at all	0	0%
2		0	0%
3		0	0%
4		9	20%
5 -	Very	36	80%

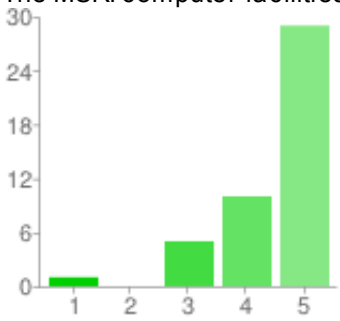
The MSRI physical facilities were conducive for such a workshop



1 -	Not at all	0	0%
2		0	0%
3		4	9%
4		6	13%
5 -	Very	35	78%

Not at all Very

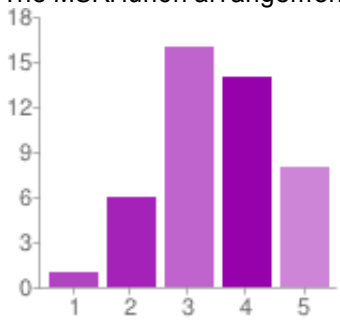
The MSRI computer facilities were adequate for such a workshop



Not at all Very

1 -	Not at all	1	2%
2		0	0%
3		5	11%
4		10	22%
5 -	Very	29	64%

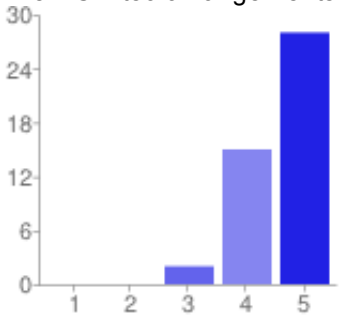
The MSRI lunch arrangements were satisfactory



Not at all Very

1 -	Not at all	1	2%
2		6	13%
3		16	36%
4		14	31%
5 -	Very	8	18%

The MSRI tea arrangements were satisfactory



Not at all Very

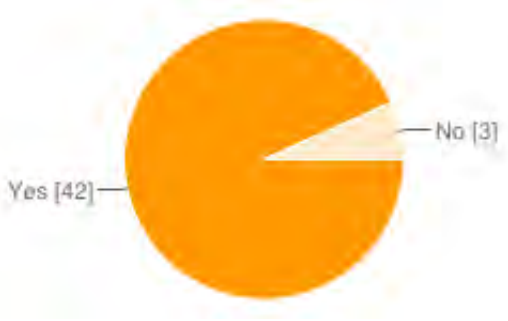
1 -	Not at all	0	0%
2		0	0%
3		2	4%
4		15	33%
5 -	Very	28	62%

Additional comments on the venue

While the location of MSRI is great, the transport conditions could be improved. I cannot comment on the computer facilities. I did not use them. It should be pointed out clearly that food will only b ...

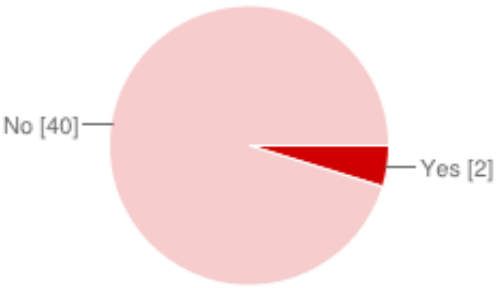
MSRI Wireless Network

Did you use MSRI's wireless network?



Yes	42	93%
No	3	7%

Did you experience any difficulties with the network?



Yes	2	4%
No	40	89%

If you did experience difficulties with the network, please explain:

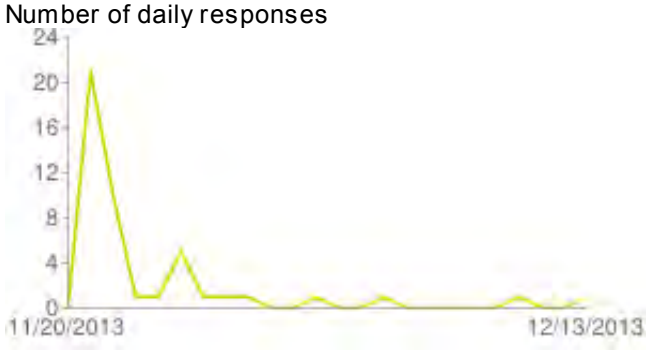
printing didn't work Weak signal. Even with full signal was the internet connection not good

Thank you for completing this survey

We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.

Instead of adding any comments I woulld like to take this opportunity to thank the personal for the wunderful job they are doing. Always have Monday women's dinners. Thank you very much! Perhaps, one ...

Number of daily responses



Initial Data and Evolution Problems in General Relativity
November 18 - 22, 2013

Additional Survey Responses

Additional comments on your personal assessment

- Extra women's dinner Monday night provided mentoring opportunities.
- Great selection of people!
- My interest in the subject was not increased significantly, since this subject is already my main area of research.

Additional comments on the venue

- While the location of MSRI is great, the transport conditions could be improved.
- I cannot comment on the computer facilities. I did not use them.
- It should be pointed out clearly that food will only be delivered if the oder has be confirmed by e-mail
- thermostat difficulties in main lecture hall
- I sometimes arrived late and there was virtually nothing left for lunch (or no snacks left at teatime)!

We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.

- Instead of adding any comments I woulld like to take this opportunity to thank the personal for the wunderful job they are doing.
- Always have Monday women's dinners.
- Thank you very much!
- Perhaps, one can help participants coming to MSRI at the first time for some arrangements such getting from San Francisco to Downtown Berkeley and to the hotels.

If you did experience difficulties with the network, please explain:

- printing didn't work
- Weak signal. Even with full signal was the internet connection not good

Please provide any comments on the reception

- I gives the opportunity to talk with people about topics which go beyond some immediate mathematical problems. This givevs a much wider prespective on their activities.

Additional comments on the workshop organization

- Very smoothly organized
- I learned about the work of various people in direct way which otherwise I hardly could have done. The workshop was extremely useful for me.
- Perfect.
- One fewer talk Monday afternoon....

Hot Topics: Perfectoid Spaces and their Applications

February 17 to 21, 2014

MSRI, Berkeley, CA, USA

Organizers:

Sophie Morel (Princeton University)

Peter Scholze (Universität Bonn)

Richard Taylor (Institute for Advanced Study)

Jared Weinstein (Boston University)

Report on the Hot Topics Workshop on 'Perfectoid Spaces and their Applications' held February 17-21, 2014.

Organizing committee: Sophie Morel (Princeton University), Peter Scholze (Bonn), Richard Taylor (IAS, lead organizer), Jared Weinstein (Boston University)

Subject matter: Three years ago Peter Scholze introduced perfectoid spaces. Since then he has used them to resolve a amazingly diverse set of major problems in arithmetic algebraic geometry.

- First he proved Deligne's weight-monodromy conjecture for complete intersections in toric varieties. (This conjecture is a p-adic analogue of the Weil's Riemann Hypothesis over finite fields, which Deligne famously proved. Before Scholze's work it was only known in dim ≤ 2 and for a few very special examples.)
- Then he worked out the analogue of Hodge theory for rigid analytic spaces. (Rigid analytic spaces are the p-adic analogue of complex analytic spaces. Tate suggested they should satisfy an analogue of Hodge theory. For those that arise from algebraic varieties this has been worked out by many people including Fontaine, Faltings and Kato. However just as the natural setting for Hodge theory is complex analytic spaces not algebraic varieties, so the natural setting for p-adic Hodge theory should be rigid analytic spaces. Scholze was the first (only) person to develop such a theory and gives what may well be the most useful approach to the subject.)
- Thirdly he and Jared Weinstein used perfectoid spaces to give a classification of p-divisible groups over the ring of integers of $\mathbb{C}_p$ in terms very similar to Riemann's classification of abelian varieties over the complex numbers, and then to give a linear algebra description of Rapoport-Zink spaces at infinite level, a bit like the description of period domains for variations of Hodge structures.
- Fourthly Scholze constructed Galois representations associated to torsion classes in the cohomology of arithmetic locally symmetric spaces associated to GL_n over a CM or totally real field. Note that, except for the case that $n = 2$ and the base field is totally real, these manifolds have no natural complex structure and so no direct relationship to algebraic geometry. The first numerical evidence for such a relationship goes back 40 years, but until Scholze's work there were no theoretical results at all.

Perfectoid spaces are sophisticated objects, requiring many technical pre-requisites: Huber's adic spaces, the Faltings-Gabber-Ramero almost ring theory, the pro-etale site, ... The aim of the workshop was to educate other mathematicians to work with perfectoid spaces, and at the same time to describe Scholze's startling applications of them.

Program: The organizers conceived a detailed plan for the week and when we approached speakers we asked them to report on precisely defined topics. For the most part we asked them to report on the work of others and to cover their own travel expenses. Nonetheless everyone we approached to speak agreed to do so, with the single exception of Faltings. It is our belief that this worked very well providing a coherent introduction to perfectoid spaces.

The week began with a lecture by Scholze (Bonn) giving an extremely beautiful overview of the subject. Many people expressed their appreciation of this lecture to us.

After that we got straight down to hard work. Bhargav Bhatt (IAS) gave two lectures on almost ring theory. In the first he introduced the subject and in the second he applied it to prove the tilting equivalence for perfectoid rings. Finally on the first day Eugen Hellman (Bonn) introduced general adic spaces. At the end of the day we had the first question/discussion session. This was mostly taken up with the description of the points of the adic unit disc, which was very helpful in making adic spaces more concrete.

On Tuesday Scholze gave two lectures introducing perfectoid spaces. In the second of these he highlighted a number of foundational open questions. These don't seem to be essential for the applications of the subject, but they would allow for more natural foundations. For instance, is every affinoid subdomian of a perfectoid space a perfectoid affinoid? Also on the second day Caraiani (Princeton and the IAS) explained the first application of perfectoid spaces: the weight-monodromy conjecture for complete intersections. Moreover Fontaine (Orsay) gave the first of two lectures on explicit untitling and the Fargues-Fontaine curve. Fargues (Jussieu) gave the second such lecture on the third day. Finally on the second day Weinstein (Boston University) gave the first of two lectures on the universal cover of p-divisible groups and Lubin-Tate space at infinite level. His lectures contained a wealth of explicit formulae, helping to make concrete some of the abstract theory from the earlier lectures. The 5 full lectures made Tuesday a long day.

Wednesday was a half day. Fargues gave the second lecture about the Fargues-Fontaine curve; de Jong (Columbia) introduced the pro-etale site for adic spaces, and Kedlaya (UCSD) gave a lecture on his work with Liu on relative p-adic Hodge theory. Kedlaya's lecture was not part of our systematic development of the subject, but covered related work he and Liu had been doing at about the same time. During the free afternoon a select group of participants persuaded Scholze to give an additional lecture on his very recent work using the Lubin-Tate tower and perfectoid spaces to construct a candidate for the mod p local Langlands correspondence for GL_n over a p-adic field. This supernumerary talk inspired a lot of (so far inconclusive) conversations for the rest of the week about how Scholze's construction jibed with other approaches to this problem.

On Thursday morning Niziol (ENS Lyon) explained the use of perfectoid spaces to develop p-adic Hodge theory for rigid analytic spaces and Weinstein gave the

second of his two talks on the explicit theory of Lubin-Tate spaces. In the afternoon Emerton (Chicago) introduced completed cohomology, which provides a setting for the study of torsion in the cohomology of locally symmetric spaces. Moreover Scholze gave a lecture introducing general formal $\mathbb{Q}_p$-vector spaces, and discussed the important open problem of whether they could exist in the most naive sense. In discussion following the lecture, both positive and negative answers were proposed, which created some serious confusion. Eventually, a problem with the positive solution was found, and Colmez (Jussieu) gave a negative answer to Scholze's question, thus showing that a more sophisticated language is needed to describe formal $\mathbb{Q}_p$-vector spaces. Thursday finished with our second question and discussion session, which addresses some more technical questions.

On Friday Niziol explained the construction of Scholze's Hodge-Tate spectral sequence, and then Kisin (Harvard) gave two lectures explaining how to put everything together to construction Galois representations for torsion classes in the cohomology of arithmetic locally symmetric spaces. The final lecture was supposed to be another talk by Scholze on what he considered important open problems in the area, but instead, by popular, demand he repeated the additional lecture on his recent work that he had given to a small group on Wednesday afternoon. Fortunately the lecture he had originally intended to give was not entirely lost - he explained his conjectures about the existence of 'character sheaves' on $\mathbb{P}^{n-1}$ giving the local Langlands correspondence as part of the final question discussion session. Moreover during that session Weinstein gave some useful explicit formulae for the Hodge-Tate period map (introduced earlier in the day by Kisin) in the case of modular curves.

Summary: We were very pleased with the workshop.

We got a very large number of applicants. Thanks to the grant from the Clay Institute we were able to offer all serious applicants partial support. (Usually minimal local expenses, but no travel expenses.) We are told that 240 people actually attended the conference, a very surprising number for such a technically demanding subject. This had the unfortunate side effect that some of the participants had to watch the proceedings via video link in an overflow room. More surprising still, at the end of a tough week, the Simon's auditorium was still completely full for Scholze's last lecture and there were people watching in the overflow room. The scale of the interest in this workshop, and the seriousness of that interest, was very gratifying for us. (There was even a historian present, but it was unclear to us what she would be able to get out of the week.)

The quality of the lectures, with a very few exceptions, was extremely high. Questions were asked throughout the lectures as well as at the end of lectures. Scholze's instant command of the whole subject meant that these all got good answers. We didn't have any of the embarrassing question free silences at the end of the lectures that usually indicate people hadn't been able to follow the lectures. This speaks well of the good job all the lecturers did.

We were unsure whether the question/discussion sessions would be successful. As it turns out they were very successful, both for getting questions answered, examples given and engendering discussion. However most of the questions came from senior mathematicians. If we organized such a thing again, we would need to think about how to encourage the younger participants to ask questions.

Organizers		
First Name	**Last Name**	**Institution**
Sophie	Morel	Princeton University
Peter	Scholze	Universitat Bonn
Richard	Taylor	Institute for Advanced Study
Jared	Weinstein	Boston University

Speakers		
First Name	**Last Name**	**Institution**
Bhargav	Bhatt	Institute for Advanced Study
Ana	Caraiani	Princeton University
Jean Marc	Fontaine	Universite Paris-Sud (Orsay)
Eugen	Hellmann	Universitat Bonn
Kiran	Kedlaya	University of California, San Diego
Mark	Kisin	Harvard University
Arthur-Cesar	Le Bras	Ecole Normale Superieure
Peter	Scholze	Universitat Bonn
Jared	Weinstein	Boston University

Mathematical Sciences Research Institute

Hot Topics: Perfectoid Spaces and their Applications

February 17-21, 2014

Schedule

Monday, February 17, 2014			
9:00 AM - 9:15 AM	Simons Auditorium		Welcome
9:15 AM - 10:15 AM	Simons Auditorium	Peter Scholze	Overview
10:15 AM - 10:45 AM	Atrium		Tea
10:45 AM - 11:45 AM	Simons Auditorium	Bhargav Bhatt	Almost ring theory 1
11:45 AM - 1:15 PM	Atrium		Lunch
1:15 PM- 2:15 PM	Simons Auditorium	Eugen Hellman	Adic Spaces 1
2:15 PM- 2:30 PM	Atrium		
2:30 PM- 3:30 PM	Simons Auditorium	Bhargav Bhatt	Almost ring theory 2: Perfectoid rings
3:30 PM - 4:00 PM	Atrium		Tea
4:00 PM - 4:45 PM	Simons Auditorium		Question and Discussion Session

Buses will depart for Hearst Mining Circle at 5:15 and 5:45

Tuesday, February 18, 2014			
9:00 AM - 10:00 AM	Simons Auditorium	Peter Scholze	Adic Spaces 2: Perfectoid rings
10:00 AM - 10:30 AM	Atrium		Tea
10:30 AM - 11:30 AM	Simons Auditorium	Jean Marc Fontaine	Introduction to p-adic comparison theorems
11:30 AM- 11:45 AM	Atrium		Break
11:45 AM - 12:45 PM	Simons Auditorium	Peter Scholze	Adic spaces 3
12:45 PM - 2:30 PM	Atrium		Lunch
2:30 PM - 3:30 PM	Simons Auditorium	Ana Caraiani	The weight-monodromy conjecture
3:30 PM - 4:00 PM	Atrium		Tea
4:00 PM - 5:00 PM	Simons Auditorium	Jared Weinstein	Lubin-Tate spaces 1
5:00 PM - 6:20 PM	Atrium		Reception

Additional Charter Bus will depart for Hearst Mining Circle at 6:15 and 6:45

Wednesday, February 19, 2014			
9:00 AM - 10:00 AM	Simons Auditorium	Laurent Fargues	The Fargues-Fontaine curve
10:00 AM - 10:30 AM	Atrium		Tea
10:30 AM - 11:30 AM	Simons Auditorium	Aise de Jong	The Pro-etale site
11:30 AM - 11:45 AM	Atrium		Break
11:45 AM - 12:45 PM	Simons Auditorium	Kiran Kedlaya	Relative p-adic Hodge theory

Thursday, February 20, 2014			
09:00 AM - 10:00 AM	Simons Auditorium	Wieslawa Niziol	p-adic Hodge theroy for rigid spaces 1
10:00 AM - 10:45 AM	Atrium		Tea
10:45 AM - 11:45 AM	Simons Auditorium	Jared Weinstein	Lubin-Tate spaces 2
11:45 AM - 01:15 PM	Atrium		Lunch
12:00 PM - 01:00 PM	Atrium		Poster Session
1:15 PM - 2:15 PM	Simons Auditorium	Matthew Emerton	Shimura varieties and perectoid spaces 1: completed cohomology
2:15 PM - 2:30 PM	Atrium		Break
2:30 PM - 3:30 PM	Simons Auditorium	Peter Scholze	Future directions 1: formal Q_p vector spaces of slope >1
3:30 PM - 4:00 PM	Atrium		Tea
4:00 PM - 4:45 PM	Simons Auditorium		Question and Discussion Session

Friday, February 21, 2014			
9:00 AM - 10:00 AM	Simons Auditorium	Wieslawa Niziol	p-adic Hodge theory for rigid spaces 2
10:00 AM - 10:45 AM	Atrium		Tea
10:45 AM - 11:45 AM	Simons Auditorium	Mark Kisin	Shimura varieties and perfectoid spaces 2
11:45 AM - 01:15 PM	Atrium		Lunch
1:15 PM - 2:15 PM	Simons Auditorium	Mark Kisin	Shimura varieties and perfectoid spaces 3
2:15 PM - 2:30 PM	Atrium		Break
2:30 PM - 3:30 PM	Simons Auditorium	Peter Scholze	Future directions 2: the local Langlands and equivariant sheaves on projective space
3:30 PM - 4:00 PM	Atrium		Tea
4:00 PM - 4:45 PM	Simons Auditorium		Question and Discussion Session

Participants

First Name	Last Name	Institution
Ahmed	Abbes	Institut des Hautes Etudes Scientifiques (IHES)
Adebisi	Agboola	University of California, Santa Barbara
Shishir	Agrawal	University of California, Berkeley
Patrick	Allen	Northwestern University
Zavosh	Amir-Khosravi	Fields Institute for Research in Mathematical Sciences
CADORET	Anna	Institute for Advanced Study
Konstantin	Ardakov	University of Oxford
Soumya	Banerjee	Yale University
Joel	Bellaiche	Brandeis University
Rebecca	Bellovin	Imperial College, London
John	Bergdall	Boston University
Laurent	Berger	Ecole Normale Superieure de Lyon
Vladimir	Berkovich	Weizmann Institute of Science
Bhargav	Bhatt	Institute for Advanced Study
Stephane	BIJAKOWSKI	Universite de Paris XIII (Paris-Nord)
Chris	Blake	University of Cambridge
Don	Blasius	University of California, Los Angeles
Jeremy	Booher	Stanford University
George	Boxer	Harvard University
Pascal	Boyer	University Paris 13
David Lukas Benjam	Brantner	Harvard University
Christophe	Breuil	Centre National de la Recherche Scientifique (CNRS)
Oliver	Bueltel	unemployed
Ashay	Burungale	University of California, Los Angeles
Bryden	Cais	University of Arizona
Frank	Calegari	Northwestern University
Ana	Caraiani	Princeton University
Scott	Carnahan	University of Tsukuba
Francesc	Castella	University of California, Los Angeles
Kestutis	Cesnavicius	Massachusetts Institute of Technology
Zoe	Chatzidakis	Centre National de la Recherche Scientifique (CNRS)
Przemyslaw	Chojecki	L'Institut de Mathematiques de Jussieu
Dan	Collins	Princeton University
Brian	Conrad	Stanford University
David	Corwin	Massachusetts Institute of Technology
Shaunak	Das	University of California, San Diego
Samit	Dasgupta	University of California, Santa Cruz
Christopher	Davis	University of Copenhagen
Johan	de Jong	Columbia University
Ehud	de Shalit	Hebrew University
Shaunak	Deo	Brandeis University
Bjorn	Dundas	University of Bergen
Taylor	Dupuy	University of California, Los Angeles
Bas	Edixhoven	Universiteit Leiden
Ellen	Eischen	University of North Carolina
Veronika	Ertl	University of Utah
Lorenzo	Fantini	Katholieke Universiteit Leuven
Jessica	Fintzen	Harvard University
Benjamin	Fischer	Boston University
Jean Marc	Fontaine	Universite Paris-Sud (Orsay)

Arthur	Forey	Ecole Normale Superieure
Tyler	Foster	University of Michigan
Olivier	Fouquet	Universite Paris-Sud (Orsay)
James	Freitag	University of California, Berkeley
Ildar	Gaisin	L'Institut de Mathematiques de Jussieu
Toby	Gee	Imperial College, London
David	Geraghty	Boston College
Ulrich	Goertz	Universitat Duisburg-Essen
Jesper	Grodal	University of Copenhagen
Thomas	Haines	University of Maryland
David	Hansen	L'Institut de Mathematiques de Jussieu
Jeffrey	Hatley	University of Massachusetts
Shin	Hattori	Kyushu University
Mohammad Hadi	Hedayatzadeh	California Institute of Technology
Eugen	Hellmann	Universitat Bonn
Florian	Herzig	University of Toronto
Haruzo	Hida	University of California, Los Angeles
Martin	Hils	Universite Paris Diderot - Paris VII
Auguste	Hoang Duc	Universite Louis Pasteur Strasbourg
Sean	Howe	University of Chicago
Roland	Huber	University of Wuppertal
Brian	Hwang	California Institute of Technology
Naoki	Imai	University of Tokyo
Alexander	Ivanov	TU Munchen
Lalit	Jain	University of Wisconsin
Christian	Johansson	University of Oxford
Andrei	Jorza	University of Notre Dame
Aditya	Karnataki	Boston University
Payman	Kassaei	McGill University
Kiran	Kedlaya	University of California, San Diego
Jiae	Keem	Seoul National University
Jukka	Keranen	University of California, Los Angeles
Keenan	Kidwell	University of Texas
Chan-Ho	Kim	University of California, Irvine
Mark	Kisin	Harvard University
Erick	Knight	Harvard University
Jean-Stefan	Koskivirta	Universitat-GHS Paderborn
Arno	Kret	Institute for Advanced Study
Watson	Ladd	University of California, Berkeley
Kai-Wen	Lan	University of Minnesota, Twin Cities
Jaclyn	Lang	University of California, Los Angeles
Daniel	Le	University of Chicago
Arthur-Cesar	Le Bras	Ecole Normale Superieure
Emmanuel	Lecouturier	Ecole Normale Superieure
Dong Uk	Lee	Institute for Basic Science
Brandon	Levin	Institute for Advanced Study
Chao	Li	Harvard University
Binglin	Li	University of California, Davis
Daniel	Litt	Stanford University
Zheng	Liu	Columbia University
Ruochuan	Liu	Peking University
Francois	Loeser	Universite de Paris VI (Pierre et Marie Curie)

Tom	Lovering	Harvard University
Judith	Ludwig	Imperial College, London
Mohamed Rafik	Mammeri	Universite de Lille I (Sciences et Techniques de Lille Flandres Artois)
Florent	Martin	Universite de Lille I (Sciences et Techniques de Lille Flandres Artois)
Anna	Medvedovsky	Brandeis University
Yoichi	Mieda	Kyoto University
Tomoki	Mihara	University of Tokyo
Daniel	Miller	Cornell University
Lucia	Mocz	Princeton University
Yong Suk	Moon	Harvard University
Sophie	Morel	Princeton University
Stefano	Morra	University of Toronto
Johannes	Nicaise	Katholieke Universiteit Leuven
Andrew	Niles	University of California, Berkeley
Andrew	Obus	University of Virginia
Arthur	Ogus	University of California, Berkeley
shun	ohkubo	University of Tokyo
Takeshi	Okada	Kyoto University
Martin	Olsson	University of California, Berkeley
Sascha	Orlik	Bergische Universitat-Gesamthochschule Wuppertal (BUGH)
Bharathwaj	Palvannan	University of Washington
Lue	Pan	Princeton University
celine	pan	Extra-D Life Sciences (In Prep)
Matthew	Pancia	University of Texas
Chol	Park	University of Toronto
cedric	pepin	Universite de Paris XIII (Paris-Nord)
Eric	Peterson	University of California, Berkeley
Jonathan	Pottharst	unknown
Joseph	Rabinoff	Georgia Institute of Technology
Michael	Rapoport	Universitaet Bonn
Charles	Rezk	University of Illinois at Urbana-Champaign
Kenneth	Ribet	University of California, Berkeley
joaquin	rodrigues jacinto	Universite Paris VI
David	Roe	University of Calgary
Matthieu	Romagny	Universite Rennes 1
Daniel	Ross	University of Wisconsin
Aaron	Royer	University of Texas
David	Savitt	University of Arizona
Justin	Scarfy	University of British Columbia
Michael	Schein	Bar-Ilan University
Peter	Scholze	Universitat Bonn
Benjamin	Schraen	Centre National de la Recherche Scientifique (CNRS)
Arijit	Sehanobish	University of Maryland
Shrenik	Shah	Princeton University
Ananth	Shankar	Harvard University
Romyar	Sharifi	University of Arizona
Yiwei	She	University of Chicago
Koji	Shimizu	Harvard University
Kazuma	Shimomoto	Meiji University
Sug Woo	Shin	Massachusetts Institute of Technology
Jack	Shotton	Imperial College, London
Claus	Sorensen	University of California

Florian	Sprung	Institute for Advanced Study
Sergei	Starchenko	University of Notre Dame
Ander	Steele	University of Calgary
Vesna	Stojanoska	Massachusetts Institute of Technology
Benoit	Stroh	Centre National de la Recherche Scientifique (CNRS)
Lenny	Taelman	Universiteit Leiden
Fucheng	Tan	Michigan State University
Yunqing	Tang	Harvard University
Richard	Taylor	Institute for Advanced Study
Yichao	TIAN	Morningisde Center of Mathematics
Pham	Tiep	University of Arizona
Adam	Topaz	University of California, Berkeley
Naoya	Umezaki	University of Tokyo
Eric	Urban	Columbia University
Ila	Varma	Princeton University
Kevin	Ventullo	University of California, Los Angeles
Alberto	Vezzani	Universitat Zurich
Marie-France	Vigneras	Universite de Paris VII et Universite de Paris VI
Christelle	Vincent	Stanford University
Paul	Vojta	University of California, Berkeley
Preston	Wake	University of Chicago
Haining	Wang	Pennsylvania State University
Haoran	Wang	Max-Planck-Institut fur Mathematik
Siqi	Wei	University of British Columbia
Jared	Weinstein	Boston University
Jun Ho	Whang	Princeton University
Carol	Wood	Wesleyan University
Hwajong	Yoo	University of Luxembourg
Sho	Yoshikawa	University of Tokyo
Shou-Wu	Zhang	Princeton University
Naizhen	Zhang	University of California, Davis
Bin	Zhao	University of California, Los Angeles
Rong	Zhou	Harvard University
Xinwen	Zhu	Northwestern University
Yihang	Zhu	Harvard University
Hong (also Runpu)	Zong	Princeton University

Officially Registered Participant Information

Participants		190

Gender		190
Male	87.89%	167
Female	11.58%	22
Declined to state	0.53%	1

Ethnicity*		190
White	54.74%	104
Asian	29.47%	56
Hispanic	0.53%	1
Pacific Islander	0.00%	0
Black	0.53%	1
Native American	0.00%	0
Mixed	1.58%	3
Declined to state	13.16%	25

* ethnicity specifications are not exclusive

40 responses

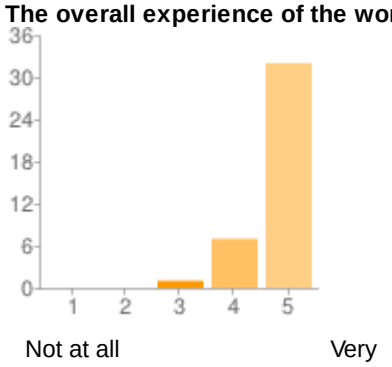
Summary See complete responses

Workshop assessment

The workshop was intellectually stimulating

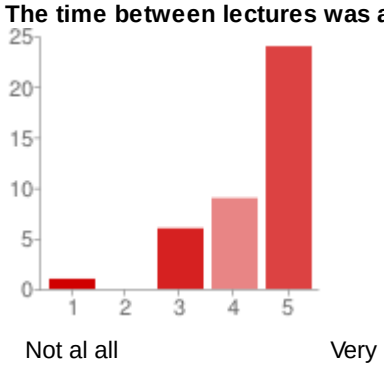
1 -	Not at all	**0**	0%
2		**0**	0%
3		**0**	0%
4		**5**	13%
5 -	Very	**35**	88%

The overall experience of the workshop was worthwhile



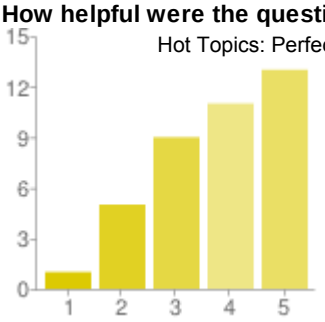
1 -	Not at all	**0**	0%
2		**0**	0%
3		**1**	3%
4		**7**	18%
5 -	Very	**32**	80%

The time between lectures was adequate for discussion



1 -	Not al all	**1**	3%
2		**0**	0%
3		**6**	15%
4		**9**	23%
5 -	Very	**24**	60%

How helpful were the question/discussion sessions?



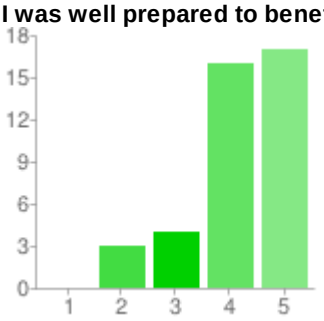
1 -	Not at all	**1**	3%
2		**5**	13%
3		**9**	23%
4		**11**	28%
5 -	Very	**13**	33%

Additional comments on the workshop organization

Peter Scholze should have given every talk | good job | The organization was excellent. | Excellent selection of speakers | Maybe a more unified system of collecting questions/discussions? Maybe just an anonymo ...

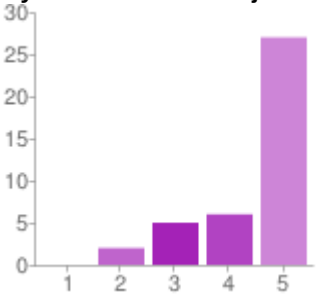
Personal assessment

I was well prepared to benefit from the lectures



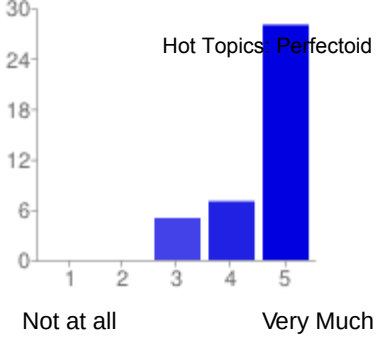
1 -	Not at all	**0**	0%
2		**3**	8%
3		**4**	10%
4		**16**	40%
5 -	Very	**17**	43%

My interest in the subject matter was increased by the workshop



1 -	Niot at all	**0**	0%
2		**2**	5%
3		**5**	13%
4		**6**	15%
5 -	Very	**27**	68%

The workshop helped me meet people with similar scientific interests



1 -	Not at all	**0**	0%
2		**0**	0%
3		**5**	13%
4		**7**	18%
5 -	Very Much	**28**	70%

Additional comments on your personal assessment

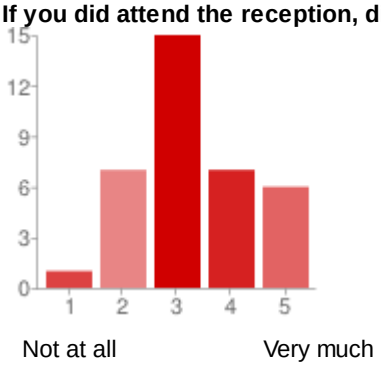
Wow Just what I needed to get into this exciting new area. The topic was not directly related to my research -- I only went because it was local (not a complaint, just putting my answers in context)

Additional Activities

Did you attend the reception?

Yes		**36**	90%
No		**4**	10%

If you did attend the reception, did it help to solidify the contacts you made in the workshop?



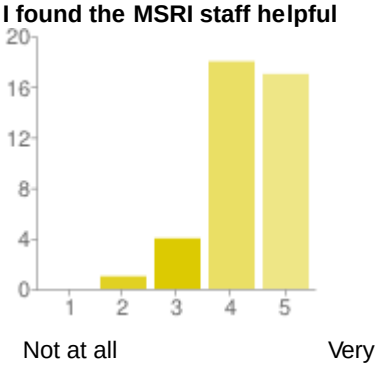
1 -	Not at all	**1**	3%
2		**7**	18%
3		**15**	38%
4		**7**	18%
5 -	Very much	**6**	15%

Please provide any comments on the reception

I missed the first 20 minutes (and hence all the food was gone). I spoke to people I already new (but then I know most people here) not enough red wine or food Pleasant The food was

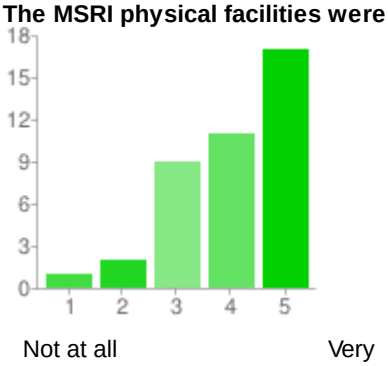
Venue

I found the MSRI staff helpful



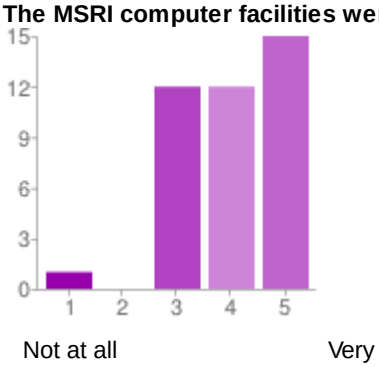
1 -	Not at all	**0**	0%
2		**1**	3%
3		**4**	10%
4		**18**	45%
5 -	Very	**17**	43%

The MSRI physical facilities were conducive for such a workshop



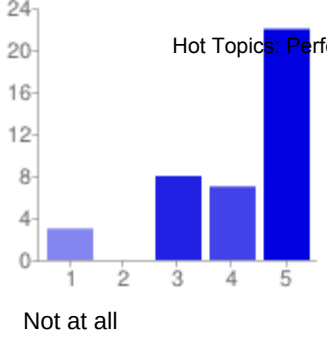
1 -	Not at all	**1**	3%
2		**2**	5%
3		**9**	23%
4		**11**	28%
5 -	Very	**17**	43%

The MSRI computer facilities were adequate for such a workshop



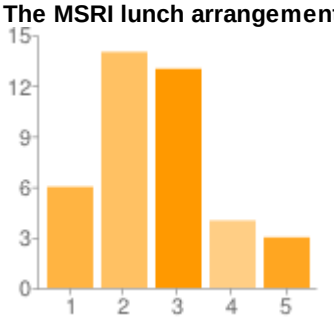
1 -	Not at all	**1**	3%
2		**0**	0%
3		**12**	30%
4		**12**	30%
5 -	Very	**15**	38%

How satisfactory was the transportation to and from MSRI?



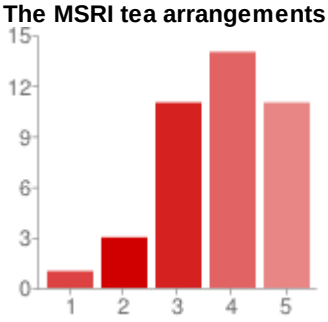
1 -	Not at all	**3**	8%
2		**0**	0%
3		**8**	20%
4		**7**	18%
5 -	Very	**22**	55%

The MSRI lunch arrangements were satisfactory



1 -	Not at all	**6**	15%
2		**14**	35%
3		**13**	33%
4		**4**	10%
5 -	Very	**3**	8%

The MSRI tea arrangements were satisfactory



1 -	Not at all	**1**	3%
2		**3**	8%
3		**11**	28%
4		**14**	35%
5 -	Very	**11**	28%

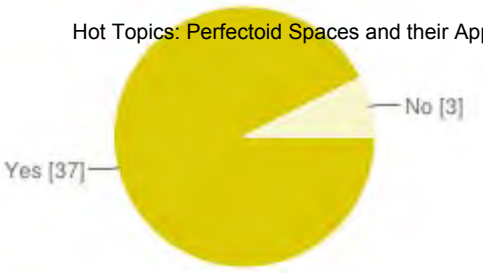
Additional comments on the venue

The workshop was too popular, so one had to arrive 90 minutes before the talks started to get a good seat. I came by car so I could avoid the bus and the average lunch. (This website insists I answe ...

MSRI Wireless Network

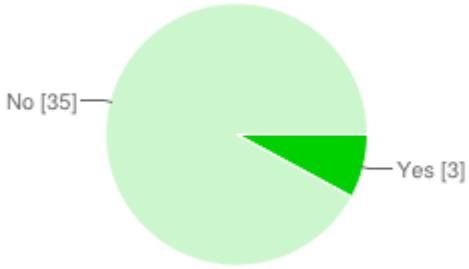
Did you use MSRI's wireless network?

Yes	**37**	93%
No	**3**	8%



Did you experience any difficulties with the network?

Yes	**3**	8%
No	**35**	88%



If you did experience difficulties with the network, please explain:

Not fast enough Intermittent dropouts My connection to the network was spotty - sometimes it worked fine and other times I couldn't connect at all.

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 a wonderful workshop. Brilliant job! Keep up the great work! The people I talked to were all very appreciative. One of the most remarkable workshops I have attended.

Number of daily responses

Hot Topics: Perfectoid Spaces and their Applications
February 17 – 21, 2014

Additional Survey Responses

Additional comments on your personal assessment

- Wow
- Just what I needed to get into this exciting new area.
- The topic was not directly related to my research -- I only went because it was local (not a complaint, just putting my answers in context)

Additional comments on the venue

- The workshop was too popular, so one had to arrive 90 minutes before the talks started to get a good seat. I came by car so I could avoid the bus and the average lunch. (This website insists I answer questions concerning transportation which I didn't even use....)
- Not enough good seats in the auditorium when there are chalkboard talks
- The weakest aspect of MSRI seems to be the lunch arrangements. Not convenient at all.
- Wonderful.
- The lecture room though beautiful didn't seem ideally suited for such a conference. There was insufficient seating and it was hard to see from the sides of the room. There were long lines for lunch, but this was probably inevitable
- Some of the time, the quality of the caterer seemed mediocre.
- MSRI did a great job with the abnormally high attendance. Although the auditorium was not designed well (low capacity, the wings had poor chalkboard visibility), the overflow room worked quite well, and the staff was very helpful.
- the warm lunch during the MSRI summer school for graduate students was much better (this time I preferred to bring my own sandwiches, but I would have preferred a warm lunch)
- The line at lunch was too long, so I always ate elsewhere
- there was a long line for lunch, the selling should be done faster
- auditorium inadequate for 200 people (too few seats with good view of boards)
- Access to the building earlier (e.g. unlocked doors) would've been helpful.
- lunch line was long. Suggest two lines with same food for workshop as big as this one. Food was adequate but not more.

If you did experience difficulties with the network, please explain:

- Not fast enough
- Intermittent dropouts
- My connection to the network was spotty - sometimes it worked fine and other times I couldn't connect at all.

We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.

- Thank you for a wonderful workshop
- Brilliant job!
- Keep up the great work! The people I talked to were all very appreciative.
- One of the most remarkable workshops I have attended.

Please provide any comments on the reception

- I missed the first 20 minutes (and hence all the food was gone). I spoke to people I already new (but then I know most people here)
- not enough red wine or food
- Pleasant
- The food was great.
- There wasn't quite enough space/food for everybody, in my opinion.

Additional comments on the workshop organization

- Peter Scholze should have given every talk
- good job
- The organization was excellent.
- Excellent selection of speakers
- Maybe a more unified system of collecting questions/discussions? Maybe just an anonymous online form?
- too crowded, blackboard too small for such a large audience
- Should have had a mechanism to record the questions and answers and discussions during the talks. They can't be heard on the video lectures, the speakers often did not repeat anything or the issue was settled between Peter and the audience.
- 65 bus should have been mentioned in literature about workshop, esp. for President's Day.

Critical Issues in Mathematics Education 2014: The role of the mathematics department in the mathematical preparation of teachers

March 26 to 28, 2014

MSRI, Berkeley, CA, USA

Organizers:

Deborah Ball (University of Michigan)

Solomon Friedberg (Boston College)

Jim Lewis* (University of Nebraska)

Despina Stylianou (City College, CUNY)

Peter Trapa (University of Utah)

Hung-Hsi Wu (University of California, Berkeley)

Darryl Yong (Harvey Mudd College)

Mathematical Sciences Research Institute
2014 Critical Issues in Mathematics Education Workshop
The Role of the Mathematics Department in the Mathematical Preparation of Teachers
Final Report

For the eleventh Critical Issues in Mathematics Education (CIME) workshop, the MSRI Educational Advisory Committee (EAC) chose to focus on the role played by mathematics departments in preparing future teachers of mathematics. The EAC leadership felt both that this topic was timely and that it might help attract more mathematicians to participate in a CIME workshop.

Major funding for the CIME workshop was provided by Math for America, with additional funding provided by the National Science Foundation. The University of Utah and the University of Nebraska-Lincoln generously provided additional support. This was particularly helpful as the workshop was very large, reflecting the wide interest in the subject: 152 people participated.

The workshop was held March 26-28, 2014. The organizing committee for the 11th CIME workshop consisted of: Deborah Ball (University of Michigan), Solomon Friedberg (Boston College), Jim Lewis (University of Nebraska-Lincoln) chair, Despina Stylianou (City College, CUNY), Peter Trapa (University of Utah), Hung-Hsi Wu (University of California, Berkeley), and Darryl Yong (Harvey Mudd College).

In addition to posting information about the workshop on the MSRI web page, efforts to recruit participants included email letters that were sent to participants in past CIME workshops, Academic Sponsors representatives, and participants in the 2014 AMS chairs' workshop at the Joint Mathematics Meetings. As has been the case for all CIME workshops, participants were drawn from diverse communities interested in mathematics education including mathematicians, mathematics education researchers, and K-12 teachers. In keeping with the workshop theme, there was significant participation by faculty from departments of mathematics.

As part of widely disseminating the talks that were presented at the CIME workshop, each presentation was videotaped. Both the video of each session and each speaker's slides are posted on the MSRI website. In addition, a science writer has been engaged to create a booklet that will report on the workshop. Once produced, the booklet will be distributed in hard copy and will be posted on the MSRI web site at http://library.msri.org/cime/index.html.

By focusing on the role of the mathematics department in the mathematical preparation of teachers, workshop organizers sought to focus on two broad questions: What mathematics should teachers know, and how should they come to know this mathematics? Attention was drawn to the Conference Board of the Mathematical Sciences publication, *The Mathematical Education of Teachers II*, which recommends that, at institutions that prepare teachers, teacher education should be "an important part of a mathematics department's mission" (p.19). While there are excellent examples where this is true, workshop organizers were concerned that far too often departments fail to give sufficient attention to the important work of educating teachers of mathematics.

Thus, the CIME workshop had three core aims:

(A) to acquaint mathematicians with basic facts about teacher education and how teacher education intersects with the math department even when no one is taking special note of the department's role;

(B) to explore a set of key questions and best practices central to taking advantage of the role that mathematics departments do – or could – play in the mathematical preparation of teachers:

1. What is and what could be the role of universities in the preparation of teachers of mathematics?
2. What are the key demands and challenges of preparing teachers of mathematics?
3. What are some of the resources and examples that can help in preparing teachers of mathematics?

and

(C) to identify possible action steps to provide more collective capacity for math departments to contribute to teachers' mathematical education.

Over the three days of the workshop, 57 speakers discussed some aspect of mathematics teacher preparation either in a plenary session or in one of three parallel sessions. The opening session on Wednesday, March 26, 2014, was designed to frame the workshop issues and to encourage active participation by those participating in the workshop. After MSRI Director, David Eisenbud, welcomed participants to MSRI, Howard Gobstein, Executive Vice President for Research, Innovation, and STEM Education for the Association of Public and Land-grant Universities offered an overview of the challenges that universities face in a time of economic and societal change. He argued that universities are struggling to address severe financial constraints and to enhance degree completion. He described mathematics courses as the most important gateway courses to bachelor degree completion and expressed the viewpoint that there was a critical need to transform mathematics education.

Gobstein's presentation was followed by a conversation about the mathematical preparation of teachers and the challenges universities face among Deborah Ball, Dean of the School of Education at the University of Michigan, Herb Clemens, Chair of the Conference Board of the Mathematical Sciences and a mathematics professor at Ohio State University currently visiting the University of Utah, and Hung-Hsi Wu, a professor emeritus at the University of California, Berkeley.

Ball commented that 90% of the people who teach in the US came through the US higher education system. Thus, we have both a responsibility and the opportunity to improve what she described as a national crisis. She spoke of the importance of preparing beginning teachers who are prepared to be responsible teachers because so many teachers in the US are early in their careers. Wu argued that with respect to the mathematical preparation of teachers, universities are busy selling what they have rather than thinking about what pre-service teachers need. He placed substantial blame for the state of K-12 mathematics education at the foot of what he calls "Textbook School Mathematics." Clemens took the position that if mathematics teacher

education is to flourish in a mathematics department, the department needs a teacher education group just as it has research groups in various areas of mathematics.

After the three speakers made opening remarks, Ball moderated a conversation about mathematics teacher education among the speakers and members of the audience. At the conclusion of their session, participants were rewarded with an excellent reception that enabled participants to get to know each other better and to continue discussing the issues raised by the speakers.

The opening session on Thursday morning featured presentations designed to give mathematicians a better understanding of various aspects of mathematics teacher education that one might describe as "outside the department of mathematics." Diana Suddreth, President of the Association of State Supervisors of Mathematics and STEM Coordinator for Secondary Mathematics, Teaching and Learning at the Utah Department of Education, discussed mathematics teacher preparation from the point of view of those working in public education. She discussed licensure requirements and how they vary from state to state and discussed alternate certification routes in addition to a more traditional undergraduate education route to obtaining credentials to teach. She stressed the need for teachers to understand the students they teach and urged mathematics departments to design mathematics courses targeted to meet the needs of future teachers and urged them to build stronger relationships with both public education and colleges of education.

Deborah Ball spoke from the perspective of a mathematics educator and dean of a School of Education, arguing that there is no professionally-grounded, common system for preparing teachers. Linda Gojak, President of the National Council of Teachers of Mathematics (NCTM), discussed the role of professional organizations with respect to program review and the teacher accreditation process. She also discussed, Principles to Action, a new publication of NCTM which pulls together current research about mathematics teaching to identify eight Mathematics Teaching Practices that can guide improvements in K-12 mathematics teaching.

Bill McCallum, professor of mathematics at the University of Arizona and lead author of the Common Core State Standards for Mathematics (CCSS), then discussed the what faculty in mathematics need to know about the CCSS if they are to educate mathematics teachers prepared to teach to these standards.

Following a break, participants were treated to two outstanding panel presentations. In the first, four super mathematics teachers discussed their preparation to teach mathematics and the realities of the classroom. One (Allison Krasnow) is a Math for America master teacher, who spoke passionately about the impact of Professor Wu's professional development program and the Park City Mathematics Institute, a second (Stephanie Hassan) discussed how a speech pathology major made the transition to being an excellent mathematics teacher, in part because of Wu's professional development program and a third (Andrea LaGala Lamb) spoke of how Professors Albert and Friedberg inspired her to be a teacher at Boston College. The fourth (Breeden Murray) spoke about taking an indirect route to first avoiding mathematics in her undergraduate program and later coming to education by way of working as an educator at the

Museum of Flight and teaching science workshops for the Girl Scouts, before obtaining her mathematics teaching credential.

From the second panel, four current or former department chairs (Solomon Friedberg, Boston College, Brigitte Lahme, Sonoma State University, Steve Rosenberg, Boston University, and Peter Trapa, University of Utah) discussed the work of mathematicians in mathematics education, collaboration with math educators, and tenure and advancement for the individuals who do this work.

The first session on Thursday afternoon was a plenary session to discuss recommendations for the mathematical and statistical education of math teachers. Sybilla Beckmann, University of Georgia, and Bill McCallum (Arizona) who were the lead authors of the elementary and high school chapters of CBMS publication, *The Mathematical Education of Teachers II*, discussed recommendations found in that publication for the mathematics that teachers should know and how they should come to know that mathematics. Anna Bargagliotti, Loyola Marymount University, then discussed recommendations for teacher preparation in statistics to be found in a new publication, *Statistics Education of Teachers* that is being produced by a joint ASA-NCTM committee and is due out by the end of 2014.

The discussion of mathematical and statistical education need by teachers was followed by a presentation by Gary Martin, Auburn University, who discussed APLU's Mathematics Teacher Education Partnership (MTEP), an initiative that seeks to transform secondary mathematics teacher preparation in the US.

Following a break, the remainder of Thursday afternoon was devoted to parallel sessions that discussed resources and examples that support the preparation of mathematics teachers by departments of mathematics. Topics included the UTeach program that began at the University of Texas, courses for mathematics teachers at Arizona State University, the University of Arizona, the University of Michigan, Montana State University, the University of California, Berkeley, and Sonoma State University. One other presentation expanded on Martin's presentation with discussions of the work of the MTEP at Auburn University, the University of Arizona, the University of Nebraska-Lincoln, and West Virginia University.

The opening session on Friday morning returned to the question of demands and challenges of preparing teachers of Mathematics. Joan Ferrini-Mundy, Assistant Director, Education and Human Resources at the National Science Foundation. She discussed data that pertain to our current shortage of STEM teachers, how states certify mathematics teachers, the role of college and university mathematics departments in the preparation of teachers, and the challenge of tailoring an effective approach to career-long professional development. She discussed long-term consequences for economic growth, global competitiveness, and the general well-being of American society if we fail to ensure that students at the K-12 level are taught by well-educated teachers.

Dr. Ferrini-Mundy's talk was followed by two presentations focused on attending to diversity and equity in the recruitment and preparation of K-12 teachers of mathematics. Fabio Milner, a professor of mathematics at Arizona State University offered data that dramatically show that the

US teacher workforce is overwhelmingly white while a large percentage of the student population is brown and black. He stressed the importance of attention to social justice in the overall preparation of teachers. He discussed the work that he and his colleagues at ASU are doing to recruit and educate a more diverse mathematics teacher workforce.

Lillie Albert, a mathematics educator at Boston College discussed programs at BC including the Donovan Urban Teaching Scholars Program and the BC Noyce Teaching Fellows Program which works in collaboration with Math for America Boston. Her comments emphasized the need for mentoring of teachers by both mathematicians and master teachers, not just during their teacher preparation program but also during the first few years of teaching. She stressed the importance of working in partnership with school districts and across departments in our colleges and universities as well as the importance of addressing social justice issues.

The morning concluded with another round of parallel sessions, this time with special emphasis on universities with mathematics departments that have made a major commitment to mathematics teacher education including the University of Utah, the University of Arizona, UC-Santa Cruz, San Francisco State University, CSU San Bernardino, and Louisiana State University.

Friday afternoon began with a plenary session in which four mathematicians (two tenured and two not yet tenured) discussed their engagement in mathematics education. Dev Sinha, University of Oregon, maintains an active program of research in algebraic topology but he is also a Content Leader at Illustrative Mathematics, is working on professional learning with local districts, is involved in some state-wide efforts, and is also consulting for the Smarter Balanced Assessment Consortium. At the University of Texas-Arlington, James Epperson directs a Master of Arts in Mathematics program for secondary teachers, served as a member of a select group of advisors to Texas' Commissioner of Education that produced the Commissioner's Draft of the Texas Mathematics Standards, and regularly serves on expert review panels for state assessments in mathematics as well as advisory groups for mathematics teacher professional development.

Yvonne Lai, University of Nebraska-Lincoln, and Sunita Vatuk, City College of New York, discussed their personal journeys from postdocs at Michigan and Princeton respectively to positions as untenured assistant professors that are focused on mathematics education research within a department of mathematics.

The final set of parallel sessions were forced on professional development opportunities for mathematics teachers both within mathematics departments and in programs outside mathematics departments. The CIME workshop organizers selected this session to offer examples of involvement in professional development in order to make visible examples of how other mathematics departments could become more involved in mathematics teacher professional development.

Darryl Yong, a professor of mathematics at Harvey Mudd College, discussed Math for America with special emphasis on its Master Teacher Fellowships which honor accomplished teachers and support them as leaders. He focused on the programs in New York City and Los Angeles. Yong then teamed with Gail Burrill to discuss the Park City Mathematics Institute Summer

School Teacher Program. Hung-Hsi Wu discussed the Mathematical Professional Development Institute that he created at MSRI and a team of presenters discussed Math Teachers' Circles that are organized and supported by the American Institute for Mathematics. Two other sessions discussed the Focus on Mathematics program at Boston University and NebraskaMATH at the University of Nebraska-Lincoln, two programs that were started with NSF funding.

To bring the CIME workshop to closure, Deborah Ball and Jim Lewis offered their reflections on the ideas they heard discussed at the workshop. Ball, in particular, discussed the role that the CIME workshops have played in the development of a community of people who care about mathematics education and who come together to work on these issues.

Organizers		
First Name	**Last Name**	**Institution**
Deborah	Ball	University of Michigan
Solomon	Friedberg	Boston College
Jim	Lewis	University of Nebraska
Peter	Trapa	University of Utah
Hung-Hsi	Wu	University of California, Berkeley
Darryl	Yong	Harvey Mudd College

Speakers		
First Name	**Last Name**	**Institution**
Lillie	Albert	Boston College
Emina	Alibegovic	University of Utah
Gretchen	Andreasen	University of California, Santa Cruz
Cynthia	Anhalt	University of Arizona
Scott	Baldridge	Louisiana State University
Deborah	Ball	University of Michigan
Anna	Bargagliotti	Loyola Marymount University
Hyman	Bass	University of Michigan
Matthias	Beck	San Francisco State University
Sybilla	Beckmann	University of Georgia
Nandini	Bhattacharya	University of California, Santa Cruz
Gail	Burrill	Michigan State University
Elizabeth	Burroughs	Montana State University
Thomas	Clark	University of Nebraska
Herb	Clemens	University of Utah
Margarita	Cummings	University of Utah
James	Epperson	University of Texas
John	Ewing	Math for America
Joan	Ferrini-Mundy	National Science Foundation
Davida	Fischman	California State University
Solomon	Friedberg	Boston College
Howard	Gobstein	Association of Public and Land-grant Universities
Linda	Gojak	National Council of Teachers of Mathematics
Ole	Hald	UC Berkeley Math Faculty
Stefanie	Hassan	Little Lake School District
Allison	Krasnow	University of California, Berkeley
Andrea	LaGala Lamb	Waltham Public Schools
Brigitte	Lahme	Sonoma State University
Yvonne	Lai	University of Nebraska
Jim	Lewis	University of Nebraska
Debra	Lewis	University of California, Santa Cruz
James	Madden	Louisiana State University
Michael	Marder	University of Texas
Tom	Marley	University of Nebraska
W. Gary	Martin	Auburn University

Michael	Mays	West Virginia University
William	McCallum	University of Arizona
Fabio	Milner	Arizona State University
Breedeen	Murray	The Bay School of San Francisco
Cody	Patterson	University of Arizona
Robert	Perlis	Louisiana State University
Steven	Rosenberg	Boston University
Hugo	Rossi	University of Utah
Dev	Sinha	University of Oregon
Wendy	Smith	University of Nebraska
Glenn	Stevens	Boston University
Diana	Suddreth	Utah State Office of Education
Patrick	Thompson	Arizona State University
Peter	Trapa	University of Utah
Sunita	Vatuk	City College, CUNY
Diana	White	University of Colorado
Hung-Hsi	Wu	University of California, Berkeley
Darryl	Yong	Harvey Mudd College

Mathematical Sciences Research Institute
2014 Critical Issues in Mathematics Education Workshop

The Role of The Mathematics Department in the Mathematical Preparation of Teachers

Schedule Overview

Wednesday, March 26, 2014

1. What is and what could be the role of universities in the preparation of teachers of mathematics?

4:00 – 6:00 **Session 1.....Simons Auditorium**
Welcome and Workshop Overview
4:15 Keynote Address – The Signal and the Noise and Changing Teacher Preparation
4:45 A conversation about the mathematical preparation of teachers and the challenges universities face

6:00 – 7:15 **Reception ..... Atrium**

7:15 **Last Bus leaves MSRI**

Thursday, March 27, 2014

2. What are the key demands and challenges of preparing teachers of mathematics?

8:30 – 10:00 **Session 2.....Simons Auditorium**
8:30 Understanding mathematics teacher education
9:30 What faculty in mathematics should know about the Common Core State Standards for Mathematics (CCSS)

10:00 – 10:30 **Break..... Atrium**

10:30 – 12:30 **Session 3.....Simons Auditorium**
10:30 Listening to our graduates
11:30 Panel of mathematics department chairs

12:30 – 1:30 **Lunch..... Atrium**

1:30 – 3:20 **Session 4.....Simons Auditorium**
1:30 Recommendations of the Mathematical Education of Teachers II
2:30 Statistics Education for Teachers (SET)
2:55 APLU's Mathematics Teacher Education Partnership

3:20 – 3:50 **Break..... Atrium**

3. What are some of the resources and examples that can help in preparing teachers of mathematics?

3:50 – 6:00 **Session 5: Parallel Sessions**
Mathematics courses for teachers and examples of math teacher education programs with strong involvement from the institution's department of mathematics.

Session 5A .....Simons Auditorium
3:50 – 4:30 UTeach: Preparing 6500 students to teach secondary mathematics and science
4:35 – 5:15 Courses in a mathematics department that emphasize mathematical meanings for teaching mathematics
5:20 – 6:00 A course on making mathematical connections (for teachers and math majors)

Session 5B..... Baker Boardroom
3:50 – 4:30 Three specialized mathematics courses for teaching
4:35 – 5:15 Collaboration between mathematicians and mathematics educators at Sonoma State University
5:20 – 6:00 The UC Berkeley teaching concentration for math majors

Session 5C.....Space Sciences Lab Addition Conference Room
3:50 – 4:30 The MTE-Partnership: Rethinking secondary mathematics teacher education
4:35 – 5:15 Three dimensions of course design for preservice secondary teachers

Friday, March 28, 2014

2. What are the key demands and challenges of preparing teachers of mathematics?

8:30 – 10:20 **Session 6.....Simons Auditorium**
8:30 National perspectives on mathematical teacher education and preparation
9:15 Attending to diversity and equity in the recruitment and preparation of K-12 teachers of mathematics

10:20 – 10:50 **Break..... Atrium**

3. What are some of the resources and examples that can help in preparing teachers of mathematics?

10:50 – 12:15 **Session 7: Parallel Sessions**
Mathematics departments' engagement in the mathematical preparation of teachers.

Session 7A ..... Simons Auditorium
10:50 – 11:30 Mathematics learning with teachers
11:35 – 12:15 Combining policy and practice: new directions for the institute for mathematics and education at the University of Arizona

Session 7B..... Baker Boardroom
10:50 – 11:30 Slugs on STEM: preparing competent and diverse teachers
11:35 – 12:15 Teacher preparation and the Common Core

Session 7C.....Space Sciences Lab Addition Conference Room
10:50 – 11:30 Mathematics department involvement in K-12 mathematics education at Louisiana State University: A half century of growth
11:35 – 12:15 Adventures of mathematicians in school mathematics

12:15 – 1:15 **Lunch..... Atrium**

1:15 – 2:35 **Session 8.....Simons Auditorium**
Mathematicians engaged in mathematics education

2:35 – 3:05 **Break..... Atrium**

3:05 – 4:30 **Session 9: Parallel Sessions**
Professional development opportunities for mathematics teachers

Session 9A .....Simons Auditorium
3:05 – 3:45 Math for America
3:50 – 4:30 Developing teachers as professionals: The Park City Mathematics Institute Summer School Teacher Program

Session 9B..... Baker Boardroom
3:05 – 3:45 Focus on Mathematics
3:50 – 4:30 MSRI's Mathematical Professional Development Institute

Session 9C.....Space Sciences Lab Addition Conference Room
3:05 – 3:45 Math Teachers' Circles: Building mathematical communities of teachers and mathematicians
3:50 – 4:30 NebraskaMATH

4:35 – 5:00 **Session 10.....Simons Auditorium**
Reflections on ideas discussed at the workshop.

Participants

First Name	Last Name	Institution
Malcolm	Adams	University of Georgia
Lillie	Albert	Boston College
Emina	Alibegovic	University of Utah
fahd	alshammari	King Saud University
Gretchen	Andreasen	University of California, Santa Cruz
alejandro	andreotti	Iowa State University
Uri	Andrews	University of Wisconsin
Cynthia	Anhalt	University of Arizona
Carlos	Arriola	The American School Foundation
Erin	Baldinger	Stanford University
Scott	Baldridge	Louisiana State University
Deborah	Ball	University of Michigan
Anna	Bargagliotti	Loyola Marymount University
Hyman	Bass	University of Michigan
Matthias	Beck	San Francisco State University
Jerry	Becker	Southern Illinois University
Sybilla	Beckmann	University of Georgia
Nandini	Bhattacharya	University of California, Santa Cruz
Chris	Bose	University of Victoria
Priscilla	Bremser	Middlebury College
Tammy	Brown	National Math and Science Initiative
Gregory	Budzban	Southern Illinois University
Gail	Burrill	Michigan State University
Elizabeth	Burroughs	Montana State University
Wesley	Calvert	Southern Illinois University
Santiago	Camacho	University of Illinois at Urbana-Champaign
Bem	Cayco	San Jose State University
Guantao	Chen	Georgia State University
Michelle	Chenal-Ducey	Tulare County Office of Education
Michael	Ching	University of Massachusetts, Amherst
Phyllis	Chinn	Humboldt State University
Thomas	Clark	University of Nebraska
Herb	Clemens	University of Utah
Amy	Cohen-Corwin	Rutgers University
J.	Conrey	AIM - American Institute of Mathematics
Ricardo	Cortez	Tulane University
David	Crombecque	University of Southern California
Margarita	Cummings	University of Utah
Heather	Dallas	University of California, Los Angeles
Jessica	Deshler	West Virginia University
Jacqueline	Dewar	Loyola Marymount University
Thomas	Dick	Oregon State University
Lew	Douglas	Lawrence Hall of Science
Becky	Duprey	SUNY College at Potsdam
Wade	Ellis	West Valley College

Susanna	Epp	DePaul University
James	Epperson	University of Texas
Kelly	Estrada	Sonoma State University
Chrisitna	Eubanks-Turner	Loyola Marymount University
Kellie	Evans	California State University, Northridge
John	Ewing	Math for America
melissa	fabros	University of California, Merced
Joan	Ferrini-Mundy	National Science Foundation
Davida	Fischman	California State University
Solomon	Friedberg	Boston College
Daniel	Frohardt	Wayne State University
Eddie	Fuller	West Virginia University
Terence	Gaffney	Northeastern University
Angela	Gallegos	Loyola Marymount University
Howard	Gobstein	Association of Public and Land-grant Universities
Linda	Gojak	National Council of Teachers of Mathematics
Joanne	Goodell	Cleveland State University
Frances	Gulick	University of Maryland
Denny	Gulick	University of Maryland
Ole	Hald	UC Berkeley Math Faculty
Kathleen	Hamon	Stanford University
Cymra	Haskell	University of Southern California
Stefanie	Hassan	Little Lake School District
Shandy	Hauk	WestEd
Aloysius	Helminck	North Carolina State University
Jennifer	Hogan	Fondesch
John	Holcomb	Cleveland State University
Mark	Hoover	University of Michigan
Theresa	Jorgensen	University of Texas
Cathy	Kessel	consultant
Myong-Hi	Kim	College at Old Westbury, SUNY
Victoria	Klawitter	SUNY College at Potsdam
Allison	Krasnow	University of California, Berkeley
Oh Hoon	Kwon	University of Wisconsin
Andrea	LaGala Lamb	Waltham Public Schools
Brigitte	Lahme	Sonoma State University
Yvonne	Lai	University of Nebraska
Juwen	Lam	Alameda County of Education
Brian	Lawler	California State University
Jim	Lewis	University of Nebraska
Debra	Lewis	University of California, Santa Cruz
Aihua	Li	Montclair State University
Maria	Lorenz	Temple University
Miroslav	Lovric	McMaster University
James	Madden	Louisiana State University
Robert	Maillardet	University of Melbourne
Michael	Marder	University of Texas

Tom	Marley	University of Nebraska
W. Gary	Martin	Auburn University
Samuel	Martinez	University of California, Berkeley
Michael	Mays	West Virginia University
William	McCallum	University of Arizona
Emily	McCullough	San Francisco State University
Lee	McEwan	The Ohio State University-Mansfield
Robert	Megginson	University of Michigan
Fabio	Milner	Arizona State University
Calvin	Moore	University of California, Berkeley
Charles	Moore	Washington State University
Jen	Munson	Stanford University
Breedeen	Murray	The Bay School of San Francisco
Douglas	O'Roark	University of Chicago
Matthew	Pancia	University of Texas
Marina	Papkovich	Polotsk State University
Cody	Patterson	University of Arizona
Robert	Perlis	Louisiana State University
Rebecca	Poon	University of California, Berkeley
Laura	Pyzdrowski	West Virginia University
Katherine	Reid	University of California, Berkeley
Lisa	Rezac	University of St. Thomas
Birgit	Richter	Universitat Hamburg
Emily	Riehl	Harvard University
Tom	Roby	University of Connecticut
Steven	Rosenberg	Boston University
Hugo	Rossi	University of Utah
Silvia	Saccon	University of Texas at Dallas
Thorsten	Scheiner	Universitat (Hochschule) der Bundeswehr Hamburg
Wilhelm	Schlag	University of Chicago
Daniel	Schultz-Ela	Colorado Mesa University
David	Scott	University of Puget Sound
Sarah	Selling	Stanford University
Keyur	Shah	Alameda County of Education
Meghan	Shaughnessy	University of Michigan
Dev	Sinha	University of Oregon
Melanie	Smith	Math for America
Wendy	Smith	University of Nebraska
Dick	Stanley	University of California, Berkeley
Glenn	Stevens	Boston University
Diana	Suddreth	Utah State Office of Education
Yahya	Tabesh	Sharif University of Technology
Patrick	Thompson	Arizona State University
Peter	Trapa	University of Utah
Susan	Troutman	Rice University
Kristin	Umland	University of New Mexico
Sunita	Vatuk	City College, CUNY

Rajeev	Virmani	University of San Francisco
jane	wentzel	California State University
Maria	Wesslen	University of Toronto, Mississauga
Nina	White	University of Michigan
Diana	White	University of Colorado
Brandy	Wiegers	San Francisco State University
marlene	Wilson	Oakland Unified School District
Aaron	Wilson	University of Texas Pan American
Alistair	Windsor	University of Memphis
Christopher	Wu	Contra Costa College
Hung-Hsi	Wu	University of California, Berkeley
Ze'ev	Wurman	Stanford University
Darryl	Yong	Harvey Mudd College

Officially Registered Participant Information

Participants		**152**

Gender		**152**
Male	50.66%	77
Female	49.34%	75
Declined to state	0.00%	0

Ethnicity*		**152**
White	73.68%	112
Asian	9.21%	14
Hispanic	7.24%	11
Pacific Islander	0.66%	1
Black	2.63%	4
Native American	0.66%	1
Mixed	1.97%	3
Declined to state	3.95%	6

* ethnicity specifications are not exclusive

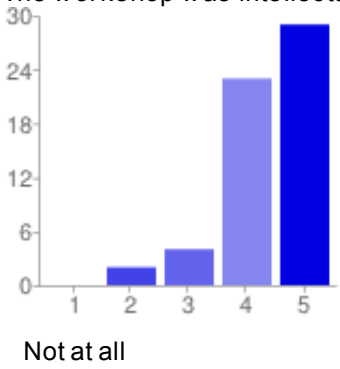
This form will soon be upgraded to the new version of Google Forms. Learn more.

58 responses

Summary See complete responses

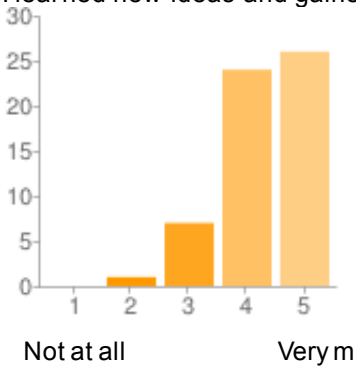
Workshop assessment

The workshop was intellectually stimulating



1 -	Not at all	0	0%
2		2	3%
3		4	7%
4		23	40%
5 -	Very	29	50%

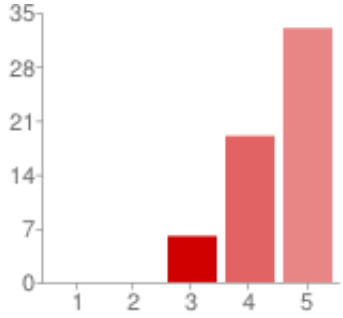
I learned new ideas and gained new perspectives at the workshop



1 -	Not at all	0	0%
2		1	2%
3		7	12%
4		24	41%
5 -	Very much	26	45%

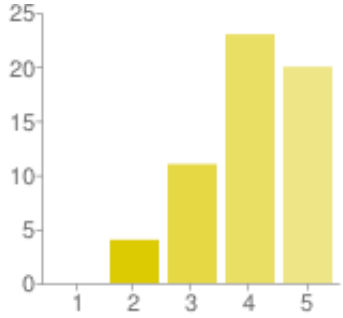
The overall experience of the workshop was worthwhile

1 -	Not at all	0	0%
2		0	0%
3		6	10%
4		19	33%
5 -	Very	33	57%



Not at all Very

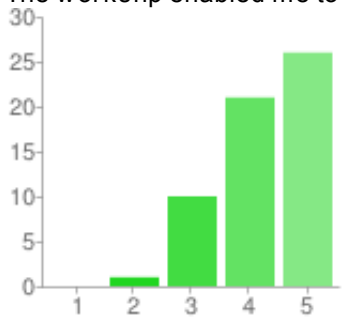
The structure of plenary sessions, concurrent sessions and breaks was adequate for discussion



1 -	Not al all	0	0%
2		4	7%
3		11	19%
4		23	40%
5 -	Very	20	34%

Not al all Very

The workshp enabled me to learn and make connections that will help me advance my efforts



1 -	Not al all	0	0%
2		1	2%
3		10	17%
4		21	36%
5 -	Very	26	45%

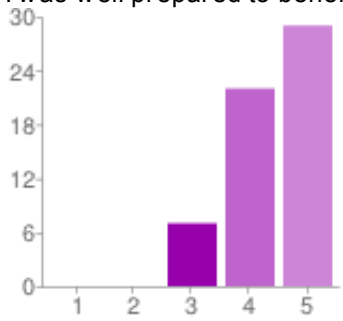
Not al all Very

Additional comments on the workshop organization

Facilitators should monitor time of presenters and audience comments better I was disappointed that none of the presentations were interactive -- this is different than allowing a few minutes for que ...

Personal assessment

I was well prepared to benefit from the sessions



1 -	Not at all	0	0%
2		0	0%
3		7	12%
4		22	38%
5 -	Very	29	50%

My interest in the subject matter was increased by the workshop

1 -	Niot at all	2	3%
2		0	0%
3		11	19%
4		20	34%
5 -	Very	25	43%

The workshop helped me meet people with similar interests

1 -	Not at all	0	0%
2		1	2%
3		8	14%
4		14	24%
5 -	Very Much	35	60%

Additional comments on your personal assessment

Have roundtable discussions to let less known people talk/interact with the well known

This workshop was great. Sometimes I get confused about who the audience is though. Research-I mathematicians? ...

Additional Activities

Did you attend the first night reception?

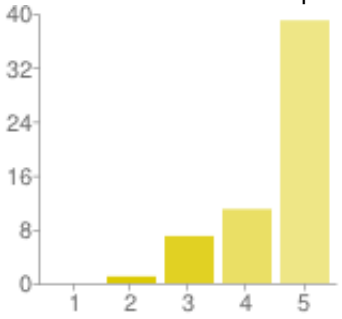
Yes	48	83%
No	10	17%

Please provide any comments on the reception

it was really nice! Thank you. Good food! Good food Good food and company. great opportunity for socialization/conversations! Awesome company and food. happy with it It was very nice and a great opportunit ...

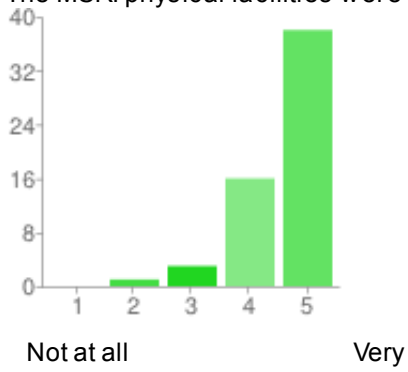
Venue

I found the MSRI staff helpful



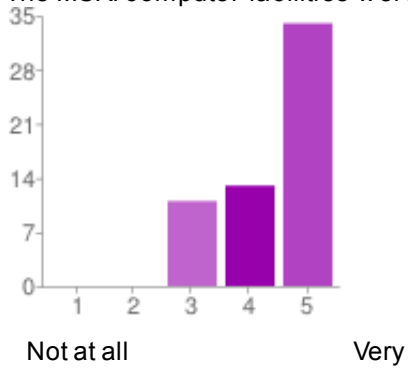
1 -	Not at all	0	0%
2		1	2%
3		7	12%
4		11	19%
5 -	Very	39	67%

The MSRI physical facilities were conducive for such a workshop



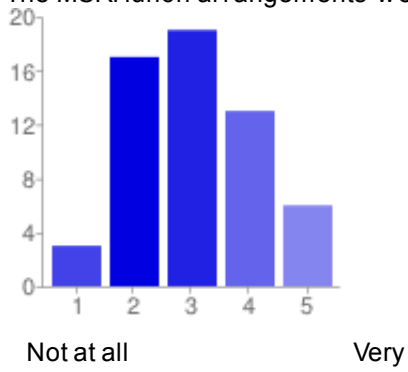
1 -	Not at all	0	0%
2		1	2%
3		3	5%
4		16	28%
5 -	Very	38	66%

The MSRI computer facilities were adequate for such a workshop



1 -	Not at all	0	0%
2		0	0%
3		11	19%
4		13	22%
5 -	Very	34	59%

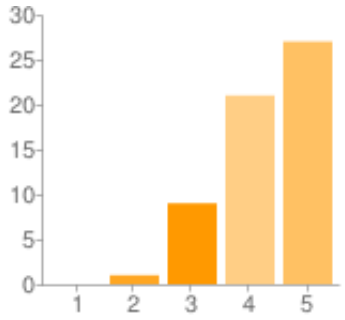
The MSRI lunch arrangements were satisfactory



1 -	Not at all	3	5%
2		17	29%
3		19	33%
4		13	22%
5 -	Very	6	10%

The MSRI tea arrangements were satisfactory

1 -	Not at all	0	0%
2		1	2%
3		9	16%
4		21	36%



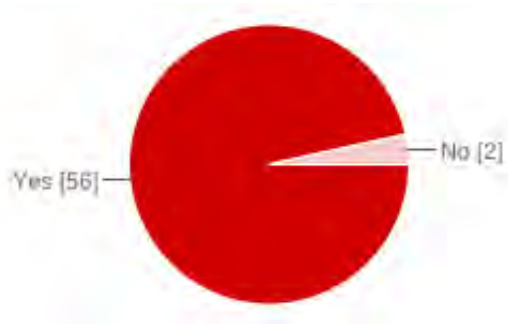
5 -	Very	27	47%

Additional comments on the venue

Let people know about free street parking on Grizzly Peak the colors in the slides did not show well Large workshops need more efficent feeding mechanisms ran out of food in one lunch Trouble anticipati ...

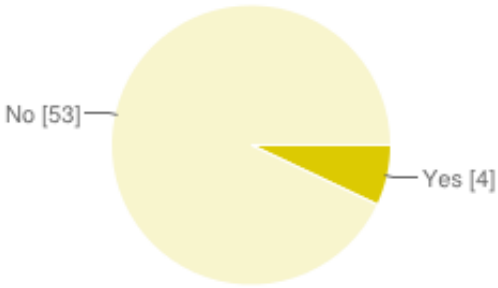
MSRI Wireless Network

Did you use MSRI's wireless network?



Yes	56	97%
No	2	3%

Did you experience any difficulties with the network?



Yes	4	7%
No	53	91%

If you did experience difficulties with the network, please explain:

It is slow during breaks I'm slightly amazed by how well the public WiFi network there works. I'm really unused to having good, fast internet (or any internet at all) at conferences. Thanks. occasio ...

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 breaks, variety of speakers, scheduling the conference during Cal's spring break Funding seemed to be significantly less than in previous years... Thank you. I look forward to (hopeful ...

Number of daily responses

Critical Issues In Mathematics Education 2014: The Role Of The Mathematics Department In The Mathematical Preparation Of Teachers
March 26, 2014 - March 28, 2014

Additional Survey Responses

Additional comments on workshop organization

- Facilitators should monitor time of presenters and audience comments better
- I was disappointed that none of the presentations were interactive -- this is different than allowing a few minutes for questions
- Too many people talking without slides
- Last year, I felt like there was a clear work product that we were supposed to walk away with. This year, that hasn't felt as tangible.
- Thank you so much for a wonderful time! Great facilitation overall ("that wasn't a question"), also liked the break times to connect to new and old colleagues. Sometimes I leave wondering what to do with what I have heard at the workshop, especially if there is a lot of big picture "we need to change the field" exhortations but no concrete individually actionable items. I like some big picture ideas, but it's confusing and anxiety-building to have only moral imperatives thrown at us and fewer examples/details of mathematics programs that can be brought back/perhaps adapted to my own institution.
- The website was badly designed and did not provide a comprehensive two page schedule of the talks
- I heard from a number of people that they wanted to attend my concurrent session, but it ran at the same time as another one that was thematically similar. This isn't a complaint about having concurrent sessions, though, because it gave a number of people (like me) the chance to talk about their work.
- I would have liked more time for questions at the end of the sessions - the plenary sessions in particular. I think the session facilitators can help make this happen in the future.
- The bizarre rule of the organizers that audience members could ask questions but not make statements after presentations stifled useful discussion.
- small thing: parallel sessions would be better presented on the schedule showing all the ones happening at the same time together instead of organizing by room.
- I really appreciated the structure and the breaks that were long enough to have conversations.
- Good, but less opportunity for exchange than other years
- This mix of plenary's, breakouts, and breaks was very good.
- Better structure for discussion would be valuable.
- I have attended many CIME workshops so much, while very worthwhile, was not new. One detail that would have been helpful to me would have been to group the concurrent sessions by time rather than by location. I prefer having a schedule that goes by time as I go down the page.
- The opportunity to hear from so many prominent people in the field was remarkable--that, in and of itself, made the experience worthwhile. I would have liked more variety in the way the presentations were organized however--time for turn and talk with other audience members, for example. Also, I'd like more intentional opportunities for networking on the first day. I made connections, but anything to foster this more would have been great!

- Schedule more time between parallel sessions for people who would like to attend sessions in different locations.
- the seamless and near invisible help from the staff is amazing
- The overall conference was missing perspectives from mathematics educators working in mathematics departments. It is important to hear different perspectives of all faculty that do teacher preparation in a math department
- well organized
- I'm not sure how to fix it, but the plenary followed by Q&A didn't always work - not enough time for discussion. Perhaps structured small group discussions with reports out to the whole group would be a format worth trying.
- Kudos to the organizers for an engaging and informative session. Loved the panels, especially the student panel.
- Workshop was beneficial in understanding the lack of teaching to the teachers. However it did not deal with how to teach and what to teach. I was looking forward to some constructive solutions to the problem.
- Very salient presentations and discussions!

Additional comments on your personal assessment

- Have roundtable discussions to let less known people talk/interact with the well known
- This workshop was great. Sometimes I get confused about who the audience is though. Research-I mathematicians? Community college? Liberal arts faculty? Department chairs, pre-tenure, tenured?
- This workshop was a bit edgier than previous ones I have attended. People were more open about divergent points of view, etc.
- The chance to make connections with others doing similar work was the most valuable aspect of the workshop for me. Thanks.
- The workshop was a great network opportunity for me. I was able to meet many mathematicians and math educators with similar interests and goals.
- A list with readings suggested by organizers, speakers, panelists would have been beneficial.
- I didn't feel there was an action plan for moving forward.
- Hy Bass' talk was the most interesting. He should have been given more time.
- I am a chair of a math department in canada, so some of the issues discussed were outside my area of familiarity, but overall, I see a lot of things we should be thinking about in my own department.
- I do not teach a course specifically to teachers but a lot of teachers take my class. By background in both Education and Math made this conference interesting.

Provide any comments on the reception

- it was really nice! Thank you.
- Good food!
- Good food
- Good food and company.
- great opportunity for socialization/conversations!
- Happy with it
- It was very nice and a great opportunity to get to know other participants.
- Food was great, especially after a day of travel in which I hadn't had the chance to eat. Thanks.
- Great food

- very welcoming, & the food and drinks were fabulous
- Fine - good chance to meet people
- It was worthwhile, and I met others with similar interests.
- Very nice
- Nice way to begin the program
- The reception was lovely, a nice way to begin the workshop.
- As someone from 'outside' the math ed community, I found this very helpful. Nicely done. Great venue!
- The food was fabulous. But the place was small so mingling with other people was difficult.
- Very lovely, delicious; ample choices and amounts. Thank you!
- thank you for the variety of options.
- Not enough room to move.

Additional comments on the venue

- Let people know about free street parking on Grizzly Peak
- the colors in the slides did not show well
- Large workshops need more efficent feeding mechanisms
- ran out of food in one lunch
- Trouble anticipating demand
- I wouldn't mind paying for lunch so much if we had the ability to go off-campus and choose what we want to eat. Having a sole caterer with a captive market paying for lunch seems a little wrong to me.
- They ran out of sandwiches on the first day. This was difficult. The food was much better on the second day: Noah's bagels instead of packaged breakfast pastries, the strawberries were excellent, there were enough sandwiches - all these things were very good. I would have liked better coffee. Peet's? A different brew?
- Question on computers not applicable
- obviously the lunch was lacking (both in quantity but also quality). Using the Space Science conference room was less than ideal--no guest wifi and the connector for the projector kept cutting out on us.
- As you know the caterer did not bring sufficient food for lunch on Thursday. I did not mind going to Space Sciences, but the need to do so points out the fact that MSRI does not have enough breakout rooms.
- I would have preferred it to be down in the main Berkeley campus. A bit isolated and hard to get. Beautiful, certainly.
- I appreciate the staff, and everyone was helpful. I would like to have been in spaces with smaller groups at times where we talked and interacted more.
- I understand that it is not the planning committee's error for the shortage of lunches (there was another workshop going on)
- I think the lunch problem the first day was not MSRI's fault.
- ice would have been nice
- I would like to have had juice or hot chocolate instead of coffee or tea.
- It was unfortunate that we ran out of lunch on Thursday. However, I appreciated the attempt to remedy the situation by ordering pizza.
- MSRI is a real jewel for math science.
- Beautiful location!!

- I felt so sorry that not all participants were able to buy lunch on Thursday due to inadequate supplies.
- Not enough lunch one day. Needs another tea station and more varied (healthy) snacks

If you did experience difficulties with the network, please explain:

- It is slow during breaks
- I'm slightly amazed by how well the public WiFi network there works. I'm really unused to having good, fast internet (or any internet at all) at conferences. Thanks.
- occasionally was kicked off
- Network unavailable in the science addition building where some breakout sessions were held.
- I could not access the wireless in the space building.
- None whatsoever. Great bandwidth.

We welcome any additional comments or suggestions you may have to improve the overall experience for future participants

- Thanks for the breaks, variety of speakers, scheduling the conference during Cal's spring break
- Funding seemed to be significantly less than in previous years...
- Thank you. I look forward to (hopefully) joining you again next year!
- Love you guys. Thanks for a great experience again.
- This workshop provides a unique platform where mathematicians and mathematics educators can dialogue about important issues in teaching in learning of mathematics. Important connections to bridge the academic and historical cultures of both groups in order to understand how to move forward in advancing mathematics education for all.
- I was hoping to hear more about specific courses directed to each of elementary, ms, and hs preservice teachers in more detail. Not enough detail for my needs.
- Thank you for offering this opportunity!
- Thanks for a great workshop!
- It was excellent- thank you!
- Hope to have a chance to work at MSRI again in the near future.
- The conference did a great job of presenting the critical issue. I wish we could learn about some specifics about how to solve it.
- Thank you for choosing this topic.
- The organizers made a strong effort to keep questions from turning into statements, but perhaps every participant should be limited to two questions (at plenary sessions) so that conversation isn't dominated by a few? I also would have appreciated a broader view of the goals of education -- not just training a workforce but preparing future citizens to make informed decisions.

Summer Graduate School: Introduction to the Mathematics of Seismic Imaging

July 29, 2013 to August 9, 2013

MSRI, Berkeley, CA, USA

Organizers:

Gunther Uhlmann* (University of Washington)

Final Report for Graduate Summer School: Introduction to the Mathematics of Seismic Imaging

Organizer: Gunther Uhlmann

In this two week program some of the mathematical foundations of seismic imaging were discussed. This was one of the components of the Mathematics of Planet Earth (MPE) year in 2013. The goal in seismic imaging is to determine the inner structure of the Earth from the crust to the inner core by using information provided by earthquakes in the case of the deep interior or by measuring the reflection of waves produced by acoustic or elastic sources on the surface of the Earth. The mathematical problem can be formulated as an inverse problem for the wave equation: can one recover the sound speed of a medium by measuring information produced at the boundary by seismic waves?

The lecturer during the first week was Laurent Demanet, an Assistant Professor at the Department of Mathematics at MIT, and one of the leading figures in seismic imaging. During the second week the lecturer was William Symes the Noah Harding Professor at Rice University who is also one of the world experts on seismic imaging and a director of the Rice Inversion Project. There were computer labs and problem sessions to complement the lectures. The computer labs were run by Russell Hewett a postdoc of Demanet at MIT and Francois Monard, a postdoc of Gunther Uhlmann at the University of Washington. The problem sessions were run by Sean Holman a postdoc of Maarten de Hoop at Purdue.

Seismic imaging is an interdisciplinary subject, not typically offered in the graduate curriculum at US universities. The summer school took students to the doorstep of research in the area. It showed the participants that geophysics has important open problems of a strong mathematical nature, and also showed the intellectual significance of engineering challenges. The links to industry practice, make students attractive hiring prospects for the oil and gas industry.

It was encouraging to see that a good majority of students were personally very involved in the labs and exercise sessions. Many of them used the breaks to work on the assigned exercises.

On the last day it was assigned a blind imaging exercise where the stu-

dents were supposed to make sense of a seismic dataset. Many students succeeded in reaching meaningful conclusions and were very engaged. Much of week 1 was dedicated to bringing the students to the level where they could think on their own about this particular exercise. This was a very successful experiment.

Organizers* and Lecturers		
First Name	**Last Name**	**Institution**
Laurent	Demanet	Massachusetts Institute of Technology
Bruce	Pell	Arizona State University
William	Symes	Rice University
Gunther	Uhlmann*	University of Washington

Teaching Assistant		
First Name	**Last Name**	**Institution**
Russell	Hewett	Massachusetts Institute of Technology
Sean	Holman	Purdue University
Francois	Monard	University of Washington

Intro to the Mathematics of Seismic Imaging

July 29, 2013-August 9, 2013

Schedule

Monday July 29, 2013			
9:15 AM - 9:30 AM	Simons Auditorium		Welcome
9:30 AM - 10:30 AM	Simons Auditorium	Laurent Demanet	Lecture
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00 PM	Simons Auditorium	Laurent Demanet	Lecture
12:00 PM - 2:00 PM	Atrium		Lunch
2:00 PM- 3:00 PM	Simons Auditorium		Problem Session
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:30 PM	Simons Auditorium		Computer Lab

Tuesday July 30, 2013			
9:30 AM - 10:30 AM	Simons Auditorium	Laurent Demanet	Lecture
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00 PM	Simons Auditorium	Laurent Demanet	Lecture
12:00 PM - 2:00 PM	Atrium		Lunch
2:00 PM -3:00 PM	Simons Auditorium		Problem Session
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM -4:30 PM	Simons Auditorium		Computer Lab

Wednesday July 31, 2013			
9:00 AM - 10:00 AM	Simons Auditorium	Laurent Demanet	Lecture
10:00 AM -10:30 AM	Atrium		Tea
10:30AM - 11:30 AM	Simons Auditorium	Laurent Demanet	Lecture
11:30AM - 2:00 PM	Cordornices Park		BBQ Lunch
2:00 PM - 3:00 PM	Simons Auditorium		Problem Session
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM-4:30 PM	Simons Auditorium		Computer Lab

Thursday Aug 1, 2013			
9:30 AM - 10:30 AM	Simons Auditorium	Laurent Demanet	Lecture
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00 PM	Simons Auditorium	Laurent Demanet	Lecture
12:00PM- 2:00 PM	Atrium		Lunch
2:00PM - 3:00 PM	Simons Auditorium		Problem Session
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:30 PM	Simons Auditorium		Computer Lab

Friday Aug 2, 2013			
9:30 AM - 10:30 AM	Simons Auditorium	Laurent Demanet	Lecture
10:30 AM - 11:00 AM	Atrium		Tea
11:00 PM - 12:00 PM	Simons Auditorium	Laurent Demanet	Lecture
12:00 PM - 2:00 PM	Atrium		Lunch
2:00 PM- 3:00 PM	Simons Auditorium		Problem Session
3:00 PM -3:30 PM	Atrium		Tea
3:30 PM - 4:30 PM	Simons Auditorium		Computer Lab

Monday Aug 5, 2013			
9:30 AM - 10:30 AM	Simons Auditorium	William Symes	Lecture
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00 PM	Simons Auditorium	William Symes	Lecture
12:00 PM - 2:00 PM	Atrium		Lunch
2:00 PM- 3:00 PM	Simons Auditorium		Problem Session
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:30 PM	Simons Auditorium		Computer Lab

Tuesday Aug 6, 2013			
9:30 AM - 10:30 AM	Simons Auditorium	William Symes	Lecture
10:30 AM - 11:00 AM	Atrium		Coffee Break
11:00 AM - 12:00	Simons Auditorium	William Symes	Lecture
12:00 PM - 2:00 PM	Atrium		Lunch
2:00 PM -3:00 PM	Simons Auditorium		Problem Session
3:00PM - 3:30 PM	Atrium		Coffee Break
3:30 PM - 4:30 PM	Simons Auditorium		Computer Lab

Wednesday Aug 7, 2013			
9:30 AM - 10:30 AM	Simons Auditorium	William Symes	Lecture
10:30 AM - 11:00 AM	Atrium		Tea
11:00AM - 12:00 PM	Simons Auditorium	William Symes	Lecture
12:00 PM - 2:00 PM	Atrium		Lunch
2:00 PM - 3:00 PM	Simons Auditorium		Problem Session
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM -4:30 PM	Simons Auditorium		Computer Lab

Thursday Aug 8, 2013			
9:30 AM - 10:30 AM	Simons Auditorium	William Symes	Lecture
10:30 AM - 11:00 AM	Atrium		Tea
11:00AM - 12:00 PM	Simons Auditorium	William Symes	Lecture
12:00 PM - 2:00 PM	Atrium		Lunch
2:00PM - 3:00 PM	Simons Auditorium		Problem Session
3:00 PM -3:30 PM	Atrium		Tea
3:30 PM - 4:30 PM	Simons Auditorium		Computer Lab

Friday Aug 9, 2013			
9:30 AM - 10:30 AM	Simons Auditorium	William Symes	Lecture
10:30 AM - 11:00 AM	Atrium		Tea
11:00AM - 12:00 PM	Simons Auditorium	William Symes	Lecture
12:00 PM - 2:00 PM	Atrium		Lunch
2:00PM - 3:00 PM	Simons Auditorium		Problem Session
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:30 PM	Simons Auditorium		Computer Lab

Attending Students		
First Name	**Last Name**	**Institution**
Yajun	An	University of Washington
Diana	Atanasova	Boston University
Patrick	Bardsley	University of Utah
Philip	Benge	Georgia Institute of Technology
James	Broda II	University of Oklahoma
Lopamudra	Chakravarty	Kent State University
Yifan	Chang	University of British Columbia
Jacqueline	Davis	Vanderbilt University
Michele	De La Chevrotiere	University of Victoria
Olaseni	Fadipe	Central Michigan University
Shubin	Fu	Texas A & M University
Meghan	Galiardi	University of Illinois at Urbana-Champaign
Denitza	Gintcheva	University of Rochester
Yuntao	He	Northeastern University
Jeremy	Hoskins	University of Michigan
Yin	Huang	Rice University
Tania	Ibanez	California State University
Donghun	Kim	Seoul National University
Manuel	Larenas	Rutgers University
Khoa	Le	University of Kansas
Wenjing	Liao	University of California
Kaloyan	Marinov	University of Washington
Clyde-Emmanuel	Meador	University of Kansas
Sunghwan	Moon	Texas A & M University
Ayon	Mukherjee	University of Alberta
Michael	Northington V	Vanderbilt University
Derya	Sahin	University of California, Merced
Tonatiuh	Sanchez-Vizuet	University of Delaware
Louis	Saumier	University of Victoria
Marina	Terzi	Kent State University
Fatma	Terzioglu	Texas A & M University
Andrew	Thaler	University of Utah
Zhicong	Wang	University of Tennessee
Fan	Yang	University of Delaware
Quan	Yuan	Wayne State University
Shuangjian	Zhang	University of Toronto
lin	zhao	Dartmouth College
Yimin	Zhong	University of Texas
Muhong	Zhou	Rice University

Student Statistics

Total Students		39

Gender		39
Male	56.41%	22
Female	41.03%	16
Declined to state	2.56%	1

Ethnicity*		39
White	38.46%	15
Asian	46.15%	18
Hispanic	10.26%	4
Pacific Islander	0.00%	0
Black	2.56%	1
Native American	0.00%	0
Declined to state	2.56%	1

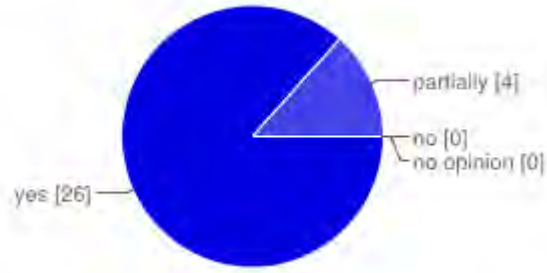
* ethnicity specifications are not exclusive

30 responses

Summary See complete responses

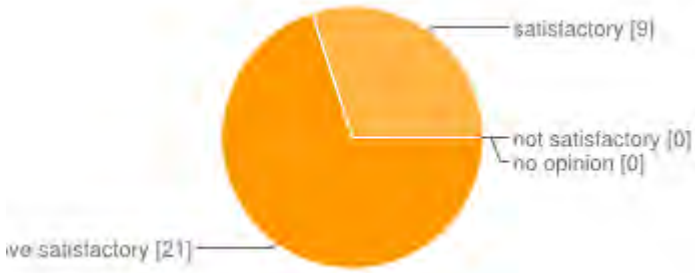
Topic presentation and organization

Did the various topics within the workshop integrate into a coherent picture?



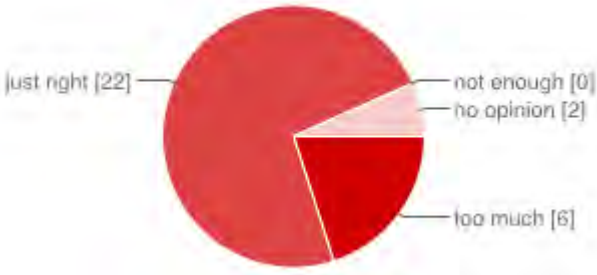
yes	**26**	87%
partially	**4**	13%
no	**0**	0%
no opinion	**0**	0%

Were the faculty speakers generally clear and well organized in their presentation?



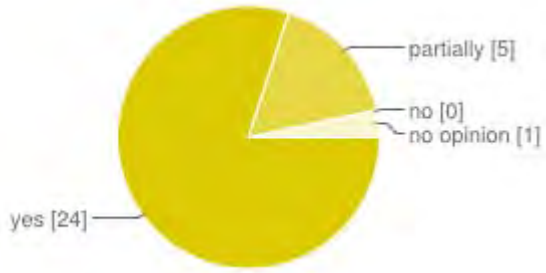
above satisfactory	**21**	70%
satisfactory	**9**	30%
not satisfactory	**0**	0%
no opinion	**0**	0%

Was there too much material presented; was the school too ambitious?



too much	**6**	20%
just right	**22**	73%
not enough	**0**	0%
no opinion	**2**	7%

Were the problem sessions helpful?



yes	**24**	80%
partially	**5**	17%
no	**0**	0%
no opinion	**1**	3%

Were the computer labs helpful?

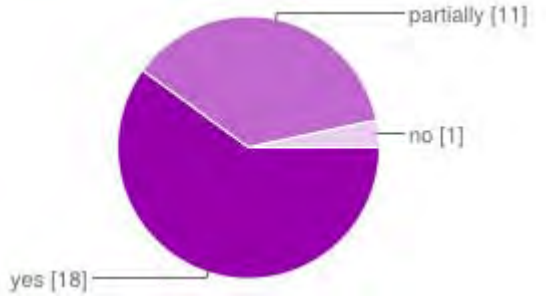
yes	**26**	87%
partially	**2**	7%
no	**1**	3%
no opinion	**1**	3%

Please comment on the panel discussions. What did you like? What would you have liked to see?

very nice . On the lectures: more detailed calculations would be helpful, some citations to refer the audience to the exact papers will definitely make the workshop better. On computer lab: the link between the computer lab and the lectures can be clearer. It is however an interesting experience to learn python. the lunch break could be shorter to extend the time for computer lab programming sessions Maybe the lunch break can be made shorter and we get to spend more time on computer lab problems The summer school was interesting and helpful. The lectures were great! They were very informative an ...

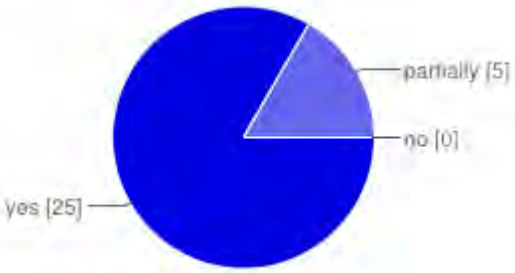
Personal assessment

Was your background adequate to access a reasonable portion of the material?



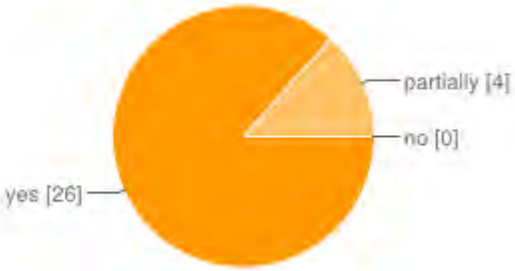
yes	**18**	60%
partially	**11**	37%
no	**1**	3%

Did the workshop increase your interest in the subject?



yes	**25**	83%
partially	**5**	17%
no	**0**	0%

Was the school worth your time and effort?

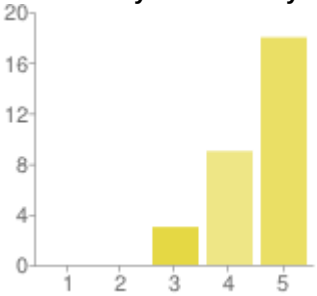


yes	**26**	87%
partially	**4**	13%
no	**0**	0%

Is it likely that you will work in the area of the workshop subject in the future?

yes	**10**	33%
may be	**18**	60%
no	**2**	7%

How would you evaluate your interaction with other participants?



1 -not satisfactory	**0**	0%
2	**0**	0%
3	**3**	10%
4	**9**	30%
5 -above satisfactory	**18**	60%

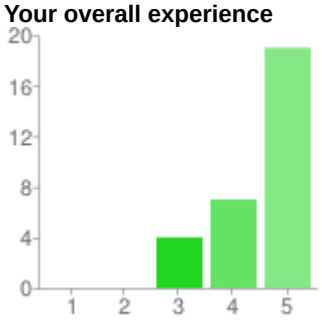
Additional comments on your personal assessment

very nice experience. Thanks to the orginazer The workshop was a great place to meet new people from all over the world, and discuss new ideas. Overall I think I learned a great deal from lectures as well as discussions with the other participants. For me, the academic aspect and the social aspect of the MSRI Summer School in Seismic Imaging equalled each other in the categories *Quality* and *Excitement*! Overall this is one of the most rewarding summer schools I have attended! Thank you! This was a great opportunity to interact and connect with other math PhD/Master students. I particularly ...

MSRI Venue

Please rate the different categories

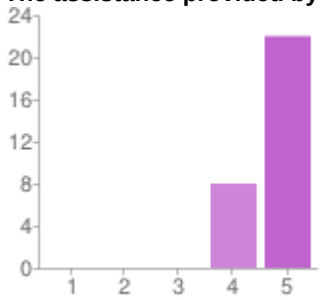
Your overall experience



not satisfactoryabove satisfactory

1 -not satisfactory	**0**	0%
2	**0**	0%
3	**4**	13%
4	**7**	23%
5 -above satisfactory	**19**	63%

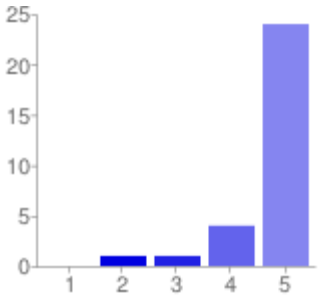
The assistance provided by staff



not satisfactoryabove satisfactory

1 -not satisfactory	**0**	0%
2	**0**	0%
3	**0**	0%
4	**8**	27%
5 -above satisfactory	**22**	73%

The physical surroundings



not satisfactoryabove satisfactory

1 -not satisfactory	**0**	0%
2	**1**	3%
3	**1**	3%
4	**4**	13%
5 -above satisfactory	**24**	80%

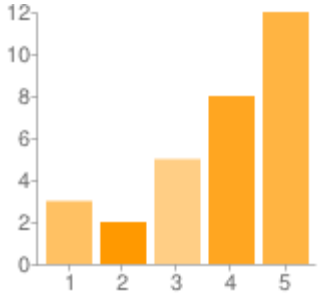
Additional comments on the MSRI venue

being not able to bring coffee to Simon hall may be the only downside, however I support your reasons for doing so. MSRI is a great establishment. I am happy to have attended the summer school here. Great place overall. It will be perfect if there is a bigger screen for projector. Everything was fantastic! Exceptional venue! There were too many floor vents in the Simons hall. It could be quite uncomfortable to try to sit in some of the chairs close to the vents. MSRI is a wonderful location to visit for the summer school.

Accommodation and Food

Please rate the different categories

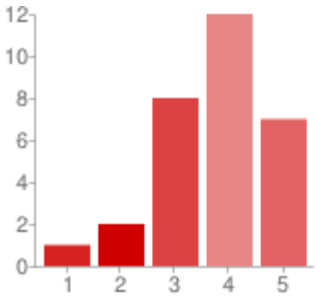
The summer school accommodation



not satisfactoryabove satisfactory

1 -not satisfactory	**3**	10%
2	**2**	7%
3	**5**	17%
4	**8**	27%
5 -above satisfactory	**12**	40%

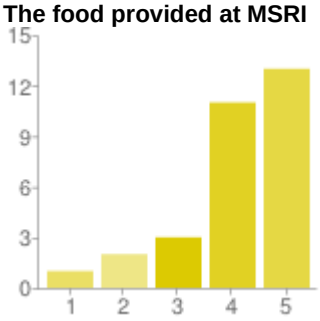
The food at the dormitories



not satisfactoryabove satisfactory

1 -not satisfactory	**1**	3%
2	**2**	7%
3	**8**	27%
4	**12**	40%
5 -above satisfactory	**7**	23%

The food provided at MSRI



not satisfactoryabove satisfactory

1 -not satisfactory	**1**	3%
2	**2**	7%
3	**3**	10%
4	**11**	37%
5 -above satisfactory	**13**	43%

Additional comments on accommodation and food

breakfast in dormitories has only a few options. However, overall the food quality provided during my visit is fair and fine. My answers to the three questions above provide a very complete summary of my views on the accommodation and food. The residence and food were quite decent. It was nice to share the dorms with the other fellows. The foothill dorms were quite dirty and one of the two bathroom stalls (shared by 10 males) was inoperable for the whole two week stay. Additionally, the climate control (heat) only worked in some of the rooms; Berkeley staff was notified, but these issues w ...

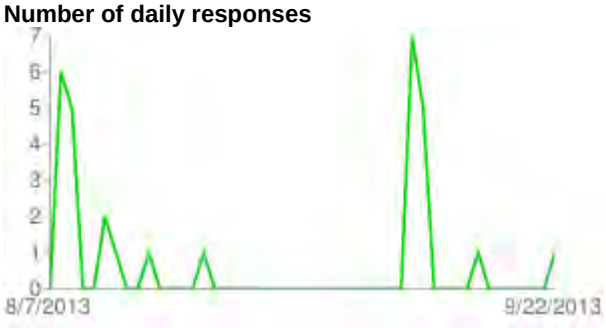
Thank you for completing this survey

We welcome any additonal comments or suggestions you may have to improve the overall experience for future participants.

Thanks a lot! Overall, this summer school was great, I hope there will be some other ones for the following years. PS: Personally, I prefer lecturing on blackboard rather than ppt slides since it seems to me that it is relatively easier for people without enough specific academic background to digest the material. I would have liked to

have an officially scheduled 2-hour session per day (rather than a 1 hour long one) for the computer labs, This summer school has been a remarkable experience on all levels. The organizers and TA leaders were extremely generous in their explanation and help, and ...

Number of daily responses



Summer Graduate School:
Introduction to the Mathematics of Seismic Imaging
July 29 – August 9, 2013

Additional Survey Responses

Additional comments on your personal assessment:

- very nice experience. Thanks to the orginazer
- The workshop was a great place to meet new people from all over the world, and discuss new ideas. Overall I think I learned a great deal from lectures as well as discussions with the other participants.
- For me, the academic aspect and the social aspect of the MSRI Summer School in Seismic Imaging equalled each other in the categories *Quality* and *Excitement*!
- Overall this is one of the most rewarding summer schools I have attended! Thank you!
- This was a great opportunity to interact and connect with other math PhD/Master students. I particularly enjoyed the fact that the school was well gender balanced.
- My interest in the field of seismic imaging were greatly increased throughout the conference. I had almost no background in the subject.

Additional comments on the MSRI venue:

- being not able to bring coffee to Simon hall may be the only downside, however I support your reasons for doing so.
- MSRI is a great establishment. I am happy to have attended the summer school here.
- Great place overall. It will be perfect if there is a bigger screen for projector.
- Everything was fantastic!
- Exceptional venue!
- There were too many floor vents in the Simons hall. It could be quite uncomfortable to try to sit in some of the chairs close to the vents.
- MSRI is a wonderful location to visit for the summer school.

We welcome any additional comments or suggestions you may have to improve the overall experience for future participants:

- Thanks a lot!
- Overall, this summer school was great, I hope there will be some other ones for the following years.

  PS: Personally, I prefer lecturing on blackboard rather than ppt slides since it seems to me that it is relatively easier for people without enough specific academic background to digest the material.
- I would have liked to have an officially scheduled 2-hour session per day (rather than a 1 hour long one) for the computer labs
- This summer school has been a remarkable experience on all levels. The organizers and TA leaders were extremely generous in their explanation and help, and took great care of us. Thank you to the organizers and MSRI!
- Overall, the experience was great. MSRI and its staff were wonderful and made for a welcoming and productive study environment. While the foothill dorms were less than stellar, the good company made up for it(plus we did not have to pay ;)
- I had a truly fantastic time.
- This was one of the best learning experiences I had in a while!! Thanks for organizing it!

Additional comments on accommodation and food:

- breakfast in dormitories has only a few options. However, overall the food quality provided during my visit is fair and fine.
- My answers to the three questions above provide a very complete summary of my views on the accommodation and food.
- The residence and food were quite decent. It was nice to share the dorms with the other fellows.
- The foothill dorms were quite dirty and one of the two bathroom stalls (shared by 10 males) was inoperable for the whole two week stay. Additionally, the climate control (heat) only worked in some of the rooms; Berkeley staff was notified, but these issues were never resolved.
- It would have been nice to have our own room since many of us are older or married now, but the dorms were nice nonetheless.
- Foothill is a depressing dorm on the inside.

Please comment on the panel discussions. What did you like? What would you have liked to see?

- very nice
- On the lectures: more detailed calculations would be helpful, some citations to refer the audience to the exact papers will definitely make the workshop better.

  On computer lab: the link between the computer lab and the lectures can be clearer. It is however an interesting experience to learn python.
- the lunch break could be shorter to extend the time for computer lab programming sessions
- Maybe the lunch break can be made shorter and we get to spend more time on computer lab problems
- The summer school was interesting and helpful.
- The lectures were great! They were very informative and were at an accessible level. It was slightly difficult at first to switch to slide presentations, I feel as though I learn more from chalkboard presentations, but this is also personal preferences for some.
- It is an interesting topic in general and the organization, lecture - problem - computer lab, is great. The instructors are also very helpful.
- The chalkboard presentations were very accessible. The second half was very quick with a lot of notation and definitions. I would have liked for some notation and definitions to be on the board so that we could refer to them while viewing future slides.
- I really enjoy this two weeks, thanks to all the contributors.
- I like the way that we were given the corresponding exercise problems and coding projects right after each lecture which facilitate our understanding of the material.
- I don't entirely understand the question, because I don't recall any components of the MSRI Summer School in Seismic Imaging in the form of "panel discussions".

  Nevertheless, I can confidently state that all discussions during the summer school were very well organized and extremely enriching.
- The lectures during the first week of the course were fantastic! I learned a lot and really enjoyed the material!! The lectures during the second week were difficult to follow, primarily because they were given through slide presentations. The lecturer was great, but I am sure I would have been able to follow much better if the lectures were done on the black board.
- The first and second weeks of lectures were different in format and delivery. The first week of lectures was like a mini-course and as such, the concepts were taught and introduced with more time to ensure the students were following.
  The second week of lecture was interesting, but since it was on slides and not on the blackboard, it felt more like a seminar-type talk. The concepts were more rapidly introduced, and it was harder to see the connection between the theory (wavefront sets) and practical problem resolution. Regardless, I still very much enjoyed the second week of lectures.
  The theoretical problem session and computer problem session reflected well the theory we learned in the lectures, and were nicely constructed. I particularly enjoyed the computer lab sessions.

- I enjoyed the emphasis on actual application of the mathematical theory. What exactly is meant by panel discussion? (I am interpreting it as lectures)
- The first week was fantastic and flowed very smoothly. The second week moved too fast and left too many of us confused. Overall, I still got something out of the second week, but it was not as good as the first.
- I think we had no panel discussions.
- Everything was just right.
- very good form of learning knowledge
- Need more on theoretical part.
- Very useful. No further comments.
- To be honest, I am not sure what panel discussions this question is referring to.
- Just a brief comment on the lecture style and perhaps some feedback for the instructors. Prof. Demanet's lectures were very well organized and structured as a class/course, details were presented and developed on the board (as opposed to slides) which made it easier to follow, understand , and learn. This is exactly how I believe a summer course should be approached. On the other hand, prof. Symes' lectures followed the style of a seminar/conference talk where results were being presented, rather than derived and explained and, despite him being an excellent speaker, this made it harder to follow. I'm convinced that had he followed the "class" approach his lectures would have been superb and everybody's experience would have been even better.
- The amount of material was ambitious considering most of us had no background in inverse problems, and limited physics/PDE experience.
- This summer school was wonderful. Both instructors were well organized. Materials were broad enough, but not too much. I learned a LOT from it. And hope there will be more schools like this.
- The teachers were great, the problem sessions and computer labs were very useful.
- It is a great session to discuss with different people who have various point of views for such specific topics
- lectures were good. organizers were helpful.lab session part was good to understand the material.
- The enthusiasm of those who presented the material was great. It made the subject matter more interesting.

MSRI Mathematical Sciences Research Institute

Summer Graduate School: New Geometric Techniques in Number Theory

July 1 – 12, 2013

MSRI, Berkeley, CA, USA

Organizers:

Toby Gee (Imperial College, London)

Ariane Mézard (Institut de Mathématiques de Jussieu)

David Nadler (University of California, Berkeley)

Peter Scholze (University of Bonn, Germany)

New Geometric Techniques in Number Theory

Short Term Impact

This MSRI summer school benefitted enormously from an international team of lecturers. Having these recognized specialists (rarely simultaneously present on the American continent) for doctoral courses in a very active research area enabled us to attract brilliant graduate students from many American universities. There was intense concentration in the air, even if the atmosphere was very friendly. All students wanted to attend all the lectures. It was impossible to organize simultaneous sessions, since they did not want to miss anything!

Middle Term Impact

One of the first reached objectives was to introduce graduate students to these very active areas of research in Number Theory, to motivate them in a very efficient and concrete way for the 2014 MSRI programs: New Geometric Methods in Number Theory and Automorphic Forms as well as the program on Geometric Representation Theory. The lectures were extremely clear despite their high level. P-adic Langlands correspondence, perfectoid spaces and geometric Langlands were covered.

It also facilitated the concrete organization since two organizers (A. Mezard and D. Nadler) met with administrative and scientific staff from MSRI.

Longer Term Impact

The future American post-docs realized that a post-doctoral position in Europe could be an extremely positive opportunity for their academic and scientific career in the US. The lecturers have played a full part in mentoring graduate students not only through career advices (how to get post-doctoral positions in US and Europe) but also through scientific discussions: advanced students were given many opportunities to present their own works and to discuss possible further developments, the less advanced students returned home with open research questions.

Please find herewith enclosed: the complete program of activities, abstracts of lectures and talks, list of participants.

New Geometric Techniques In Number Theory

July 01-July 12, 2013

Schedule

Monday, July 01, 2013			
9:00 AM - 9:15 AM	Simons Auditorium		Welcome
9:15 AM - 10:45 AM	Simons Auditorium	David Nadler	Lecture
10:45 AM - 11:15 AM	Atrium		Coffee Break
11:15 AM - 12:15 PM	Simons Auditorium	Ariane Mezard	Lecture
12:15PM - 1:45 PM	Atrium		Lunch
1:45PM- 2:45 PM	Simons Auditorium	Peter Scholze	Lecture
2:45PM - 3:15 PM	Simons Auditorium	Arunabha Biswas	Asymptotic Behaviors of higher Mahler Measure
3:15 PM - 3:45 PM	Atrium		Tea
3:45 PM - 4:45 PM	Simons Auditorium	Gabriel Dospinescu	Problem Session

Tuesday, July 2, 2013			
9:15 AM - 10:45 AM	Simons Auditorium	Ariane Mezard	Lecture
10:45 AM - 11:15 AM	Atrium		Coffee Break
11:15 AM - 12:15 PM	Simons Auditorium	Penghui Li	Problem Session
12:15 PM - 1:45 PM	Atrium		Lunch
1:45 PM -2:45 PM	Simons Auditorium	David Nadler	Lecture
2:45PM - 3:15 PM	Simons Auditorium	Carl Wang Erickson	Representations and Pseudorepresentations
3:15 PM - 3:45 PM	Atrium		Tea
3:45 PM -4:45 PM	Simons Auditorium	Timo Richarz	Problem Session

Wednesday, July 3, 2013			
9:15 AM - 10:45 AM	Simons Auditorium	Peter Scholze	Lecture
10:45 AM - 11:15 AM	Atrium		Coffee Break
11:15AM - 1:45 PM	Tilden Park		BBQ

Monday, July 8, 2013			
9:15 AM - 10:45 AM	Simons Auditorium	Toby Gee	Lecture
10:45 AM - 11:15 AM	Atrium		Coffee Break
11:15 AM - 12:15 PM	Simons Auditorium	Gabriel Dospinescu	Lecture
12:15PM - 1:45 PM	Atrium		Lunch
1:45PM- 2:45 PM	Simons Auditorium	David Nadler	Lecture
2:45PM - 3:15 PM		Karol Koziol	Towards a Langlands corresepondence for Hecke modules of SL_n in characteristic p
3:15 PM - 3:45 PM	Atrium		Tea
3:45PM- 4:45PM	Simons Auditorium	George Boxer	Problem Session

Tuesday, July 09, 2013			
9:15 AM - 9:45 AM	Simons Auditorium	Ariane Mezard	Lecture
10:45 AM - 11:15 AM	Atrium		Coffee Break
11:15 AM - 12:15 PM	Simons Auditorium	Timo Richarz	Problem Session
12:15 PM - 1:45 PM	Atrium		Lunch
1:45 PM -2:45 PM	Simons Auditorium	Toby Gee	Lecture
2:45PM - 3:15 PM	Simons Auditorium	Judith Ludwig	p-adic functoriality
3:15 PM - 3:45 PM	Atrium		Tea
3:45 PM -4:45 PM	Simons Auditorium	George Boxer	Problem Session

Wednesday, July 10, 2013			
9:15 AM - 10:45 AM	Simons Auditorium	Peter Scholze	Lecture
10:45 AM - 11:15 AM	Atrium		Coffee Break
11:15AM - 12:15 PM	Simons Auditorium	Gabriel Dospinescu	Problem Session
12:15 PM - 1:45 PM	Atrium		Lunch
1:45 PM - 2:45 PM	Simons Auditorium	Toby Gee	Lecture
2:45 PM -3:15 PM	Simons Auditorium	Jaclyn Lang	On images of Galois representations associated to non-CM Hida families of modular forms
3:15 PM-3:45 Pm	Simons Auditorium	Gilbert Moss	Local constants for families of representations of GL(2) of a local field
3:45 PM-4:45 PM	Simons Auditorium	George Boxer	Problem Session

Thursday, July 11, 2013			
9:15 AM - 10:45 AM	Simons Auditorium	Toby Gee	Lecture
10:45 AM - 11:15 AM	Atrium		Coffee Break
11:15AM - 12:15 PM	Simons Auditorium	Timo Richarz	Problem Session
12:15 PM - 1:45 PM	Atrium		Lunch
1:45PM - 2:45 PM	Simons Auditorium	Gabriel Dospinescu	Problem Session
1:45PM - 2:45 PM	Atrium	Penghui Li	Problem Session
2:45 PM - 3:15 PM	Simons Auditorium	Shrenik Shah	Interpolating Periods
3:15 PM - 3:45 PM	Atrium		Tea
3:45 PM - 4:45 PM	Simmons Auditorium	George Boxer	Problem Session

Friday, July 12, 2013			
9:15 AM - 10:45 AM	Simons Auditorium	George Boxer	Problem Session
9:15 AM - 10:45 AM	Atrium	Timo Richarz	Problem Session
11:15AM - 12:15 PM	Simons Auditorium	Penghui Li	Problem Session
12:15 PM - 1:45 PM	Atrium		Lunch
1:45PM - 2:45 PM	Simons Auditorium		Group Presentation
2:45 PM - 3:15 PM	Simons Auditorium		Group Presentation
3:15 PM -3:45 PM	Atrium		Tea
3:45 PM - 4:45 PM	Simons Auditorium		Group Presentation

Abstract of lectures
New Geometric Techniques in Number Theory

Toby Gee
Modularity lifting theorems

The typed notes covered modularity lifting theorems for GL2 in reasonable detail (available http://www2.imperial.ac.uk/~tsg/), using the most modern version of the arguments (and in particular incorporating Taylor's Ihara avoidance technique). The first lecture was a summary of the notes, and an overview of the Taylor-Wiles-Kisin method. In the remaining lectures, three recent developments in the field were covered. Firstly, there was an overview of the recent progress on Artin's conjecture for odd two-dimensional representations over totally real fields. Secondly, there was a lecture on Clozel and Thorne's new cases of symmetric power functoriality for GL2. The final lecture covered the relationship of patching constructions to the p-adic Langlands correspondence.

Ariane Mézard
Deformations of Galois Representations

The series of lectures will developp the theory of deformations of Galois representation. First the main result of Galois cohomology is Poitou-Tate exact sequence relying Global and local cohomology. Then we define Deformation functor and we present some explicit computations of universal deformation ring. We list some open problem relying deformation rings and Iwasawa Theory. At least, we present some ideas paving the way to the patching method, which will be explain during the second week by Toby Gee.

Gabriel Dospinescu, Ariane Mezard's TA, gave 5 lectures, which were either complements to this course or problem-solving sessions (the problems being based on the material covered in the course). The topics covered were, first relatively formal but crucial functorial properties of deformation rings and basic commutative algebra, arguments related to local complete noetherian rings. Then Galois cohomology and its applications to presentations of deformation rings and to the study of their Krull dimension and related conjectures. At last, cohomology of pro-p groups and applications to Greenberg's construction of global Galois representations with open image in GLn(Zp).

David Nadler
Spectral Geometry of Affine Hecke Categories

The series of lectures will develop the derived algebraic geometry, homotopical algebra and representation theory needed to understand the trace theory of the affine Hecke category.

Specific topics will include: local and infinitesimal theory of differential graded schemes, convolution categories of coherent sheaves, singular support of coherent sheaves. Our goal will be to construct a spectral category of affine character sheaves within the framework of Geometric Langlands.

Peter Scholze

My first three lectures gave an introduction to the method of Langlands and Kottwitz of computing the zeta function of the modular curve in terms of modular forms. Because people kept telling me to change topic, my last lecture, and an extra lecture, were on my recent work on constructing Galois representations associated with torsion classes in the cohomology of locally symmetric varieties. In particular, I explained Shimura varieties at infinite level as perfectoid spaces, and the Hodge-Tate period map.

Abtract of talks
New Geometric Techniques in Number Theory

Karol Koziol
karol@math.columbia.edu
Towards a Langlands correspondence for Hecke modules of SL_n in characteristic p

We show how to realize the pro-p-Iwahori-Hecke algebra of SL_n as a subalgebra of the pro-p-Iwahori-Hecke algebra of GL_n. Using the interplay between these two algebras, we deduce a numerical Langlands correspondence between "packets" of Hecke modules and mod-p projective Galois representations.

Kestutis Cesnavicius
<kestutis@math.mit.edu>
Selmer groups and class groups

Abstract: Let A be an abelian variety over a number field K. If A has nontrivial (resp. full) K-rational p-torsion for a prime p, exploiting the fppf cohomological approach to Selmer groups, we obtain inequalities bounding the size of the p-Selmer group of A from below (resp. above) in terms of the size of the p-torsion subgroup of the ideal class group of K. When K varies in a family of field extensions, these inequalities relate the growth of Selmer groups to that of class groups; I will discuss such relations in several different settings.

Arunabha Biswas

<arunabha.biswas@ttu.edu>

Asymptotic behaviors of higher Mahler Measure

Abstract: We study behaviors of higher Mahler measure which is a generalization of classical Mahler measure. Apart from giving a broad overview of classical Mahler measure and higher Mahler measure, in this talk we shall show several new asymptotic properties of zeta Mahler measure (of a specific class of x-a) involving partitions of integers, the Rieman zeta function, the Dirichlet η-function and π.

Shrenik Shah
snshah@math.princeton.edu

Interpolating Periods
Abstract: We study the interpolation of Hodge-Tate and de Rham periods in families of Galois representations. Given a Galois representation on a coherent locally free sheaf over a reduced rigid space and a bounded range of weights, we obtain a stratification of this space by locally closed subvarieties where the Hodge-Tate and bounded de Rham periods (within this range) form locally free sheaves. At every thickened geometric point within one of the strata, we obtain a corresponding number of unbounded de Rham periods. If the number of interpolated de Rham periods is the number of fixed Hodge-Tate-Sen weights, we prove similar statements for non-reduced affinoid spaces. We also prove strong vanishing results for higher cohomology. These results encapsulate a robust theory of interpolation for Hodge-Tate and de Rham periods that simultaneously generalizes results of Berger-Colmez and Kisin.

Judith Ludwig
<j.ludwig10@imperial.ac.uk>

p-adic functoriality

Abstract: I will explain a notion of p-adic functoriality. Roughly speaking the goal is to extend classical Langlands functoriality to a transfer of p-adic families of automorphic representations. As these p-adic families can be organized into mysterious geometric objects, so called eigenvarieties, one aims at giving this p-adic functoriality a geometric structure as well. I will explain what this means and if time permits discuss some results in the context of unitary groups.

Gil Moss
<gmoss@math.utexas.edu>

Local constants for families of representations of GL(2) of a local field.

Abstract: We will attempt to motivate and introduce the local Langlands

conjecture for GL(2) in families proposed by Emerton and Helm, and discuss how the classical theory of zeta integrals and local constants works in this setting.

Carl Wang Erickson
<erickson@math.harvard.edu>
Representations and Pseudorepresentations

Abstract: We will explain what a pseudorepresentation is, and describe a few examples of the appearance of this concept in number theory.

Jackie Lang
<jaclynlang@math.ucla.edu>
On images of Galois representations associated to non-CM Hida families of modular forms

Abstract: In the 1980s Ribet and Momose determined the image of Galois representations associated to non-CM classical modular forms in terms of conjugate self-twists of those modular forms. Recent work of Hida shows that Galois representations associated to non-CM Hida families have large image. We define conjugate self-twists in the context of Hida families and combine the above mentioned results to obtain a description of the images of Galois representations associated to Hida families.

Attending Students

First Name	Last Name	Institution
Faisal	Al-Faisal	University of Toronto
Gagik	Amirkhanyan	Georgia Institute of Technology
Jitendra	Bajpai	University of Alberta
Dianbin	Bao	Temple University
Arunabha	Biswas	Texas Tech University
Clifford	Blakestad	University of Colorado
Kestutis	Cesnavicius	Massachusetts Institute of Technology
Jessica	Fintzen	Harvard University
Holley	Friedlander	University of Massachusetts, Amherst
Heidi	Goodson	University of Minnesota Twin Cities
Zhenyu	Guo	University of Missouri
Marc	Horn	University of Maryland
Lalit	Jain	University of Wisconsin
Pierre	Jaliniere	Universite Paris VI
Xin	Jin	University of California, Berkeley
Liudmyla	Kadets	University of Toronto
Pin-Hung	Kao	Central Michigan University
Ed	Karasiewicz	Rutgers University
Nayoung	Kim	Seoul National University
Eren	Kiral	Brown University
Clemens	Koppensteiner	Northwestern University
Karol	Koziol	Columbia University
Jaclyn	Lang	University of California, Los Angeles
Robert	Lazar	San Diego State University
Daniel	Le	University of Chicago
Jake	Levinson	University of Michigan
Binglin	Li	University of California, Davis
Jingbo	Liu	Wesleyan University
Judith	Ludwig	Imperial College, London
Gilbert	Moss	University of Texas
Chol	Park	University of Arizona
James	Ricci	Wesleyan University
Ryan	Rodriguez	University of California, San Diego
Ryan	Rosenbaum	University of Colorado
Reza	Sadoughian	McMaster University
Geoffrey	Schneider	Temple University
Arijit	Sehanobish	University of Maryland
Shrenik	Shah	Princeton University
Yiwei	She	University of Chicago
Padmavathi	Srinivasan	Massachusetts Institute of Technology
Brian	Streit	Baylor University
Yunqing	Tang	Harvard University
Jeffrey	Tolliver	Johns Hopkins University
Ila	Varma	Princeton University
Robert	Walker	University of Michigan
Haining	Wang	Pennsylvania State University
Carl	Wang Erickson	Harvard University
Peng	Yu	University of Wisconsin
Myungjun	Yu	University of California, Irvine
Bin	Zhao	University of California, Los Angeles

Organizers and Lecturers		
First Name	**Last Name**	**Institution**
Toby	Gee	Imperial College, London
Ariane	Mezard	Institut de Mathématiques de Jussieu
David	Nadler	University of California, Berkeley
Peter	Scholze	University of Bonn, Germany

Teaching Assistants		
First Name	**Last Name**	**Institution**
Daniel	Appel	University of California, Berkeley
George	Boxer	Harvard University
Gabriel	Dospinescu	University of Paris VI
Penghui	Li	University of California, Berkeley
Timo	Richarz	University of Bonn, Germany

Student Statistics

Total Students		50

Gender		50
Male	72.00%	36
Female	26.00%	13
Declined to state	2.00%	1

Ethnicity*		50
White	46.00%	23
Asian	44.00%	22
Hispanic	2.00%	1
Pacific Islander	0.00%	0
Black	2.00%	1
Native American	0.00%	0
Decline to state	6.00%	3

* ethnicity specifications are not exclusive

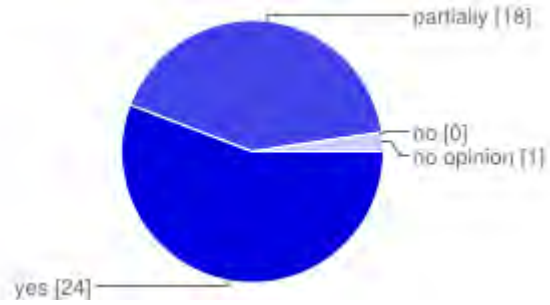
43 responses

43 responses / 62 participants = 69% response rate

Summary See complete responses

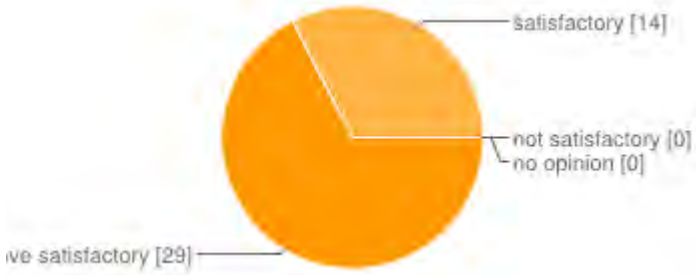
Topic presentation and organization

Did the various topics within the workshop integrate into a coherent picture?



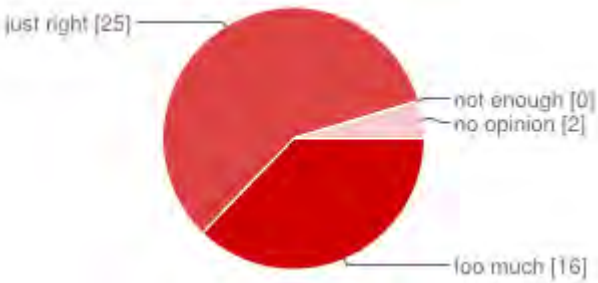
yes	**24**	56%
partially	**18**	42%
no	**0**	0%
no opinion	**1**	2%

Were the faculty speakers generally clear and well organized in their presentation?



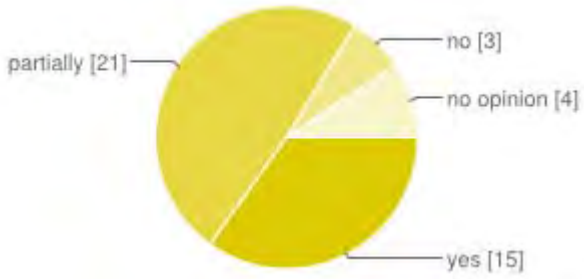
above satisfactory	**29**	67%
satisfactory	**14**	33%
not satisfactory	**0**	0%
no opinion	**0**	0%

Was there too much material presented; was the school too ambitious?



too much	**16**	37%
just right	**25**	58%
not enough	**0**	0%
no opinion	**2**	5%

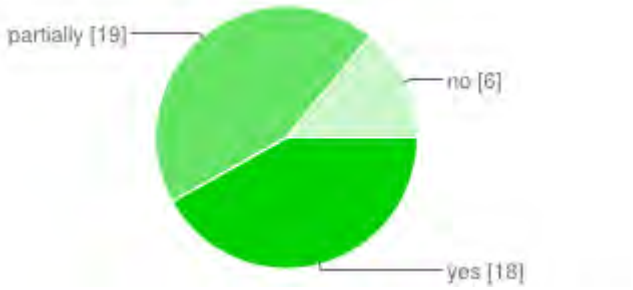
Were the problem sessions helpful?



yes	**15**	35%
partially	**21**	49%
no	**3**	7%
no opinion	**4**	9%

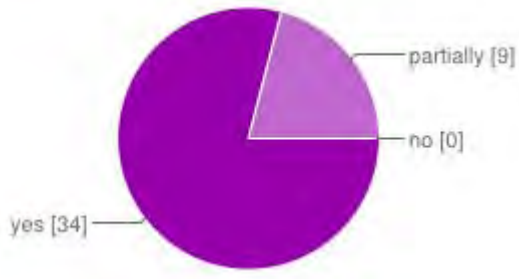
Personal assessment

Was your background adequate to access a reasonable portion of the material?



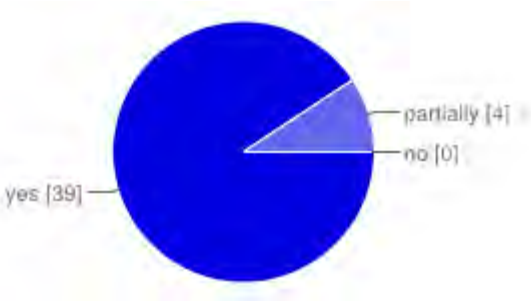
yes	**18**	42%
partially	**19**	44%
no	**6**	14%

Did the workshop increase your interest in the subject?



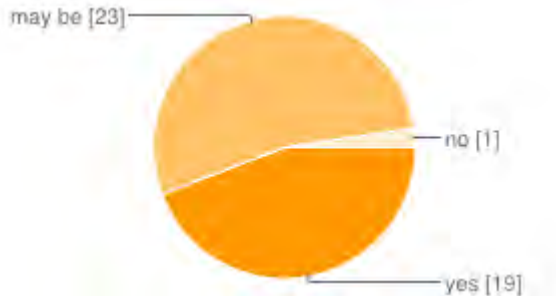
yes	**34**	79%
partially	**9**	21%
no	**0**	0%

Was the school worth your time and effort?



yes	**39**	91%
partially	**4**	9%
no	**0**	0%

Is it likely that you will work in the area of the workshop subject in the future?



yes	**19**	44%
may be	**23**	53%
no	**1**	2%

How would you evaluate your interaction with other participants?

1 -not satisfactory	**0**	0%
2	**2**	5%
3	**6**	14%
4	**17**	40%
5 -above satisfactory	**18**	42%

Additional comments on your personal assessment

Although I could tell the talks were very interesting and well thought out, they started at a level that I was not on par with. It required a wide variety of knowledge that I just am not familiar with. I had been hoping that as a 2 week workshop that there would be opportunities to follow and participate at varying levels but I found a lot of students were lost very early on. I think it would have been very helpful to have gotten some materials or references before the workshop so that we could be better prepared for the material being covered. Short version: I really liked all of the cour ...

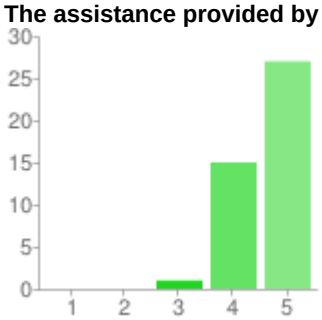
MSRI Venue

Please rate the different categories

Your overall experience

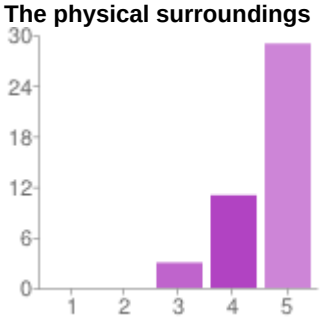
1 -not satisfactory	**0**	0%
2	**0**	0%
3	**3**	7%
4	**20**	47%
5 -above satisfactory	**20**	47%

The assistance provided by staff



1 -not satisfactory	**0**	0%
2	**0**	0%
3	**1**	2%
4	**15**	35%
5 -above satisfactory	**27**	63%

The physical surroundings



1 -not satisfactory	**0**	0%
2	**0**	0%
3	**3**	7%
4	**11**	26%
5 -above satisfactory	**29**	67%

Additional comments on the MSRI venue

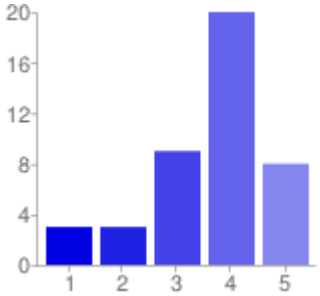
It would be nice to have an unlocked office for people to use for discussions/practicing

project or student talks/etc. MSRI is a great venue! The library is a fantastic place to do work. One needs to curb the air conditioning sometimes: it doesn't have to be freezing in the lecture room! Thanks for their service. I really appreciate. This was my first time coming to MSRI, and I really like it here, especially the Library and the view from outside the commons area! I hope to return for some program(s) next year or the year after, such as Perfectoid Spaces! I was sad that we were thrown out at 5:3 ...

Accommodation and Food

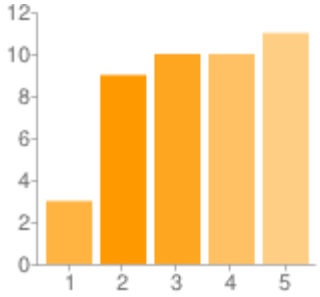
Please rate the different categories

The summer school accommodation



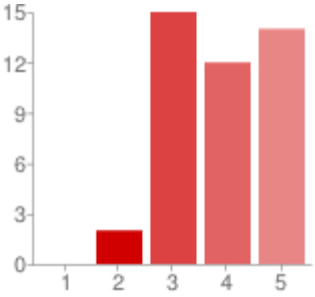
1 -not satisfactory	**3**	7%
2	**3**	7%
3	**9**	21%
4	**20**	47%
5 -above satisfactory	**8**	19%

The food at the dormitories



1 -not satisfactory	**3**	7%
2	**9**	21%
3	**10**	23%
4	**10**	23%
5 -above satisfactory	**11**	26%

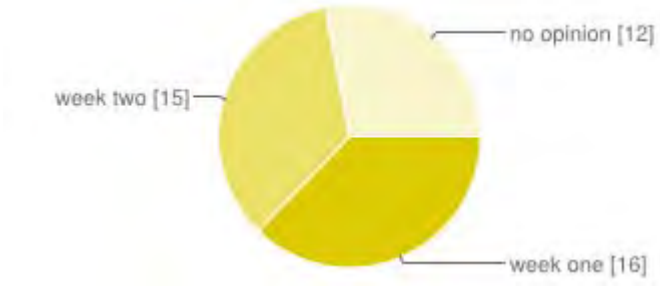
The food provided at MSRI



not satisfactoryabove satisfactory

1 -not satisfactory	**0**	0%
2	**2**	5%
3	**15**	35%
4	**12**	28%
5 -above satisfactory	**14**	33%

Did you prefer the lunch provided at MSRI in week one or week two



week one	**16**	37%
week two	**15**	35%
no opinion	**12**	28%

Additional comments on accommodation and food

MSRI food: Week 1 food was tasty but not enough vegetarian food was available, so I was quite hungry afterwards. Week 2 had enough vegetarian food, which was great. It was quite cold by the time it was served, though it was still good. (And the drinks were good too.) Dining hall food: The dining hall food was terrible, and my understanding is that MSRI pays full price for it. Pretty much anything else would be preferable, and I bet that it would be possible to get good food for less than half the price charged by the dining hall. Accommodation: The sheets on the bed didn't fit it (they ...

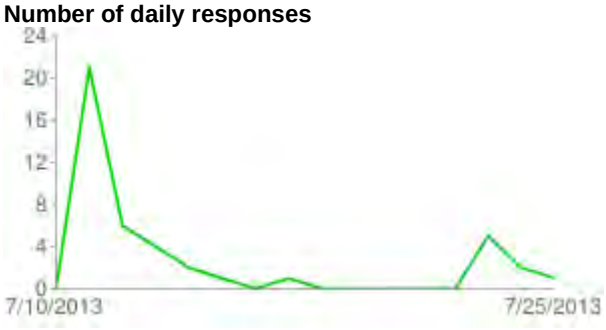
Thank you for completing this survey

We welcome any additonal comments or suggestions you may have to improve the overall experience for future participants.

I really had a great time at MSRI, and I appreciate how much hard work went into every aspect of the school. The speakers did a great job of planning their talks to make the most of the time they had, and the organization was very smooth. I liked the student talks as well, and I thought they were integrated well into the schedule. I would be excited to attend future events at MSRI. Including preparatory material prior to the workshop would've been very useful. The

problem sessions would have been more useful if they had been true problem sessions, where students were asked to group together ...

Number of daily responses



Summer Graduate School:
New Geometric Techniques in Number Theory
July 1 – 12, 2013

Additional Survey Responses

Additional comments on your personal assessment:

- Although I could tell the talks were very interesting and well thought out, they started at a level that I was not on par with. It required a wide variety of knowledge that I just am not familiar with. I had been hoping that as a 2 week workshop that there would be opportunities to follow and participate at varying levels but I found a lot of students were lost very early on. I think it would have been very helpful to have gotten some materials or references before the workshop so that we could be better prepared for the material being covered.
- Short version: I really liked all of the courses -- the lecturers clearly put a lot of work into them and they were very instructive. The students running the problem sessions did an excellent job as well. I have some small suggestions (below) that might help the participants follow the lectures better.

  The courses should have all handed out problem sets, as those were very helpful for Mezard's course, and gave structure to those problem sessions. Peter's course also had exercises, which were great, though it would be great if those exercises were handed out with some explanation of the notation (in case we didn't know what the nearby cycles meant exactly, etc.) and some hints to get started.

  There should have been fewer problem sessions and more main lectures. Nadler's course was very interesting, but only a few people had the background he was assuming. If he gave out some worked examples of the calculations with some accompanying exercises, I think that it would have been easier to keep up with his lectures.
- It would have been helpful to know what subjects to brush up on before the workshop, such as algebraic geometry.
- Thanks to the organizers for their effort and time -- the summer school was useful and interesting. A couple of critical remarks/suggestions:

  Lectures:

  Toby Gee: good job, though lecture 4 was too technical and unclear.
  Peter Scholze: good job in the first 3 lectures, but lecture 4 was a disaster -- this was not supposed to be a conference! Talking about some infinitely technical recent paper, which presumably is of interest to some experts, is out of place for a summer school.
  Ariane Mezard: there was a general lack of organization and coherence in the presentation, and lecture 4 was worse than the others; it was unclear why the mysterious Greenberg paper is of such great interest.
  David Nadler: not sure what his point was -- he didn't even try to explain things; lecture 3 was moderately interesting due to connection to classical picture, but what did he want to convey with the other ones?

  Problem sessions:

  Generally, problem sessions were not organized well: we should've been split into four groups in different rooms trying to solve doable and useful problems in groups to learn things. As it were, we've been presented solutions to problems which we barely had any time to try at all. More concretely:

Timo Richarz: Good job and was very useful, though Peter's "exercises" were often too hard.
George Boxer: Good job and the problem sessions more or less worked the way they're supposed to.
Gabriel Dospinescu: complements to the lectures were very useful and a good selection of material; problem session 4 about p-adic local Langlands was a off topic though and not really a problem session.
Whoever was for Nadler: a complete disaster.

Logistics worked quite well, I thought, except for somewhat weird schedule (the 1.5 hrs lecture in the morning felt tedious sometimes) and consecutive slots with no planned breaks were also strange.

- It is an interesting workshop. I gained a lot of information about this area for this workshop. I hope I can attend future workshop like this.
- It would have helped to have some suggested material to read prior to the beginning of the summer school.
- The talks by David Nadler on Geom.Rep.Theory were so beyond me, and were given w/ the suggestion of potential (rather than actual) connection w/ future investigations in the Langlands program; those talks seemed largely disconnected from the rest of the lectures; Scholze's and Toby Gee's talks were very nicely done, and I became the most excited about this area by hearing their perspectives; I was not prepared enough to get much out of the summer school, though the lecturers' enthusiam for the subject is somewhat infectious, and I now want to gain a better handle on the prerequisites for this kind of research!
- I understood that this was only marginally related to my field of interest before going into it. And really, I think had we (people studying different fields) been handed materials some time in advance to study from it would have gone more smoothly for me.
- It would have been more helpful if we knew a list of topics to be covered beforehand with a list of background reading and a list of references to the relevant material. Especially for a technical workshop like this, background would definitely help. It would also be nice to receive a list of participant names with their email addresses. A more up to date website with all this information on it would also be nice.
- It was hard to contact other participants, I would have wished to receive a participant list with email addresses.
- My research area is related to the topics presented in this school, however, it would have been a great help to be given some references in advance to look at ahead of time. Instead I spent most of my first week reading survey articles to fill in some holes in my background rather than working on the material presented in lecture. Of course not all students will have time to do a great deal of preparation in advance, but on the other hand we had no information on the material to be presented beyond an expectation that we had taken graduate number theory. David Nadler's course suffered particularly from students not being given notice on what topics to read. His lectures involved a great deal of high-powered algebraic geometry that was in no way mentioned or even alluded to in the workshop description. Dr. Nadler actually did an excellent job in trying to adjust his lecture to the audience's preparation, but there was only so much he could do.
- The talks on derived algebraic geometry were very difficult (I say this even as someone studying AG, not number theory), and many participants I spoke to at the conference understood little to none of them. I wish they had had a much slower pace. The other talks were excellent and challenging, though I think they would have benefited if they had all had problem sets to accompany the material (only one did, and I found it helpful).

Additional comments on accommodation and food:

- MSRI food: Week 1 food was tasty but not enough vegetarian food was available, so I was quite hungry afterwards. Week 2 had enough vegetarian food, which was great. It was quite cold by the time it was served, though it was still good. (And the drinks were good too.)
  Dining hall food: The dining hall food was terrible, and my understanding is that MSRI pays full price for it. Pretty much anything else would be preferable, and I bet that it would be possible to get good food for less than half the price charged by the dining hall.
  Accommodation: The sheets on the bed didn't fit it (they were designed for a twin bed, rather than a twin XL bed), so the bedding would fall off right away, so one basically had to sleep on the bare mattress. This made it hard to get sleep during the school. Also, sometimes the showers were very cold. If there's another option, I would suggest it, but of course the location of the housing is very convenient since it is close to Evans. It would be great if there was a place with a chalkboard available in the evenings, because many of us would have had an easier time working on the projects if we could easily do so back at Berkeley. In particular, if we could have a small # of keys to Evans (i.e. one per project group), we could go there after hours and work at a blackboard in the math department, for instance.
- The lunches were really heavy; I never eat things like lasagne in the middle of the day. I would have preferred something lighter, like sandwichs or wraps.
- It would be nice to have access to communal places to work after hours and on weekends.
- The catered food at MSRI was good. The food at the dorms was terrible. The towels and linens provided by the dorms were terrible. The linens did not fit the bed and kept coming off. The towels were too small and not soft.
- At breakfast the selection of fruits and cereals was excellent, otherwise the food was unsatisfactory. Dinner was more up to snuff, though the backup of lines full of people from other programs made getting dinner impossible a few times. Putting 10 guys into a suite with 2 showers and 2 toilets was awkward. Lunch at MSRI was better in week 1, those folks were more professional and nicer; the woman in charge of catering for week 2 rubbed several people the wrong way.
- The food was totally satisfactory in both weeks.
- I regret that there were no rolls (bread) and no knifes during the second week.

Summer Graduate Workshop: Séminaire de Mathématiques Supérieures 2013:

Physics and Mathematics of Link Homology

June 24, 2013 to July 05, 2013

University of Montreal, Canada

Organizers:

Sergei Gukov (California Institute of Technology)

Mikhail Khovanov (Columbia University)

Johannes Walcher (McGill University)

Université de Montréal

Faculté des arts et des sciences
Département de mathématiques
et de statistique

SMS 2013: Director's report.

The 52nd *Séminaire de Mathématiques Supérieures* took place in Montréal in the period June 24- July 5, 2013. It was the largest summer school in recent years, with 90 participants, and one of the most inter-disciplinary with lectures reflecting recent trends in parts of physics as well as mathematics. For the first time all lectures have been video-recorded.

The organizers, **Sergei Gukov, Mikhail Khovanov and Johannes Walcher** have done a tremendous job at all levels: scientific organization, student selection as well as insuring a stimulating environment during the school.

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**, support from the **Canadian Mathematical Society** as well as, exceptionally, with the generous support of the **Simons foundation**. We also acknowledge the contribution of the Geometry-Topology CRM Laboratory (**CIRGET**). 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 very detailed scientific, organizational and budgetary report. I thank again the organizers for taking the time to prepare such a thorough document.

Sincerely Yours,

O. Cornea

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Director, Séminaire de Mathématiques Supérieures
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August 27, 2013

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Séminaire de Mathématiques Supérieures 2013
Physics and Mathematics of Link Homology
June 24–July 5, 2013
— Scientific Report —

Dated: July 28, 2013

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* Sergei Gukov (Caltech Institute of Technology)
* Mikhail Khovanov (Columbia University)
* Johannes Walcher (McGill University)

2 Speakers

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* Dror Bar-Natan (University of Toronto)
* Hiroyuki Fuji (University of Tokyo)
* Sergei Gukov (California Institute of Technology)
* Joel Kamnitzer (University of Toronto)
* Anton Kapustin (California Institute of Technology)
* Mikhail Khovanov (Columbia University)
* Aaron Lauda (University of Southern California)
* Ciprian Manolescu (University of California at Los Angeles)
* Marcos Marino (Université de Genève)
* Alexei A. Oblomkov (University of Massachusetts Amherst)
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* Jake Rasmussen (University of Cambridge)
* Lev Rozansky (University of North Carolina at Chapel Hill)
* Marko Stošić (Instituto Superior Técnico, Lisbon)
* Piotr Sulkowski (University of Warsaw)
* Johannes Walcher (McGill University, Montreal)
* Ben Webster (Northeastern University, Boston)

3 Number of Participants

* 90

4 Summary

Throughout recent history, the theory of knot invariants has been a fascinating melting pot of ideas and cultures, blending mathematics and physics, geometry, topology and algebra, gauge theory and quantum gravity. Participants of this year's Séminaire de Mathématiques Supérieures can confirm that the explosion we are witnessing most likely is just the beginning of a larger and much more uniform story.

One of the pervasive themes is "aiming for higher dimensions" — The original construction of the Jones polynomial invariant of knots and links (one-dimensional objects non-trivially embedded in three-space) in 1984 was firmly rooted in two-dimensional mathematical physics, but did not make all symmetries manifest. An intrinsically three-dimensional interpretation was given by Witten in 1988, representing the Jones polynomial as a physicist's path-integral over the space of connections with Chern-Simons action. Following the categorification paradigm, Khovanov in 1998 lifted the Jones polynomial to a homological invariant of link cobordisms living in four dimensions. Around the same time, developments initiated by Gopakumar and Vafa began to expose relations to higher-dimensional geometric invariants of interest in superstring theory. Splitting M-theory's eleven dimensions in various ways makes room for a large number of vantage points to help explain the origin of lower-dimensional phenomena.

This two week long programme on "Physics and mathematics of link homology" brought together leading researchers in mathematics and mathematical physics, in order to provide an opportunity to educate a new generation of scientists in this growing field. The challenges were remarkable.

Theories of link homology are studied from a large variety of mathematical approaches and backgrounds — topologists will find the axiomatic framework of topological quantum field theory most accessible. Algebraic geometers could be interested in derived categories of coherent sheaves on quiver varieties and on convolution varieties of affine Grassmannians, or the enumerative geometry of (relative) Donaldson-Thomas invariants of Calabi-Yau threefolds. Symplectic geometers might study Fukaya-Floer categories associated with Heegard splittings or with Lagrangians on quiver varieties. Researchers with a background in representation theory will focus on the lifting of quantum groups and their representation theory to higher categories. As refreshing as this diversity may be, it represented a barrier for newcomers to enter the field. So one of the goals of the SMS was to address the sorely felt need for a pedagogical introduction aimed at intermediate to advanced graduate students interested in the mathematics of knot homology.

And while the physics perspective promises to ultimately help clarify the relations between all these approaches, initially it only seems to complicate matters – In fact, one of the main attractions of homological knot invariants for mathematical physics is precisely that it mixes so many different parts of topological quantum theory. Not only do knot homologies provide a bridge between topological field theories of cohomological and Chern-Simons type,

the relation with the enumerative geometry of Calabi-Yau threefolds is one of the incarnations of the celebrated large-N (or gauge/gravity) duality that has come to dominate formal theoretical physics in the last 15 years. Providing an access point into the relevant parts of theoretical physics was a declared aim of the school as well. The organizers made a particular effort to encourage interactions and fruitful exchanges between the communities in order to facilitate the development of the unified picture.

Clearly, these are a lot of different topics to cover in a two-week summer school, aiming at a coherent and unified overview of the subject! With necessary gaps, the enthusiastic response and feedback from junior as well as senior participants alike is testimony to the fact that the programme amply succeeded in balancing the various interests. The 15 main lecturers were given the leisure of 3 (first week) or 2 (second week) times 75 minutes to explain the background that they felt most necessary or useful for their particular subject, sketch their main results and end with explaining those challenges that they view as most promising. Three topical seminar style lectures rounded out the programme. All the while, the consistently streamlined schedule of the school allowed for the organization of a number of spontaneous discussion sessions between students from mathematics and physics backgrounds, as well as several social outings around Montreal.

There were countless cross-references between the various lectures. Indeed, the group of speakers is very well in tune regarding each other's lecture topic. This is due to a number of recent events with a similar topic, albeit at a rather higher level. In particular, a Simons Symposium on Knot Homologies and BPS States was held in April 2012, and an MSRI program on Knot homology was hosted in 2010. This arrangement of content contributed to a very coherent school, and conversely, the school was a very welcome opportunity for transmitting the results discussed at these events to the larger group containing the next generation of professional researchers.

To enhance the pedagogical value of the school, the organizers strived to capitalized on two effects: first of all, the interactions between mathematics and physics, which has been a spectacularly powerful force driving progress in the theory of knot invariants. Not only did students discuss with lecturers after the talks, during coffee breaks, and beyond, but also did the students organize several "math-physics clinics", in which students with different backgrounds explained some basic concepts from their respective field to each other. One can be very confident that these seeds and contact will grow during the coming years. The second notable feature were the many open questions that each lecturer highlighted towards the end of their lectures. And these are as many opportunities for the formation of the next generation! As participants prepared to leave Montréal laden with a wealth of impressions, new friendships, and as much additional knowledge as they could carry, the organizers realized once again that the ultimate success of the school will really only be measured, several years down the road, in its contribution to the launch of the participants' research careers!

As its immediate predecessors, this year's edition of the SMS was made possible by

financial support from a consortium of North American Mathematics Institutes, including the Centre de Recherches Mathématiques, the Fields Institute, the Mathematical Sciences Research Institute, the Pacific Institute for the Mathematical Sciences, the Institut des Sciences Mathématiques, the Canadian Mathematical Society, the Centre Interdisciplinaire de Recherche en Géométrie et Topologie. In addition, we received a generous contribution from the Simons Foundation for the attribution of Fellowships to 20 particularly promising students.

5 Detailed record of Activities

The first week began with a quick and down-to-earth introduction to Khovanov homology by **Dror Bar-Natan**. Without any of the modern complications, Bar-Natan first reviewed the Kauffman bracket of the Jones polynomials as Kauffman told it in 1987, then the Khovanov homology story as Khovanov told it in 1999, and finally his "local Khovanov homology" story as understood in 2003. The lectures ended with some recent new ideas about categorification of the Alexander polynomial, rooted in the concept of "meta-groups" and the construction of "meta-bicrossed-product". Bar-Natan's particular emphasis on computability was, as always, a highly appreciated feature.

The pièce de résistance of the first week were three sets of lectures on the physics of Chern-Simons theory, each of different character, and focused on different aspects: **Ramadevi** gave an inspired review of Chern-Simons theory, braid calculus and recent results on Racah coefficients. Her first lecture included a basic review of Chern-Simons theory as a physical theory of knots and links. In the second lecture, she showed explicit calculations of the polynomial invariants for a few simple knots within SU(2) Chern-Simons theory (i.e., the colored Jones polynomial) and also SU(N) Chern-Simons theory (colored HOMFLY-PT). In the third lecture, she discussed some of her recent work on homological invariants. **Mina Aganagic**'s lectures were centred around so-called refined Chern-Simons theory—the basic idea being to introduce the dependence on the homological deformation parameter directly into the modular transformation matrices of the two-dimensional conformal field theory. It turns out that this program can be pushed to the end for Seifert fibered knots and 3-manifolds. Aganagic emphasized why the additional symmetry is so crucial for computability: It means that the relevant physical quantity in the M-theory picture reduces to an index computation, and does not require a (in general, messy) identification of the exact space of ground states. **Marcos Mariño** explained in detail the why and how of the "reformulation" of the colored HOMFLY and Kauffman invariants. The basic point is that the simplest basis in which to present the colored invariants is not the most naive one, indexed by irreducible representations of the symmetric group. Instead, one should perform a sequence of rather non-trivial transformations, as suggested by the relation with the topological string. In this interpretation, the expansion coefficients of the resulting expressions are the (yet to be rigorously defined) relative Gopakumar-Vafa invariants of a corresponding D-brane setup. Some of the associated integrality and polynomiality conjectures have recently been proven. The

challenge with which Mari´ no ended his lectures is the extension of the reformation to the homological invariants.

As one of the first mathematicians to take up to the challenges of large-N duality, **Alexei Oblomkov** reviewed his conjectures (with Rasmussen and Shende) relating Khovanov-Rozansky homology and Hilbert schemes, as well as the representation theory of the rational Cherednik algebra. In more detail, the conjectures concern the link of a planar singularity and the cohomology of some moduli spaces of sheaves on the corresponding planar curve. In the case of the quasi-homogeneous singularity $x^p = y^q$, it is also expected that the homology of the link, which is a toric link, carries an action of the Cherednik algebra (this representing joint work with Gorsky, Rasmussen and Shende). Oblomkov gave a detailed introduction of all the objects involved in the conjectures and discussed recent progress in proving these conjecture.

One of the recent landmarks in the theory of knot homology is **Ben Webster**'s categorification of arbitrary Reshetikhin-Turaev invariants. In his beautifully illustrated lectures at the school, Webster explained how to generalize Khovanov-Lauda-Rouquier algebras to categorify tensor products, and how to then apply these generalizations to construct categorifications of quantum knot invariants. The first two lectures were building up the subject, starting from fundamental representation of $su(2)$. In the third talk, Webster sketched the program that will relate these invariants to A-branes on quiver varieties.

A particular highlight of the first week were two lectures, by **Piotr Sulkowski** and **Hiroyuki Fuji**, on the recently developed relation between colored homological invariants and the super-A-polynomial via the volume conjecture. The constructions fit beautifully into the general physics framework of mirror symmetry, quantum curves, and topological recursion. The lack of a representation theoretic foundation of the deformed A-polynomial stands as one of the important open problems.

Bridging the first to the second week, **Johannes Walcher** started his lectures with an overview of the physics ideas underlying the interest in knot homology. He emphasized the role of large-N transition as the most important part of the duality web. As an illustration of the physics methods and language, and a preparation for Khovanov-Rozansky homology, Walcher then reviewed the role of matrix factorizations as boundary conditions in Landau-Ginzburg models. In his second lecture at the beginning of the second week, he explained the relation between the knot homology of the unknot for minuscule representations, the cohomology of Hermitian symmetric spaces, and Jacobi rings. He ended his lectures with the Landau-Ginzburg motivation underlying the differentials on knot homology. The challenge was to complete the construction of the universal differentials relating knot homologies for unitary and orthogonal/symplectic groups.

The start of the second week proper were **Aaron Lauda**'s lectures on the use of Howe duality for categorification of quantum knot invariants. This story begins with Cautis-Kamnitzer-Licata's simple new approach to understanding these invariants using basic representation theory and the quantum Weyl group action. The basic point of Howe duality, or

more precisely a version of it for exterior algebras called skew-Howe duality, is to pair the action of the braid group to the action of the quantum Weyl group. Even the graphical (or skein theoretic) description of the knot invariants can be recovered in an elementary way from this data. Even though it is restricted to a certain type of algebras and representations, the advantage of the Howe duality approach is that it suggests a 'categorification' where knot homology theories arise in an elementary way from higher representation theory and the structure of categorified quantum groups.

Pace picked up further with **Mikhail Khovanov**'s lectures, who gave an introduction to categorification of quantum groups, starting with the notion of Grothendieck groups of algebras and categories. He explained possible framework when the direct sum of Grothendieck groups of a family of algebras admits the structure of a bialgebra or a twisted bialgebra via maps induced by induction and restriction functors. From the model case of group algebras of symmetric groups he moved on to a more refined setup of KLR algebras, explaining how Serre relations on the categorified level emerge from the diagrammatics of these algebras. He concluded by explaining an approach to categorify these groups at a prime root of unity, by equipping KLR algebras with certain p-differentials and working in the hopfological framework.

One of the basic blends of math and physics ideas underlying knot homologies is the relation between higher categories and higher topological quantum field theories. **Anton Kapustin**, who is one of the pioneers of the subject, gave two lectures on a class of 3-dimensional topological field theories known as abelian Chern-Simons theory, in which the 2-category of boundary conditions can be described completely explicitly. The theory, which turns out to be surprisingly restrictive, also has applications in condensed matter physics such as the quantum Hall effect.

Lev Rozansky, who was one of the senior participants of the school, was asked to give a one-hour seminar to share his expertise with the students. He chose to talk about the construction of colored Khovanov homology using the Jones-Wenzl projector. The idea is to cable link components and present the Jones-Wenzl projector as a limit of a directed system of twist braids. One advantage is that the twist braid representation makes colored Khovanov homology computable with the help of programs computing the non-colored theory.

The most detailed overview over the physics of knot homology was offered by **Sergei Gukov**. He explained in a stimulating lecture the diversity of relevant physical theories, involving topological quantum field theories in 2, 3, 4, and even 5 and 6 dimensions, string theories, M-theory, and dualities between all of the above. The main message was that these are really just different vantage points, from each of which particular structures become best visible. In his second lecture, Gukov explained the origin and uses of the vortex equations for the purposes of explicitly constructing knot homology.

As mentioned above, one of the most intriguing structural properties of knot homologies is the existence of differentials that relate various theories, both in rank space (where they correspond to finite-N corrections in the physics language), as well as in color space. The

excitement is due in large measure to the fact that the differentials lack an obvious counterpart before categorification, even though they are usually accompanied by new structural properties of the polynomial invariants as well. **Marko Stošić** presented a comprehensive overview of the presently known structure of differentials on theories of knot homologies. The motivations stem from physics/geometry insights that include BPS state counting and Landau-Ginzburg theories, but are also related to representation theory of superalgebras and Cherednik algebras. The main features are the "colored" differentials that relate homological invariants of knots colored by different representations. Stošić finished his lectures with a discussion of the relationship between differentials and the recursion relations of colored knot invariants encoded in the super-A-polynomial of Fuji-Gukov-Sulkowski.

Even though the theory of differentials in that full glory remains conjectural, there is a firm ground f or hope. As explained in **Jacob Rasmussen**'s lectures, one can indeed explain some of the differentials on Khovanov-Rozansky theory categorifying HOMFLY-PT by constructing appropriate spectral sequences converging to the sl(N) theories, thereby generalizing certain early observations of Lee and Gornik on knot Floer homology and Khovanov homology, respectively. Rasmussen finished his two lectures with a sketch of the uses of Cherednik algebras for further progress in this very promising area, which is fully understood at least for torus knots.

Joel Kamnitzer described his joint work with Cautis for constructing knot homology theories using the affine Grassmannian and the geometric Satake correspondence, which works well for all minuscule representations. He also gave an aperçu of the relations to other approaches to knot homology, including those of Khovanov, Mackaay, Webster and Witten. Thereby, the quantization of associated hyperkahler manifolds emerged as a very promising theme of the future.

Last not least, **Ciprian Manolescu** reviewed knot Floer homology and its relation with Heegard Floer homology. Knot Floer homology takes its origin in Seiberg-Witten theory. Manolescu reviewed the original definition given by Ozsvath-Szabo, and Rasmussen around 2003, which was based on symplectic geometry. In the meantime, at least five different combinatorial descriptions have become available. Manolescu explained the one based on grid diagrams (joint work with Ozsvath and Sarkara from 2006) and the one based on a cube of resolutions, which is reminiscent of HOMPLY-PT homology (work of Ozsvath and Szabo from 2007). One of the nice features of the symplectic approach to knot homology is the clear relation with a corresponding theory of invariants of three-mnanifolds (Heegard Floer homology). This is almost completely missing in the other approaches, and so the program of the school ended with the challenge wether the general three-manifold invariants of Reshetikhin-Turaev-Witten type could similarly be categorified.

6 Organization and Administration

We received over 120 applications from around the world. We sent out 101 invitations, offering partial support (accomodation in dormitories) to all non-local invitees. In correspondence with responsible people, we selected 23 participants for funding through MSRI. Based on excellence recommendation from their advisors, we also selected 20 students for support through Simons Fellowships. Of those invited, 28 attended with SMS support, 21 with MSRI support, 19 with Simons Fellowships, and 3 with a CMS Scholarship. 19 (mostly locals) did not receive any support from us. A number of participants received additional support from their home institutions toward travel expenses.

Around 90% of the support for participants went to graduate students. In addition, we also offered support to several high-profile senior participants with limited own funds. This decision was based in part on the pedagogical and scientific value that these participants contributed through topical seminars, interacions with students, and leading of discussion sessions.

Of the 90 participants, 13 (14%) were female. Canadian participants included 3 from the University of Toronto, 1 each from the Fields and Perimeter Institute, 7 from UQAM, 3 from McGill and 1 from Sherbrooke. The students from Toronto were awarded a CMS scholarship, valued 700$ each.

We offered full support (travel, accomodation and per diem meals) to speakers, although some instead chose to use their own funds for travel. All lectures were recorded and are available online via the SMS website.

The overall administration, arrangement of accomodation, refreshments, folders, and reimbursements, were all handled superbly by the SMS Staff.

7 Outline of Expenditures

- SPEAKERS: Housing at the Terrace Royal hotel near the Université de Montréal, reimbursement of travel expenses and per diem meals.
- SMS FUNDED PARTICIPANTS: 2 weeks at the Université de Montréal dormitories, nonrefundable, plus support for travel expenses depending on the distance to Montréal from the participant's location of study.
- MSRI FUNDED PARTICIPANTS: 21 participants. MSRI support covered housing, meals and travel expenses.
- SIMONS FELLOWSHIPS: 19, valued $1000 each.
- CMS FELLOWSHIPS: 3, valued $700 each.
- SENIOR PARTICIPANTS/SESSION LEADERS: partial support of accomodation in hotel or dormitories, and travel expenses
- SOCIAL EVENTS: daily breakfast and coffee breaks, one wine-and-cheese reception (covered by registration fee), two speakers' dinners at local restaurants.
- MISCELLANEOUS: Poster, video recording, photographs, photocopies

9 Feedback from Participants

Following the event, we collected feedback from the participants via an online questinnaire on the CRM website. Here are some results.

Question: *Which of the following statements to you most agree with?*	
The lectures were so difficult that I could not benefit at all	0
The lectures were very difficult, but I could still benefit	28
The lectures were easy to follow, and I learned a lot	23
The lectures were too easy, and I was bored	1

Question: *The schedule was*	
too light	1
about right	43
too tight	6

Comments (Selection)

- "The intention of the program is great. Bringing physicists and mathematicians to look at one particular subject of topology from different angles."
- "It's great to talk to physicists as a mathematician. This is really a rare opportunity for a math new graduate like me. "
- "De nombreux moments de discussion ont permis d'échanger avec un grand nombre de doctorants, post-doctorants et conférenciers. Je repars avec de nombreuses idées, et de nouveaux contacts !"
- "The physics lectures were far from introductory, unfortunately."
- "the main asset of this conference was meeting people. I had never meet Lou Kauffman before! Or heard Dror Bar-Natan speak. I also met Marcos Marino and Sergei Gukov. Ramadevi was excellent pedagogically. In general, I found the algebraists too... algebraic. We grad students organized our own math-physics discussion session, trying to reconcile the two disciplines. It will be a long time. Not all faculty were approachable. I couldn't really talk to Kapustin or Aganagic much. That's the way the ball bounces."
- "As the workshop was advertised as being for graduate students from multiple disciplines within both physics and mathematics, some more introductory talks would have been helpful; alternatively, the discussions would have been more useful had they been held on the second or third day, instead of the third to last day. "
- "The scientific programming was of very high quality, and I think valuable for participants of all levels. "

- "Outstanding. It was a nice blend of physicists and mathematicians. The mathematicians were not just confined to low-dimensional topologists, but also algebraic geometers and representation theorists. They gave a nice broad overview of the subject."
- "These lectures spawned new questions for me to explore. I've spent the weekend scouring the arXiv for papers by Johanes Walcher and Sergei Gukov. I have the happy problem of having yet more things to learn."
- "Talks were scheduled appropriately so that related talks were close to each other (in time)"
- "The scientific programming was excellent. Many of the speakers were well-known experts in the field, and many of them gave very useful, well-planned talks. There was also a good variety of levels of the talks. Overall they provided an excellent introduction to the field, a broad overview of the theory as a whole, and a good survey of several very interesting recent results and conjectures."
- "I learned several things at this summer school that will immediately impact my work in a positive way. The summer school also opened several new avenues of possible long-term research that may create interesting new connections between my work and the topics discussed during the lectures and conversations afterwards."
- "It was extraordinarily helpful to have a thematic program dedicated to exploring a wide variety of perspectives on and developments related to knot homologies, and aimed at graduate students or beginning researchers rather than experts in the field. I strongly feel that summer schools such as the SMS are essential for young mathematicians trying to get up to speed. I learned a lot, and I am confident that the other attendees did as well."

Centre de recherches mathématiques
Université de Montréal

École d'été SMS 2013 : Physique et Mathématiques de l'Homology des Entrelacs
Du 24 juin au 5 juillet 2013

SMS 2013 Summer School: Physics and Mathematics of Link Homology
June 24 - July 5, 2013

HORAIRE / *PROGRAM*

Le lundi 24 juin 2013 / *Monday, June 24, 2013*

08:00 - 09:00 Inscription et café croissants (Hall d'entrée Aisenstadt) / *Registration and Coffee & Croissants (Hall d'entrée Aisenstadt)*

09:00 - 10:15 **Dror Bar-Natan** (University of Toronto)
"A quick introduction to Khovanov homology-I"

10:15 - 10:45 Pause-café / *Coffee break*
(Salle / *Room* 1221)

10:45 - 12:00 **Ramadevi Pichai** (Indian Institute of Technology)
"Chern-Simons theory and knot invariants-I"

12:00 - 13:30 Pause-déjeuner / *Lunch break*

13:30 - 14:45 **Alexei A. Oblomkov** (Massachusetts Institute of Technology)
"Topology of planar curves, knot homology and representation theory of Cherednik algebras-I"

14:45 - 15:15 Pause-café / *Coffee break*
(Salle / *Room* 1221)

15:15 - 16:30 **Mina Aganagic** (University of California)
"Knots and string dualities-I"

Le mardi 25 juin 2013 / *Tuesday, June 25, 2013*

08:30 - 09:00 Café croissants (1221) / *Coffee & Croissants (1221)*

09:00 - 10:15 **Marcos Marino** (Université de Genève)
"Integrality properties of link invariants from topological-strings-I"

10:15 - 10:45 Pause-café / *Coffee break*
(Salle / *Room* 1221)

10:45 - 12:00 **Dror Bar-Natan** (University of Toronto)
"A quick introduction to Khovanov homology-II"

12:00 - 13:30 Pause-déjeuner / *Lunch break*

13:30 - 14:45 **Alexei A. Oblomkov** (Massachusetts Institute of Technology)
"Topology of planar curves, knot homology and representation theory of Cherednik algebras-II"

14:45 - 15:15 Pause-café / *Coffee break*
(Salle / *Room* 1221)

15:15 - 16:30 **Mina Aganagic** (University of California)
"Knots and string dualities-II"

16:30 Cocktail de bienvenue (6245) / *Welcoming reception (6245)*

Le mercredi 26 juin 2013 / *Wednesday, June 26, 2013*

08:30 - 09:00 Café croissants (1221) / *Coffee & Croissants (1221)*

09:15 - 10:15 **Piotr Sulkowski** (University of Warsaw)
"TBA"

10:15 - 10:45 Pause-café / *Coffee break*
(Salle / *Room* 1221)

10:45 - 12:00 **Dror Bar-Natan** (University of Toronto)
"Meta-groups, Meta-bicrossed-products, and the Alexander polynomial"

12:00 - 13:30 Pause-déjeuner / *Lunch break*

13:30 - 14:45 **Ramadevi Pichai** (Indian Institute of Technology)
"Chern-Simons theory and knot invariants-II"

14:45 - 15:15 Pause-café / *Coffee break*
(Salle / *Room* 1221)

15:15 - 16:30 **Ben Webster** (Northeastern University)
"Knot homology, KLR algebras and quiver Varietys-I"

Le jeudi 27 juin 2013 / *Thursday, June 27, 2013*

08:30 - 09:00 Café croissants (1221) / *Coffee & Croissants (1221)*

09:00 - 10:15 **Marcos Marino** (Université de Genève)
"Integrality properties of link invariants from topological strings-II"

10:15 - 10:45 Pause-café / *Coffee break*
(Salle / *Room* 1221)

10:45 - 12:00 **Ben Webster** (Northeastern University)
"Knot homology, KLR algebras and quiver Varietys-III"

12:00 - 13:30 Pause-déjeuner / *Lunch break*

13:30 - 14:45 **Alexei A. Oblomkov** (Massachusetts Institute of Technology)
"Topology of planar curves, knot homology and representation theory of Cherednik algebras-III"

14:45 - 15:15 Pause-café / *Coffee break*

15:15 - 16:30 **Ramadevi Pichai** (Indian Institute of Technology)
"Chern-Simons theory and knot invariants-III"

Le vendredi 28 juin 2013 / *Friday, June 28, 2013*

08:30 - 09:00 Café croissants (1221) / *Coffee & Croissants (1221)*

09:00 - 10:15 **Ben Webster** (Northeastern University)
"Knot homology, KLR algebras and quiver Varietys-II"

10:15 - 10:45 Pause-café / *Coffee break*

10:45 - 12:00 **Marcos Marino** (Université de Genève)
"Integrality properties of link invariants from topological strings-III"

12:00 - 13:30 Pause-déjeuner / *Lunch break*

13:30 - 14:45 **Johannes Walcher** (McGill University)
"Matrix factorizations and topological strings for knots-I"

14:45 - 15:15 Pause-café / *Coffee break*

15:15 - 16:15 **Hiroyuki Fuji** (University of Tokyo)
"TBA"

Le lundi 1 juillet 2013 / *Monday, July 1, 2013*

08:30 - 09:00 Café croissants (1221) / *Coffee & Croissants (1221)*

09:00 - 10:15 **Johannes Walcher** (McGill University)
"Matrix factorizations and topological strings for knots-II"

10:15 - 10:45 Pause-café / *Coffee break*
(Salle / *Room* 1221)

10:45 - 12:00 **Aaron Lauda** (University of Southern California)
"Knot invariants and their categorifications via Howe duality-I"

12:00 - 13:30 Pause-déjeuner / *Lunch break*

13:30 - 14:45 **Mikhail Khovanov** (Columbia University)
"Categorification of the HOMFLYPT polynomial and its specializations-I"

14:45 - 15:15 Pause-café / *Coffee break*
(Salle / *Room* 1221)

15:15 - 16:30 **Anton Kapustin** (California Institute of Technology)
"Abelian Chern-Simons theory as an extended topological field theory-I"

Le mardi 2 juillet 2013 / *Tuesday, July 2, 2013*

08:30 - 09:00 Café croissants (1221) / *Coffee & Croissants (1221)*

09:00 - 10:15 **Aaron Lauda** (University of Southern California)
"Knot invariants and their categorifications via Howe duality-II"

10:15 - 10:45 Pause-café / *Coffee break*
(Salle / *Room* 1221)

10:45 - 12:00 **Mikhail Khovanov** (Columbia University)
"Categorification of the HOMFLYPT polynomial and its specializations-II"

12:00 - 13:30 Pause-déjeuner / *Lunch break*

13:30 - 14:45 **Anton Kapustin** (California Institute of Technology)
"Abelian Chern-Simons theory as an extended topological field theory-II"

14:45 - 15:15 Pause-café / *Coffee break*
(Salle / *Room* 1221)

15:15 - 16:15 **Lev Rozansky** (University of North Carolina at Chapel Hill)
"TBA"

Le mercredi 3 juillet 2013 / *Wednesday, July 3, 2013*

08:30 - 09:00 Café croissants (1221) / *Coffee & Croissants (1221)*

09:00 - 10:15 **Sergei Gukov** (Harvard University)
"Overview of physics of knot homologies-I"

10:15 - 10:45 Pause-café / *Coffee break*
(Salle / *Room* 1221)

10:45 - 12:00 **Marko Stosic** (Instituto Superior Técnico)
"Colored HOMFLY homology of knots and links-I"

12:00 - 13:30 Pause-déjeuner / *Lunch break*

13:30 - 14:45 **Jake Rasmussen** (University of Cambridge)
"Differentials on knot homologies- I"

14:45 - 15:15 Pause-café / *Coffee break*
(Salle / *Room* 1221)

15:15 - 16:30 **Joel Kamnitzer** (University of Toronto)
"Knot homology via the affine Grassmannian-I"

Le jeudi 4 juillet 2013 / *Thursday, July 4, 2013*

08:30 - 09:00 Café croissants (1221) / *Coffee & Croissants (1221)*

09:00 - 10:15 **Ciprian Manolescu** (UCLA)
"An introduction to knot Floer homology"

10:15 - 10:45 Pause-café / *Coffee break*
(Salle / *Room* 1221)

10:45 - 12:00 **Sergei Gukov** (Harvard University)
"Overview of physics of knot homologies-II"

12:00 - 13:30 Pause-déjeuner / *Lunch break*

13:30 - 14:45 **Marko Stosic** (Instituto Superior Técnico)
"Colored HOMFLY homology of knots and links-II"

14:45 - 15:15 Pause-café / *Coffee break*
(Salle / *Room* 1221)

15:15 - 16:30 **Jake Rasmussen** (University of Cambridge)
"Differentials on knot homologies- II"

Le vendredi 5 juillet 2013 / *Friday, July 5, 2013*

08:30 - 09:00 Café croissants (1221) / *Coffee & Croissants (1221)*

09:00 - 10:15 **Joel Kamnitzer** (University of Toronto)
"Knot homology via the affine Grassmannian-II"

10:15 - 10:45 Pause-café / *Coffee break*
(Salle / *Room* 1221)

10:45 - 12:00 **Ciprian Manolescu** (UCLA)
"From knot Floer homology to invariants of 3- and 4-manifolds"

MSRI Supported Students		
First Name	**Last Name**	**Institution**
Michael	Abel	University of North Carolina
Nathaniel	Bade	Northeastern University
Michael	Brown	University of Nebraska
Nakul	Dawra	California Institute of Technology
ilknur	egilmez	University of Southern California
Ross	Elliot	California Institute of Technology
Chris	Gomes	University of Illinois
Liling	Gu	California Institute of Technology
Ana Cristina	Jimenez	University of Iowa
Seonhwa	Kim	Seoul National University
Deniz	Kutluay	Indiana University
Peter	Lambert-Cole	Louisiana State University
Caitlin	Leverson	Duke University
Francesco	Lin	Massachusetts Institute of Technology
George	Mossessian	University of California, Davis
Alex	Perry	Harvard University
You	Qi	Columbia University
Adam	Saltz	Boston College
Douglas	Schultz	Rutgers University
Yu	Tsumura	Purdue University
Qiao	Zhou	University of California, Berkeley

Graduate Student Statistics

Participants		21

Gender		21
Male	71.43%	15
Female	23.81%	5
Declined to state	4.76%	1

Ethnicity*		21
White	38.10%	8
Asian	33.33%	7
Hispanic	4.76%	1
Pacific Islander	0.00%	0
Black	0.00%	0
Native American	0.00%	0
Mixed	9.52%	2
Declined to state	14.29%	3

* ethnicity specifications are not exclusive

Summer Graduate School: Algebraic Topology

June 17, 2013 to June 28, 2013

MSRI, Berkeley, CA, USA

Organizers:

Andrew Blumberg (University of Texas)

Teena Gerhardt (Michigan State University)

Michael Hill* (University of Virginia)

Final Report: MSRI Graduate Summer Workshop 695: Algebraic Topology

Organizers:
Andrew Blumberg (University of Texas at Austin)
Teena Gerhardt (Michigan State University)
Michael Hill (University of Virginia)

17 June–28 June, 2013

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) Brooke Shipley (University of Illinois at Chicago) - Introduction to Stable Homotopy
   (b) Michael Hill (University of Virginia) - Introduction of Equivariant Stable Homotopy
   (c) Andrew Blumberg (University of Texas at Austin) - Introduction to Algebraic K-theory
   (d) Mark Behrens (MIT) - Computations in Algebraic Topology
2. A series of **4 lectures** by Gunnar Carlsson (Stanford) on the rapidly developing subfield of **applied algebraic topology**.
3. **20 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 the TAs (Aaron Royer and Anna Marie Bohmann), providing students an opportunity to ask questions about the material from lectures and to help prepare their own talks. The TAs also worked sample problems and computations, helping make more concrete the material from lecture.

5. **Career and Jobs Skills Panels** by the faculty and post-docs at the program, helping students navigate the often confusing trajectory of academia by describing their experience and answering questions.

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. Specifically, the student talks were synchronized (insofar as was possible) with the expository lectures, which allowed interplay between the new constructions and definitions in the lectures and their application in the talks.

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. 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. A few advanced students even discussed research questions together. The atmosphere fostered by the environment at MSRI was extremely conducive to mathematical interaction.

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. This played out with some direct feedback from students, both at the workshop and then subsequently via email. Several students came up towards the end of the workshop saying "this was a fantastic experience. I want to do topology now." and "before coming here, I felt someone isolated and mathematically adrift. Now I know exactly what I want to do!" Email feedback included comments like

"I became more focused on what I have to do, and have a clearer idea for my research. Remembering all the faces I spent two weeks together with, I feel like I belong to a community and that motivates me to enjoy my math way more."

Feedback like this shows the workshop to be a fantastic success!

Students and Student Lectures

We modeled the "student lecture" component on MIT's "Kan Seminar". 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 25 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. The first week focused on the beautiful work linking manifolds up to cobordism, stable homotopy, and vector bundles and K-theory. The second week abstracted this, looking at more axiomatic approaches to stable homotopy and therefore to the original problems.

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.

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

Brooke Shipley: Introduction to Stable Homotopy

Shipley's lecture series provided students with a broad background for modern algebraic topology, setting stage for the entire workshop. The first few lectures focused on concepts of stabilization, the heart of modern algebraic topology, starting with Homotopy Excision and the Freudenthal Suspension Theorem. Homotopy Excision is a fundamental result, but it is often not included in many school's algebraic topology sequence. Shipley carefully explained the mathematics around this, and then described the Suspension Theorem and stable homotopy groups. From here, she moved on to spectra, explaining Brown Representability and the link between spectra and generalized cohomology theories. She also explored several other kinds of spectra, linking these to talks by some of the students.

Spectra are the primary focus in modern algebraic topology, as the constructions and focus on algebro-geometric methods rely on rigid, symmetric monoidal categories. Shipley provided a straightforward introduction which allowed students to understand the underlying reasoning and motivation for many of the problems.

Michael Hill: Introduction to Equivariant Stable Homotopy

Hill's lectures explored the basics of equivariant stable homotopy theory, largely mirroring Shipley's lectures but also 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.

Andrew Blumberg: Introduction to Algebraic K-theory

Blumberg's lectures gave an introduction to algebraic K-theory, one of the central application areas of modern stable homotopy theory. The invariants of algebraic K-theory contain both subtle number theoretic information (e.g., when applied to the ring of integers in a number field) and geometric information (e.g., when applied to $\mathbb{Z}[\pi_1 M]$ for a high-dimensional manifold M). These talks started from the basic definitions, which make clear the connection to linear algebra, and then proceeded to work towards developing the modern homotopical viewpoint on the details and constructions of the theory. An eye towards concrete identification of low-dimensional K-groups in terms of known invariants (e.g., the class group and the Whitehead torsion) helped keep the theory grounded. Later lectures explored the explosion in the subject following Quillen's seminal construction of higher algebraic K-theory and hinted at various modern application areas.

Mark Behrens: Computations in Algebraic Topology

Behrens' talks focused the Adams spectral sequence, the primary computational tool for computations in stable homotopy theory. His early talks focused on the set-up of the spectral sequence, framing the method and providing introductory computations. He then moved into a very important toy example, connective real K-theory (ko) computations. Here the Adams spectral sequence has a more tractable form, arising from Ext over a finite subalgebra of the Steenrod

algebra. Computations here are quite accessible, and students enjoyed form ing the resolutions and seeing how easy they can be. Even the TAs had fun exploring ko computations, presenting several in the discussion sessions. Behrens' finished with discussions of the May spectral sequence (used to compute the E_2 term of the Adams spectral sequence) and other computations.

Computations in stable homotopy tend to be viewed as very difficult to approach and understand. Behrens' masterful lectures showed that a great deal of information can be gleaned from fairly simple algebraic manipulations, showing students exactly how to approach the kinds of computations which arise and how to interpret the data.

Gunnar Carlsson: Introduction of Applied Algebraic Topology

Carlsson gave a series of talks introducing the emerging area of applications of the methods of algebraic topology to data analysis. The basic approach is to start with a "point cloud" (i.e., a finite metric space) and produce from this a family of simplicial complexes that encode the topological information in the data. Carlsson is one of the founding figures in the field and continues to be a very active researcher; moreover, he has founded a company that applies these techniques to real data sets. As a consequence, the lectures were able to masterfully survey the origins and important developments in the field and also to ground the work in specific applications. Given how abstract much of the work in modern algebraic topology is, Carlsson's lectures were an excellent counterpoint and also were more accessible to students with weaker backgrounds. We were also pleased to have a concrete example for students of the kinds of vocational paths that might be available in the event that they chose not to pursue an academic career.

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. MSRI 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. 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**
Mark	Behrens	Massachusetts Institute of Technology
Andrew	Blumberg*	University of Texas
Eric	Bunch	Kansas State University
Ernest	Fontes	University of Texas
Michael	Francis	University of Victoria
Robert	Hank	University of Minnesota Twin Cities
Michael	Hill*	University of Virginia
Chris	Kapulkin	University of Pittsburgh
Maitreyee	Kulkarni	Louisiana State University
Vitaly	Lorman	Johns Hopkins University
Lorenzo	Losa	Scuola Normale Superiore
Cary	Malkiewich	Stanford University
Aaron	Mazel-Gee	University of California
Mona	Merling	University of Chicago
Nathan	Perlmutter	University of Oregon
Eric	Peterson	University of California
Matthew	Sartwell	University at Buffalo (SUNY)
Brooke	Shipley	University of Illinois
Charmaine	Sia	Harvard University
Scott	Slinker	University of Virginia
Maxim	Stykow	University of British Columbia
Jonathan	Thompson	University of Kentucky
Gabriel	Valenzuela	Wesleyan University
Jean	Verrette	University of Hawaii at Manoa
Deborah	Vicinsky	University of Oregon

Teaching Assistant		
First Name	**Last Name**	**Institution**
Aaron	Royer	University of Texas

MSRI Mathematical Sciences Research Institute

Algebraic Topology

June 17-June 28, 2013

Schedule

Monday,June 17, 2013			
9:15 AM - 9:30 AM	Simons Auditorium		Welcome
9:30 AM - 10:45 AM	Simons Auditorium	Brooke Shipley	Intro to stable homotopy and spectra I
10:45 AM - 11:15 AM	Atrium		Coffee Break
11:15 AM - 12:30 PM	Simons Auditorium	Michael Hill	Intro to equivariant stable homotopy I
12:30 PM - 2:00 PM	Atrium		Lunch
2:00 PM- 2:45 PM	Simons Auditorium	Cary Malkiewich	Thom's "Quelque proprietes globales des varietes differentiables"
2:45PM - 3:30 PM	Simons Auditorium		Problem Session
3:30 PM - 4:30 PM	Atrium		Tea
4:000 PM - 4:45 PM	Simons Auditorium	Jonathan Thompson	Milnor's "The Steenrod algebra and its dual"

Tuesday, June 18, 2013			
9:30 AM - 10:45 AM	Simons Auditorium	Brooke Shipley	Intro to stable homotopy and spectra II
10:45 AM - 11:15 AM	Atrium		Coffee Break
11:15 AM - 12:30	Simons Auditorium	Michael Hill	Intro to equivariant stable homotopy II
12:30 PM - 2:00 PM	Atrium		Lunch
2:00 PM -2:45 PM	Simons Auditorium	Gabriel Valenzuela	Quillen's "Elemetary proofs of some results of cobordism theory using Steenrod operations"
2:45PM - 3:30 PM	Simons Auditorium		Problem Session
3:30 PM - 4:00 PM	Atrium		Tea
4:00 PM -4:45 PM	Simons Auditorium	Michael Francis	Atiyah's "K-theory"

Wednesday,June 19, 2013			
9:30 AM - 10:45 AM	Simons Auditorium	Brooke Shipley	Intro to stable homotopy and spectra III
10:45 AM - 11:30 AM	Simons Auditorium	Charmaine Sai	Adams & Atiyah's "K-theory and the Hopf invariant"
11:30AM - 2:00 PM	Tilden Park		BBQ
2:00 PM - 3:15 PM	Simons Auditorium	Michael Hill	Intro to equivariant stable homotopy III
3:15 PM - 3:45 PM	Atrium		Tea
3:45 PM-5:00PM	Simons Auditorium		Faculty and Postdoc Panel

Thursday,June 20, 2013			
9:30 AM - 10:45 AM	Simons Auditorium	Brooke Shipley	Intro to stable homotopy and spectra IV
10:45 AM - 11:15 AM	Atrium		Coffee Break
11:15AM - 12:30	Simons Auditorium	Michael Hill	Intro to equivariant stable homotopy IV
12:30PM- 2:00 PM	Atrium		Lunch
2:00PM - 2:45 PM	Simons Auditorium	Lorenso Losa	Milnor & Stasheff's "Characteristic Classes"
2:45 PM - 3:30 PM	Simons Auditorium		Problem Session
3:30 PM - 4:00 PM	Atrium		Tea
4:00 PM - 4:45 PM	Atrium	Jean Verrette	Becker & Gottlieb's "The transfer map and fiber bundles"

Friday, June 21, 2013			
9:30 AM - 10:30 AM	Simons Auditorium	Gunnar Carlsson	Applied algebraic topology I
10:30 AM - 11:00 AM	Atrium		Coffee Break
11:00 PM - 12:00 PM	Simons Auditorium	Gunnar Carlsson	Applied algebraic topology II
12:00 PM - 1:30 PM	Atrium		Lunch
1:30 PM- 2:15 PM	Simons Auditorium	Maxim Stykow	Kervaire's "A manifold which does not admit any differentiable structure"
2:15 PM -2:30 PM			Break
2:30 PM - 3:15 PM	Simons Auditorium	Nathan Perlmutter	Milnor's "On manifolds hemeomorphic to the 7-sphere" and Kervaire & Milnor's "Groups of homotopy spheres I"
3:15 PM - 4:00 PM	Atrium		Tea Break & problem session
4:00 PM - 4:45 PM	Simons Auditorium	Ernie Fontes	Bass' "Categories of modules and their equivalences"

Monday,June 24, 2013			
9:30 AM - 10:30 AM	Simons Auditorium	Gunnar Carlsson	Applied algebraic toplogy III
10:30 AM - 11:00 AM	Atrium		Coffee Break
11:00 AM - 12:00 AM	Simons Auditorium	Gunnar Carlsson	Applied algebraic toplogy IV
12:00 PM - 1:30 PM	Atrium		Lunch
1:30PM- 2:15 PM	Simons Auditorium	Andre Kuney	Mlnor's "The gemoetric realization of a semi-simplicial complex"
2:15PM - 2:30 PM			Break
2:30 PM - 3:15 PM	Simons Auditorium	Maitreyee Kulkarni	Segal's "Classifying spaces and spectral sequences"
3:15 PM - 4:00 PM	Atrium		Tea Break & problem session
4:00PM- 4:45PM	Simons Auditorium	Deborah Vicinsky	Quillen's "Homotopical algebra"

Tuesday, June 25, 2013			
9:30 AM - 10:45 AM	Simons Auditorium	Mark Behrens	Intro to computational techniques in stable homotopy I
10:45 AM - 11:15 AM	Atrium		Coffee Break
11:15 AM - 12:30	Simons Auditorium	Andrew Blumberg	Intro to algebraic K-theory I
12:30 PM - 2:00 PM	Atrium		Lunch
2:00 PM -2:45 PM	Simons Auditorium	Robert Hank	Bousfield & Kan's "Homotopy limits, completions and localizations"
2:45PM - 3:30 PM	Simons Auditorium		Problem Session
3:30 PM - 4:00 PM	Atrium		Tea Break & problem session
4:00 PM -4:45 PM	Simons Auditorium	Chris Kapulkin	Dwyer & Kan's "Simplicial locatization of categories" and "Calculating simplicial localizations"

Wednesday,June 26, 2013			
9:30 AM - 10:45 AM	Simons Auditorium	Mark Behrens	Intro to computational techniques in stable homotopy II
10:45 AM - 11:15 AM	Atrium		Coffee Break
11:15AM - 12:30 PM	Simons Auditorium	Andrew Blumberg	Introduction to algebraic K-theory II
12:30 PM - 2:00 PM	Atrium		Lunch
2:00 PM - 3:30 PM	Simons Auditorium		Job Skills Workshop
3:30 PM -4:00 PM	Atrium		Tea Break
4:00 PM-4:45 PM	Simons Auditorium	Eric Bunch	Brown's "Cohomology theories"

Thursday, June 27, 2013			
9:30 AM - 10:45 AM	Simons Auditorium	Mark Behrens	Intro to computational techniques in stable homotopy III
10:45 AM - 11:15 AM	Atrium		Coffee Break
11:15AM - 12:30 PM	Simons Auditorium	Andrew Blumberg	Intro to algebraic K-theory III
12:30 PM - 2:00 PM	Atrium		Lunch
2:00PM - 2:45 PM	Simons Auditorium	Vitaly Lorman	May's "The geometry of iterated loop spaces"
2:45 PM - 3:30 PM	Simons Auditorium		Problem Session
3:30 PM -4:00 PM	Atrium		Tea Break
4:00 PM - 4:45 PM	Smmons A	Matthew Sartwell	Segals "Categories and cohomology theories"

Friday, June 28, 2013			
9:30 AM - 10:45 AM	Simons Auditorium	Mark Behrens	Intro to computational techniques in stable homotopy IV
10:45 AM - 11:15 AM	Atrium		Coffee Break
11:15AM - 12:30 PM	Simons Auditorium	Andrew Blumberg	Intro to algebraic K-theory IV
12:30 PM - 2:00 PM	Atrium		Lunch
2:00PM - 2:45 PM	Simons Auditorium	Mona Merling	Mandell, May, Schwede, & Shipley's "Model categories of diagram spectra"
2:45 PM - 3:30 PM	Simons Auditorium		Problem Session
3:30 PM -4:00 PM	Atrium		Tea Break
4:00 PM - 4:45 PM	Simons Auditorium	Eric Peterson	Mahowald's "Ring spectra which are Thom complexes"

Attending Students		
First Name	**Last Name**	**Institution**
Leyda	Almodovar	University of Iowa
Nerses	Aramyan	University of Illinois at Urbana-Champaign
Juan	Arias Uribe	Universidad de los Andes
Haldun	Bayindir	University of Illinois at Chicago
Donna	Blanton	University of California
Anna Marie	Bohmann	Northwestern University
Diana	Castaneda	Universidad de los Andes
Safia	Chettih	University of Oregon
Sophie	Choe	Portland State University
Alex	Finnegan	Washington and Lee University
Barbara	Gutierrez	Centro de Investigacion y de Estudios Avanzados del IPN
Kaylee	Hamann	University of California
Joe	Hannon	Boston University
Brendan	Healy	Tufts University
Cristhian	Hidber Cruz	Centro de Investigacion y de Estudios Avanzados del IPN
Reeve	Hunter	Baylor University
Kelley	Johnson	Tulane University
Hankyung	Ko	University of Virginia
Joaquin	Maya	Centro de Investigacion y de Estudios Avanzados del IPN
Anibal	Medina	SUNY
Andreas	Michaelides	Tulane University
Elizabeth	Pacheco	University of Oklahoma
Joshua	Parks	University of Virginia
Elaine	So	University of Pennsylvania
Luis	Sordo Vieira	University of Kentucky
Felicia	Tabing	University of California
Scott	Thuong	University of Oklahoma
Jacob	West	University of California
Mose	Wintner	University of Southern California
Yang	Xiu	Princeton University
Sarah	Yeakel	University of Illinois at Urbana-Champaign

Student Statistics

Total Students		31

Gender		31
Male	54.84%	17
Female	45.16%	14
Declined to state	0.00%	0

Ethnicity*		31
White	45.16%	14
Asian	16.13%	5
Hispanic	25.81%	8
Pacific Islander	0.00%	0
Black	0.00%	0
Native American	0.00%	0
Declined to state	3.23%	1
Mixed	9.68%	3

* ethnicity specifications are not exclusive

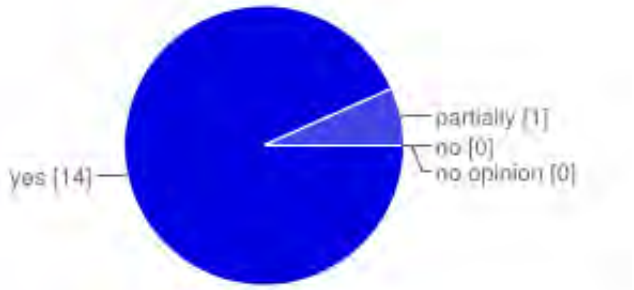
Summer Graduate School: Algebraic Topology, June 17 - 28, 2013 at MSRI, Berkeley, CA USA

15 responses

Summary See complete responses

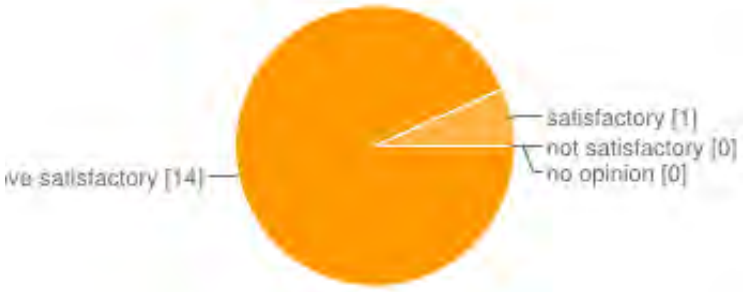
Topic presentation and organization

Did the various topics within the workshop integrate into a coherent picture?



yes	14	93%
partially	1	7%
no	0	0%
no opinion	0	0%

Were the faculty speakers generally clear and well organized in their presentation?

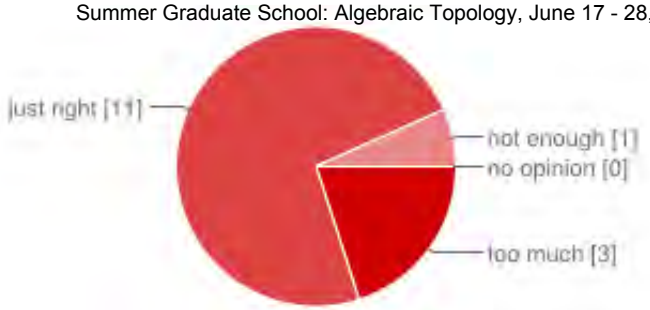


above satisfactory	14	93%
satisfactory	1	7%
not satisfactory	0	0%
no opinion	0	0%

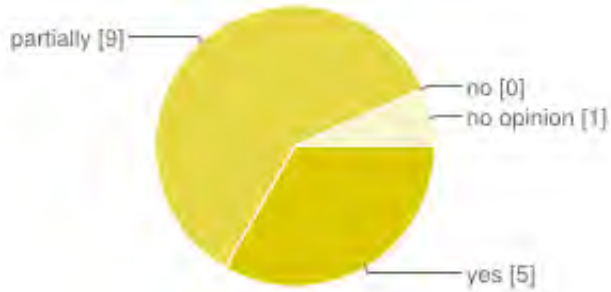
Was there too much material presented; was the school too ambitious?

too much	3	20%
just right	11	73%
not enough	1	7%
no opinion	0	0%

Summer Graduate School: Algebraic Topology, June 17 - 28, 2013 at MSRI, Berkeley, CA USA

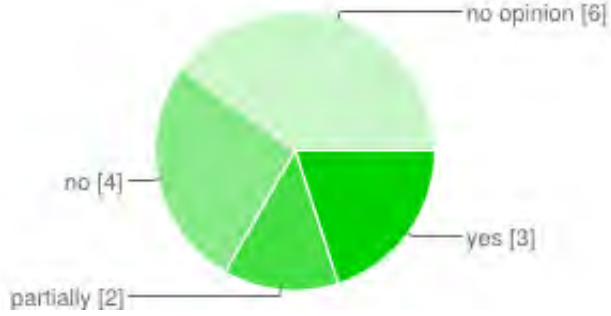


Were the problem sessions helpful?



yes	5	33%
partially	9	60%
no	0	0%
no opinion	1	7%

Were the computer labs helpful?



yes	3	20%
partially	2	13%
no	4	27%
no opinion	6	40%

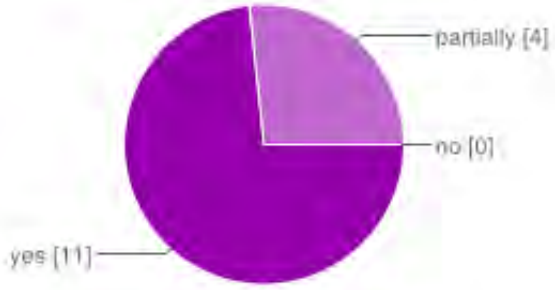
Please comment on the panel discussions. What did you like? What would you have liked to see?

I found the Faculty and Postdoc panel really helpful. Hearing the candid views and descriptions of the panelists on life after graduate school was both useful and encouraging. The second panel, on `Job Skills' I think could have been a bit more organized and focused, but the expertise of the panelists were still very much appreciated. The content was really good, but we could hardly hear them. It painted an honest depiction of how the job market works, and the possibilities to expect in the future. I appreciated the age of the panel and the advice on applying for jobs. All shared perspectives w ...

Summer Graduate School: Algebraic Topology, June 17 - 28, 2013 at MSRI, Berkeley, CA USA

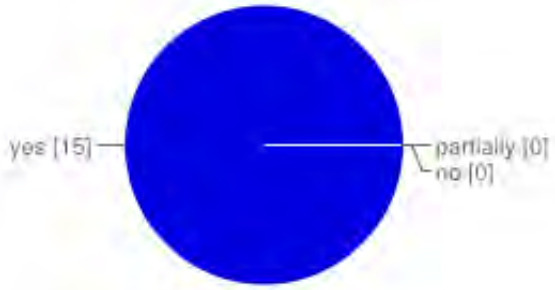
Personal assessment

Was your background adequate to access a reasonable portion of the material?



yes	11	73%
partially	4	27%
no	0	0%

Did the workshop increase your interest in the subject?



yes	15	100%
partially	0	0%
no	0	0%

Was the school worth your time and effort?

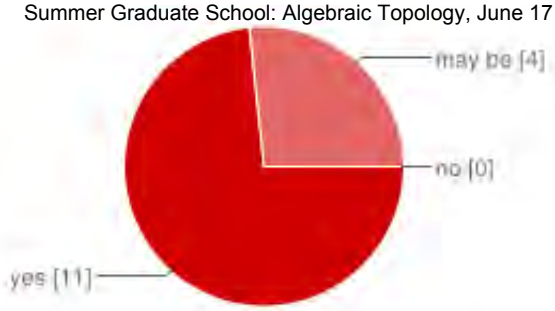
yes	15	100%
partially	0	0%
no	0	0%

Is it likely that you will work in the area of the workshop subject in the future?

yes	11	73%
may be	4	27%

Summer Graduate School: Algebraic Topology, June 17 - 28, 2013 at MSRI, Berkeley, CA, USA

no	0	0%



How would you evaluate your interaction with other participants?

1 -not satisfactory	0	0%
2	0	0%
3	1	7%
4	5	33%
5 -above satisfactory	9	60%

Additional comments on your personal assessment

I definitely increase my awareness of the importance of the subject area. This was really helpful for me for developing a background on this subject that I just started to work on. I can honestly say this was the best program I have ever attended. It gave me a huge boost in my moral. My school focuses on other areas of research and there aren't a lot of options for learning algebraic topology in an organized fashion. Until now, I had learned most things on my own, or with the help of my advisor. I had been getting a little discouraged and seriously considered not continuing with research, ...

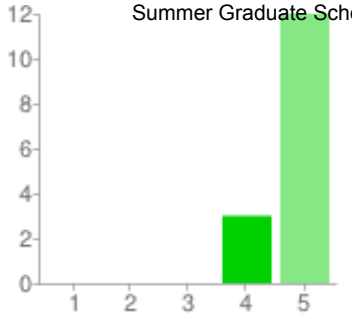
MSRI Venue

Please rate the different categories

Your overall experience

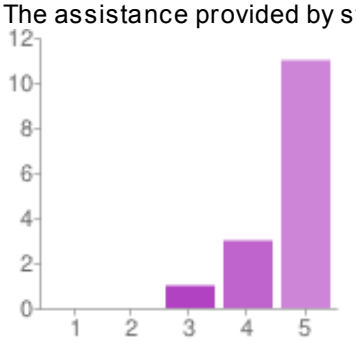
1 -not satisfactory	0	0%
2	0	0%
3	0	0%
4	3	20%

Summer Graduate School: Algebraic Topology, June 17 - 28, 2013 at MSRI, Berkeley, CA, USA



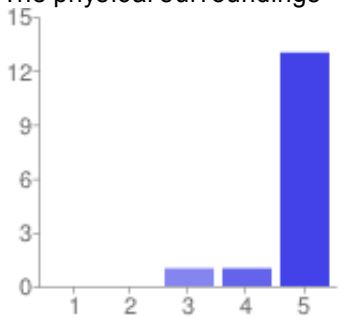
5 -above satisfactory	12	80%

The assistance provided by staff



1 -not satisfactory	0	0%
2	0	0%
3	1	7%
4	3	20%
5 -above satisfactory	11	73%

The physical surroundings



1 -not satisfactory	0	0%
2	0	0%
3	1	7%
4	1	7%
5 -above satisfactory	13	87%

Additional comments on the MSRI venue

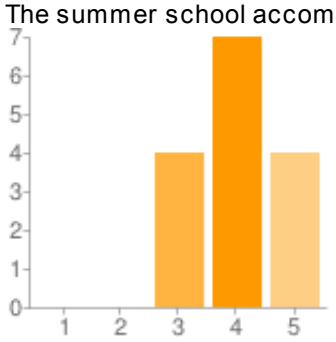
Gorgeous location. Great to look over the bay every morning and drink my coffee. The BBQ picnic in the park was a nice chance to see more of the surroundings. It would have been nice to have more chalk boards to talk math. The nicest place I've thought a lot about math. Beautiful!!! Excellent facilities with beautiful surroundings, very relaxing for doing mathematics. It is a great "mountain-top experience". The awesome views and being away from the rest of the world for the time created an environment that was very

helpful for learning. I had one problem with the venue - the temperature in the l ...

Accommodation and Food

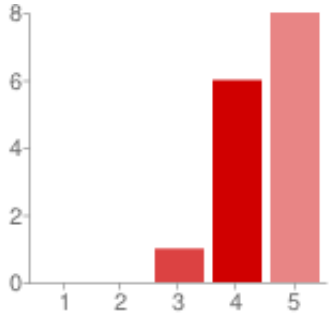
Please rate the different categories

The summer school accommodation



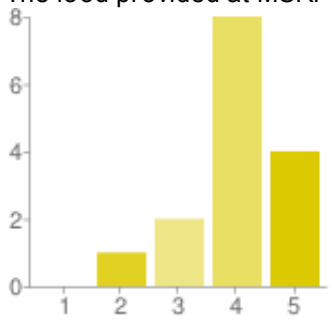
1 -not satisfactory	0	0%
2	0	0%
3	4	27%
4	7	47%
5 -above satisfactory	4	27%

The food at the dormitories



1 -not satisfactory	0	0%
2	0	0%
3	1	7%
4	6	40%
5 -above satisfactory	8	53%

The food provided at MSRI



1 -not satisfactory	0	0%
2	1	7%
3	2	13%
4	8	53%
5 -above satisfactory	4	27%

Summer Graduate School: Algebraic Topology, June 17 - 28, 2013 at MSRI, Berkeley, CA USA

Additional comments on accommodation and food

Coffee in the dormitory cafeteria was nigh undrinkable. Food there was fine. Lots of vegetarian options. The MSRI lunches were quite good. Especially in the first week (5) less so in the second (3). Initially, there was not enough food at MSRI. Regarding the food: it's 1 for the first week and 4 for the second. Please disregard my votes for the first two of these questions (I didn't stay at the dorms or take meals there) -- I voted 5 for both of these since the form requires me to choose a value. I voted 5 for the food at MSRI on purpose, though; I was extremely pleased that the quality was mu ...

Thank you for completing this survey

We welcome any additonal comments or suggestions you may have to improve the overall experience for future participants.

The problem session would have been more helpful if we were broken into groups and given assignments. Would be helpful if more details of the workshop (tentative list of topics/speakers) could be given before applications were due. I would suggest giving a little more time for students to work on problems, and have some problems prepared in advance for these sessions. All of the talks were great, but it would have been nice to have some time to work out some details. Some of the speakers gave exercises in their talks, but there was not very much time during the day devoted to working these o ...

Number of daily responses

Summer Graduate School:
Algebraic Topology
June 17 – 28, 2013

Additional Survey Responses

Additional comments on your personal assessment:

- I definitely increase my awareness of the importance of the subject area.
- This was really helpful for me for developing a background on this subject that I just started to work on.
- I can honestly say this was the best program I have ever attended. It gave me a huge boost in my moral. My school focuses on other areas of research and there aren't a lot of options for learning algebraic topology in an organized fashion. Until now, I had learned most things on my own, or with the help of my advisor. I had been getting a little discouraged and seriously considered not continuing with research, mainly because I was frustrated with the feeling of not knowing anything and not knowing how to learn it. The field of algebraic topology suffers from having a lot of work done recently and not having a good exposition of the standard material. What this school accomplished is to organize this material in a way that made it easy to pick up. The course motivated me to continue pursuing a research career in the field, and without it I doubt I would have continued much longer.

Additional comments on the MSRI venue:

- Gorgeous location. Great to look over the bay every morning and drink my coffee. The BBQ picnic in the park was a nice chance to see more of the surroundings.
- It would have been nice to have more chalk boards to talk math.
- The nicest place I've thought a lot about math.
- Beautiful!!!
- Excellent facilities with beautiful surroundings, very relaxing for doing mathematics.
- It is a great "mountain-top experience". The awesome views and being away from the rest of the world for the time created an environment that was very helpful for learning.
- I had one problem with the venue - the temperature in the lecture room fluctuated too much. In some lectures it was quite cold, but then the next lecture it was quite hot, maybe a 15 or 20 degree difference. I don't know why it changed so much, but it made it difficult to dress appropriately and pay attention to the talks.

We welcome any additonal comments or suggestions you may have to improve the overall experience for future participants.

- The problem session would have been more helpful if we were broken into groups and given assignments.
- Would be helpful if more details of the workshop (tentative list of topics/speakers) could be given before applications were due.
- I would suggest giving a little more time for students to work on problems, and have some problems prepared in advance for these sessions. All of the talks were great, but it would have been nice to have some time to work out some details. Some of the speakers gave exercises in their talks, but there was not very much time during the day devoted to working these out.
- Don't lose the survey data! I'm not going to fill this out again!

Additional comments on accommodation and food

- Coffee in the dormitory cafeteria was nigh undrinkable. Food there was fine. Lots of vegetarian options. The MSRI lunches were quite good. Especially in the first week (5) less so in the second (3).
- Initially, there was not enough food at MSRI.
- Regarding the food: it's 1 for the first week and 4 for the second.
- Please disregard my votes for the first two of these questions (I didn't stay at the dorms or take meals there) -- I voted 5 for both of these since the form requires me to choose a value. I voted 5 for the food at MSRI on purpose, though; I was extremely pleased that the quality was much higher than any sort of run-of-the-mill large-scale cafeteria fare.
- The caterers the second week were better.
- The dorm was hot, and the traffic on the street below was extremely loud, but the food was great. I liked the caterer during the second week better than the first.

Please comment on the panel discussions. What did you like? What would you have liked to see?

- I found the Faculty and Postdoc panel really helpful. Hearing the candid views and descriptions of the panelists on life after graduate school was both useful and encouraging. The second panel, on `Job Skills' I think could have been a bit more organized and focused, but the expertise of the panelists were still very much appreciated.
- The content was really good, but we could hardly hear them.
- It painted an honest depiction of how the job market works, and the possibilities to expect in the future.
- I appreciated the age of the panel and the advice on applying for jobs. All shared perspectives were appreciated, and I have no improvements to suggest.
- Panel discussions about jobs were very helpful.
- They were very helpful. I particularly profited from what Brooke Shipley said.
- I like everything, the topics were so interesting.
- They were good.
- For the panel on finding a job after graduate school, all of the panel members were people who had been successful at landing top research jobs at universities. It would be nice to have panel members who have been successful in the industry or in teaching positions.
- They very helpful.
- The panel discussions were nice. It was good to have a somewhat more informal atmosphere to discuss the topics. I think it would have been better if the organizers had planned a short spiel about each of the topics ahead of time, instead of just jumping blindly into a Q&A session; it would've given us a better understanding of the context.
- It was very helpful to hear others' experiences and to learn about some issues (when applying for jobs, say) that one might not have considered in the past but which should be taken into account.
- I received a lot of great advice from the panels. The only thing I would suggest is that the panelists come a little more prepared with their own experiences because at times they did not want to answer the questions. Also, it would be a good idea to have a microphone to pass around. Some of the panelists were quiet.
- I particularly liked the advice on jobs and future career.
- I liked hearing the information about funding. I wish there had been a little more discussion about getting jobs that are not positions at Research I universities.

MSRI Mathematical Sciences Research Institute

Summer Graduate School: IAS/PCMI Summer 2013: Geometric Analysis

June 30, 2013 to July 20, 2013

Park City, UT

Organizers:

Hubert Bray (Duke University)

Greg Galloway (University of Miami)

Rafe Mazzeo (Stanford University)

Natasa Sesum (Rutgers University)

Report of the IAS/Park City Mathematics Institute

The IAS/Park City Mathematics Institute (PCMI) is a program of professional development for the mathematics community, including research mathematicians, graduate students, undergraduate students, mathematics education researchers, undergraduate faculty, and mathematics teachers at the secondary school level. Established in 1991 through a grant from the National Science Foundation, PCMI has been an outreach program of the Institute for Advanced Study since 1994.

The annual Summer Session is the flagship activity of PCMI. Held in Park City, Utah, this three-week, residential institute combines high-quality lectures and seminars with activities and events designed to foster all-institute interaction. The unique interaction at PCMI creates strong bonds throughout the mathematical community and increases awareness of the roles and the contributions of all professionals in mathematics-based occupations.

In addition to the annual Summer Session, PCMI offers year-round professional development outreach activities to secondary school mathematics teachers around the nation through the c-TaP Project and through PCMI's Professional Development and Outreach Groups.

Another method of outreach is through the publications offered by PCMI. The Math Forum at Drexel University publishes online the products created by PCMI's Secondary School Teachers Program and the proceedings and briefs authored by PCMI's International Seminar on Mathematics Education. The Graduate Summer School lectures are collected in their own volumes, the *Park City Mathematics Series*, published by the American Mathematical Society (AMS) and targeted at graduate students and research mathematicians. Also published by the AMS is a series of lectures from PCMI's Undergraduate Summer School.

Annual Summer Session 2013

The 23rd annual Summer Session was held June 30-July 20, 2013, in Park City, Utah, and attracted some 350 participants combined in all programs.

The following programs comprised the Summer Session (except as noted, all programs met for the entire three weeks):

Graduate Summer School
High School student mathematics camp (one week)
Research Program in Mathematics
School Teachers Program
Undergraduate Faculty Program
Undergraduate Summer School
Workshop for Mentors of Minority Undergraduate Research in Mathematics

The mathematical research topic informs the courses and seminars for the Graduate Summer School, the Research Program, the Undergraduate Summer School, and the Undergraduate Faculty Program; in 2013 the topic was *Geometric Analysis.* The topic *Making Mathematical Connections* provided the focus for the three-week Summer School Teachers Program and for the one-week program for high school students.

Each program met daily for a series of courses and seminars. The programs also met together for Cross Program Activities three or four days each week.

GRADUATE SUMMER SCHOOL AND RESEARCH PROGRAM

The Graduate Summer School and the Research Program were organized by Professors Hubert Bray, Duke University; Greg Galloway University of Miami; Rafe Mazzeo, Stanford University; and Natasa Sesum, Rutgers University. *Geometric Analysis* is a very broad area of mathematics whose objective is to geometrically motivated problems using diverse tools from analysis, partial differential equations, physics, topology, and geometry; and the Graduate Summer School lecture series, as well as the Research Program's lectures reflected this diversity.

Graduate Summer School The Graduate Summer School is designed to provide graduate students with a comprehensive and diverse learning experience that few, if any, could obtain in just their own university. Attendance at all lectures was very high and included participants from the Graduate Summer School, the Research Program, the Undergraduate Faculty Program, the Undergraduate Summer School and even the Secondary School Teacher Program.

The 2013 Graduate Summer School had nine lecture series (with a total of 36 lectures), each on a particular aspect of Geometric Analysis. Each lecture series consisted of four or five lectures as well as three supplementary sessions where students worked on prepared problems guided by the lecturers' Teaching Assistants. The lectures were well-balanced between introductory and advanced research material.

Graduate Summer School Lecture Series 2013

Michael Echmair, ETH Zurich: *On the isoperimetric structure of asymptotically flat manifolds*
Fernando Marques, IMPA Brazil: *Min-max theory and the Willmore conjecture*
Tristian Riviere, ETH, Zurich: *Weak immersions of surfaces with finite total curvature'*
Igor Rodnianski, Massachusetts Institute of Technology: *Evolution problem in General Relativity*
Peter Topping, Warwick University: *Applications of Hamilton's Compactness Theorem for Ricci flow*
Jeff Viaclovsky, University of Wisconsin: *Riemannian curvature functionals*
Ben Weinkove, University of California, San Diego: *The Kahler-Ricci flow on compact Kahler manifolds*
Brian White, Stanford University: *Minimal submanifolds*
Steve Zelditch, Johns Hopkins University: *Global Harmonic Analysis*

The Research Program

A broad spectrum of highly active researchers in *Geometric Analysis* were recruited for the Research Program, with a significant number of them staying for the entire three weeks of the Summer Session.

The main formal activity of the research program consisted of nine hours of research talks each week. The speakers took into account the diversity of the audience and carefully explained the background and motivation for their work as well as their recent results. Informal activity was also extensive; small groups gathered for conversations wherever they could find space. Many of these conversations have already developed into new collaborations.

Research Program Seminars 2013

A Minkowski inequality and a Penrose inequality; Mu-Tao Wang, Columbia University

Weak null singularities in general relativity; Jonathan Luk, University of Pennsylvania

Universal profiles for MCF singularities; Dan Knopf, University of Texas

Minimal surfaces in the ball and an eigenvalue problem; Ailana Fraser, University of British Columbia

Stability of Perelman's Ricci shrinker entropy; Huai-Dong Cao, Lehigh University

Untitled; Natasa Sesum, Rutgers University

Mass-capacity inequalities for conformally flat manifolds; Alex Freire, University of Tennessee Knoxville

The topology of the limits of a sequence of embedded minimal disks; Jacob Bernstein, Johns Hopkins University

Spacetime Geometry and Gravitational Radiation; Lydia Bieri, University of Michigan

Hodge cohomology on singular spaces; Pierre Albin, University of Illinois Urbana Champaign

Asymptotic Behavior of Degenerate Neckpinches in Ricci Flow; James Isenberg, University of Oregon

Embedded constant mean curvature surfaces in Euclidean three space; Christine Breiner, Columbia University

Semistable Pairs and Lower bounds on K-Energy Maps; Sean Paul, University of Wisconsin Madison

Uniqueness of asymptotically conical shrinking Ricci solitons; Brett Kotschwar, Arizona State University

A new generation of uniformization theorems; Alessandro Carlotto, Stanford University

Volume Comparison for Asymptotically Kottler Metrics; Otis Chodosh, Stanford University

The Yang-Mills Plakom problem in supercritical dimension; Mircea Petrache, ETH Zurich

Quantization phenomena for solutions of conformally invariant problems; Paul Laurain, Insitut Mathématiques de Jussieu-Paris 7

The Charged Penrose Inequality for Multiple Black Holes; Marcus Khuri, SUNY Stony Brook

Rigidity results in CR geometry; Xiaodong Wang, Michigan State University

Gluing of Solitons in Mean Curvature Flow; Niels Martin Møller, Princeton University

Contracting the boundary of a Riemannian 2-disc; Alex Nabutovsky, University of Toronto

Invertible Dirac operators and handle attachments; Nadine Grosse, University of Leipzig

Degeneration of Kahler-Ricci solitons on Fano manifolds; Jacob Sturm, Rutgers University

Symmetres and conserved quantities; Lars Andersson, Albert Einstein Institute

Harmonic maps in rigidity problems; Chikako Mese, Johns Hopkins University

Asymptotics of radiation fields in asymptotically Minkowski spaces; Dean Baskin, Northwestern University

Polynomial Pick forms for affine spheres and real projective polygons; Michael Wolf, Rice University

Clay Senior Scholars in Residence:

Through the generous support of the Clay Mathematics Institute, PCMI is able to nominate two Senior Scholars in Residence for each Summer Session. The Scholars are nominated from among the international leadership in the research topic, and are required to be in residence at PCMI for the entire three weeks as part of the Research Program, and to give a public all-institute lecture while at PCMI. The 2013 Clay Scholars at PCMI were Gerhard Huisken, Universität Tübingen; and Richard Schoen, Stanford University. Both Scholars were active participants of the Research Program and Graduate Summer School, and both took the time to hold informal discussion sessions with the school mathematics teachers and the undergraduate students at PCMI.

CROSS PROGRAM ACTIVITIES

In order to bring together the entire PCMI community during the three weeks of the Annual Summer Session, many cross program activities are held. Some are organized informally by the participants, and some are organized more formally by PCMI.

The Opening Socials
Clay Mathematics Institute Public Lectures: Gerhard Huisken, Universität Tübingen; and Richard Schoen, Stanford University
The PCMI Opening Dinner
The Annual Park City 4th of July Parade Entry by PCMI
PCMI World Cup Soccer Match
Discussion forum: *Conversations between Undergraduate Faculty and Secondary Teachers*
Origami construction sessions
Pizza and Problem Solving Session, presented by Francis Su, Harvey Mudd College
Mathematical modeling with George Hart
Ice Cream Social, hosted by the participants of the SSTP
The Director's Hike
The PCMI Closing Dinner

Publications

PCMI publishes lectures and proceedings from each Summer Session as follows:

> Published by the American Mathematical Society, the Park City Mathematics Series comprises nearly all of the lectures ever given in PCMI's Graduate Summer School, from 1991 to 2009 thus far. The series now comprises 20 volumes, all of which are currently in print and available for sale.
>
> Also published are seven volumes in the Park City Mathematics Institute Subseries, a subsection of the AMS Student Mathematics Series. These volumes are aimed at undergraduate students and

each is written by a lecturer from the Undergraduate Summer School of PCMI's Summer Session.

The Secondary School Teachers Program will be publishing its mathematical materials with the American Mathematical Society in a new, stand-alone AMS series targeted for the professional development of in-service teachers, pre-service teachers, and mathematics educators.

The proceedings and briefs of the International Seminar on Mathematics Education are published on the PCMI website. .

IAS/Park City Mathematics Institute governance and management

PCMI Oversight Board:
Chair: Phillip Griffiths, Institute for Advanced Study
Deborah Ball, University of Michigan
Hyman Bass, University of Michigan
John Ewing, Math for America
Peter Goddard, Institute for Advanced Study
Ronald Graham, University of California San Diego
Robert MacPherson, Institute for Advanced Study
Elaine Wolfensohn, Wolfensohn Family Foundation

PCMI Steering Committee 2013:
Director: Richard Hain, Duke University
Hubert Bray, Duke University
Gail Burrill, Michigan State University
Steven Cox, Rice University
Greg Galloway, University of Miami??
Thomas Garrity, Williams College
Carol Hattan, Skyview High School, Vancouver, WA
Helmut Hofer, Institute for Advanced Study
James King, University of Washington
Johnny Lott, University of Montana
Rafe Mazzeo, Stanford University
Dennis Davenport, Howard University
John Polking, Rice University
Natasa Sesum, Rutgers University
Ronald Stern, University of California-Irvine
Karen Vogtmann, Cornell University

PCMI Diversity Sub-Committee:
Chair: Dennis Davenport, Howard University
Janis Oldham, North Carolina Agriculture and Technical State University
Erika Camacho, Arizona State University
Duane Cooper, Morehouse College
Edray Goins, Purdue University
Leona Harris, The College of New Jersey
Robert Megginson, University of Michigan
Robin Wilson, Cal Poly Pomona

MSRI Supported Students		
First Name	**Last Name**	**Institution**
Phillip	Andreae	Duke University
Mike	Benfield	North Carolina State University
Donato	Cianci	Dartmouth College
Gregory	Drugan	University of Washington
Laura	Fredrickson	University of Texas
Renato	Ghini Bettiol	University of Notre Dame
Metin Alper	Gur	Indiana University
Ryan	Hunter	University of Maryland
Mayukh	Mukherjee	University of North Carolina
Eric	Potash	Northwestern University
Melanie	Stam	Cornell University
Hung	Tran	Cornell University
Liang	Wu	University of Arizona
Min	Xue	Johns Hopkins University
Jun	Zhang	University of Georgia

Graduate Student Statistics

Participants		15

Gender		15
Male	80.00%	12
Female	20.00%	3
Declined to state	0.00%	0

Ethnicity*		15
White	66.67%	10
Asian	33.33%	5
Hispanic	0.00%	0
Pacific Islander	0.00%	0
Black	0.00%	0
Native American	0.00%	0
Mixed	0.00%	0
Declined to state	0.00%	0

* ethnicity specifications are not exclusive

Summer Graduate School: Mathematical General Relativity

July 29, 2013 to August 9, 2013

Cortona, Italy

Organizers:

Justin Corvino (Lafayette College)

Pengzi Miao (University of Miami)

Giorgio Patrizio (Instituto Nazionale di Alta Matematica)

Final Report

MSRI-INdAM-Clay Summer Graduate Workshop
Mathematical General Relativity

July 29-August 9, 2013

Scientific Organizers:
Justin Corvino (Lafayette College)
Pengzi Miao (University of Miami)

Overview. This summer school was in part a reprisal of last year's successful MSRI summer graduate workshop, which was in turn a precursor to the semester-long program on Mathematical General Relativity at MSRI in Fall 2013. In addition to the scientific committee, Giorgio Patrizio (Università di Firenze) provided the lead organization from the host country; we also note valuable support and guidance provided by Mauro Carfora (Università di Pavia); logistical support was largely provided by Silvana Boscherini and her ample and able staff at Il Palazzone in Cortona, the beautiful Renaissance villa in which the scientific activities were held.

Several changes from the 2012 program were necessary: in particular, Fernando Schwartz (University of Tennessee) had to deliver his lectures in the first week (unlike in 2012), and Pengzi Miao was not able to come. Justin Corvino made the required modifications to the first week syllabus, to deliver the background necessary for Schwartz's lectures and the rest of the program. This meant delivering more lectures in the first part of the week, and covering some material that had been covered by Miao at MSRI in 2012. Furthermore, Michael Eichmair (ETH) was recruited to give a mini-course in week two, and Mauro Carfora was recruited to give topics lectures and assist with the organization.

The goal of the summer school was to introduce to a diverse group of graduate students in mathematics and physics the basic framework of Einstein's theory of general relativity, with particular emphasis on the Einstein constraint equations and the Positive Mass Theorem. To this end, the workshop was comprised of the following academic activities:

1. **Mini-courses and topics lectures**. During each day of the workshop, there were three seventy-five minute lectures. During the first week, Justin Corvino gave eight lectures in which he introduced Special Relativity and Minkowski space-time; formulated the Einstein equations from the physical and mathematical viewpoints; discussed the Schwarzschild solution; derived the Einstein constraint equations and discussed their role in the initial-value formulation of general relativity; introduced isolated systems, and asymptotically flat solutions of the Einstein constraint equations; discussed various aspects of the analysis of the asymptotic structure of solutions. Fernando Schwartz reprised his five-lecture mini-course on aspects of the Penrose inequality. Mauro Carfora gave the first two lectures of his four-part lecture series on aspects of the geometry of the space of metrics and the Ricci flow in the context of general relativity.

In the second week, Lan-Hsuan Huang (University of Connecticut) gave a five-lecture mini-course on the center of mass and constant mean curvature surfaces of initial data sets. Michael Eichmair gave a five-lecture mini-course on the isoperimetric structure of initial data sets. In the third daily lecture slot, Corvino gave three lectures on scalar curvature deformation and a gluing method for producing solutions to the constraint equations with prescribed asymptotics. Carfora also gave the second part of his lecture series on the geometry of the space of metrics and the Ricci flow.

2. **TA Sessions**. The TA sessions were led by Peter McGrath (Brown University) and Andrea Santi (Università di Parma), and they occurred in the afternoon, following the coffee break after the third lecture. During the first week, students worked on their own or in groups on the many problem sets (largely written by Corvino, and also including problems from Schwartz and Huang) that were distributed. The students were also encouraged to ask questions about background material, as well as material from the lectures. The TAs, and often the lecturers too, circulated around the various rooms where the students spread out to work, to discuss questions or give hints to problems. The loose structure was designed to accommodate the wide range of student backgrounds and interests.

During the 2012 workshop, the students lost some momentum and/or enthusiasm for working problems toward the end of the first week. To sustain student interest in the working sessions, we compiled a list of suggested research articles and asked the students to choose one or two from the list to study, and encouraged the formation of reading groups. In particular we note articles on the list by Professor Tommasso Ruggeri (INdAM) (joint with Choquet-Bruhat), and by Mauro Carfora, the latter article providing reading material to pair with his lecture series. Along with additional problems provided by Eichmair in the second week, the students had plenty of opportunity to explore the subject matter during the TA sessions.

Description of Mini-Courses and Lectures.

Justin Corvino: Corvino's eleven lectures were organized as follows:

I. Introduction: From Minkowski space-time to Einstein's equation and the Schwarzschild solution (4 lectures). These lectures provided an introduction to the Minkowski metric, the Lorentzian notions of the light-cone and the causal type of vectors, Lorentz transformations, and the conformal compactification of Minkowski space-time. The Einstein equations were derived both by analogy with Newtonian gravity using tidal forces and Jacobi fields, and variationally via the Einstein-Hilbert action. The Schwarzschild solution was discussed in some detail, including Kruskal-Szekeres coordinates, as well as the conformal compactification and black hole interpretation.

II. The Einstein constraint equations and the initial-value problem. Asymptotically flat solutions to the constraint equations (4 lectures). The Einstein constraint equations were discussed and derived in detail. The initial-value formulation of the Einstein vacuum equations as originally formulated by Choquet-Bruhat was presented, with particular attention to the role of the constraints in showing the propagation of the wave coordinate condition. Properties of harmonic functions on Euclidean space were discussed, including behavior near an isolated singular point, the Kelvin transform, and spherical harmonic expansion at infinity. Asymptotically flat solutions to the constraints were discussed, with the Schwarzschild metric and metrics harmonically flat near infinity as key examples. The definition of mass and linear momentum was presented in detail, followed by a basic introduction to the Positive Mass Theorem. A connection of the Gauss-Bonnet Theorem to the mass via the Penrose inequality was presented, dovetailing with Schwartz's lectures.

III. Scalar Curvature Deformation and a gluing construction for the Einstein constraint equations (3 lectures). In these topics lectures, Corvino presented the Schoen-Yau obstruction to positive scalar curvature, and indicated some connection to the Positive Energy Theorem. The Fischer-Marsden scalar curvature deformation was presented, along with the lecturer's localized version. This was applied in the final lecture to sketch the proof of the existence and density of solutions to the vacuum Einstein equations which agree with the Schwarzschild solution near infinity.

Mauro Carfora: Carfora's marvelously illustrated lectures were organized as follows:

I. The geometry of the space of metrics and the diffeomorphism group (1 lecture). This lecture provided a brief introduction to some of the old and new aspects of the space of metric and the geometry of the diffeomorphism group. The Berger-Ebin decomposition of symmetric two-tensor fields and its geometrical significance was developed, as were connections with geometric analysis and the structure of the Einstein constraint equations.

II. The unexpected Ricci tensor (1 lecture). The lecture examined the geometric meaning of the Ricci tensor, and in particular interpreted the Ricci tensor as a non-trivial vector field on the space of Riemannian metrics. Also discussed were deformations of metrics and Ricci flow, as well as glimpses of the interplay between Wasserstein geometry and Ricci curvature.

III. The Einstein constraint equations and Ricci flow: going parabolic in an elliptic and hyperbolic landscape (2 lectures). The topics lectures in the second week developed a characterization of Ricci flow deformation of the Einstein initial data sets as a parabolic interpolation between distinct initial data. Particular emphasis was placed on the definition and geometric properties of the associated Lichnerowicz heat equations and of their parabolically conjugate flows. Also discussed in the relativity context was the evolution of matter fields and of the extrinsic curvature. The final lecture focused on parabolic mode conjugation between data sets and the heat kernel asymptotics of conjugated data.

Lan-Hsuan Huang. **Center of mass and constant mean curvature surfaces in initial data sets**. Huang's first four lectures comprised a mini-course, the primary goal of which was to introduce the students to the tools of geometric analysis used in mathematical general relativity, which may potentially be useful for their own research problems. The first two lectures developed recent work of Brendle on uniqueness of constant mean curvature surfaces in Schwarzschild manifolds and the related classical results in differential geometry. The third and fourth lectures presented recent progress on the stable constant mean curvature surfaces in asymptotically flat manifolds and the geometric notion of center of mass. The last lecture discussed the powerful Corvino-Schoen cut-off technique on constructing solutions to the Einstein constraints and its applications involving the center of mass and angular momentum.

Fernando Schwartz. **On the Penrose inequality**. The first lecture began by motivating the inequality proposed by Penrose in the context of horizons of black holes in general relativity. The problem was then formulated in the important special case of time-symmetric space-times. Lecture two focused on Lam's proof of the Penrose inequality for the graphical case. Lecture three introduced the Hawking mass and results about outermost minimal surfaces in asymptotically flat spaces, including a brief discussion on the topology of black holes. In lecture four, Schwartz outlined the main aspects of Huisken and Ilmanen's proof of the Penrose inequality using the inverse mean curvature flow. Lecture five gave an overview of Bray's proof of the more general Penrose inequality and explored in detail one of the central arguments in it, which involves the Bunting-Masood-ul-Alam reflection trick in conjunction with the Positive Mass Theorem.

Michael Eichmair. **Isoperimetric Structure of initial data sets**. Eichmair's five lectures can be summarized as follows:

I. The first and second variation of area and volume (1 lecture). This lecture provided a common language for geometric computations including discussion of second fundamental form and mean curvature of hypersurfaces in Riemannian manifolds. In particular, Eichmair developed the first and second variations of the area measure and the area.

II. Stable constant mean curvature surfaces in Euclidean space (1 lecture). As a first application of first and second variation of area (and in preparation for the proof of the positive mass theorem), Eichmair discussed the Bernstein theorem for two dimensional graphs and the result of Barbosa and do Carmo showing that compact stable constant mean curvature immersions into Euclidean space are spheres. He also reviewed the definition of the mass of an asymptotically flat manifold and introduced the concept of *isoperimetric mass*. The proof that the two coincide (a result due to Fan-Shi-Tam and Miao) was broken into small steps and worked out by the students as an exercise.

III. The Schoen-Yau proof of the Positive Mass Theorem (2 lectures). In these lectures was outlined the proof of the Positive Mass Theorem for three-dimensional initial data sets. Since Corvino and Schwartz developed and discussed the reduction to conformally harmonic asymptotics in the previous week, Eichmair was able to proceed quickly to the heart of the matter and focus on the main geometric ideas.

IV. Recent results on the isoperimetric structure of initial data sets (1 lecture). In the last lecture, Eichmair summarized recent results with S. Brendle and J. Metzger on the isoperimetric structure of initial data sets. The lecture connected well with the lectures of L.-H. Huang on constant mean curvature foliations of asymptotically flat manifolds. Eichmair also emphasized several open problems that might now be approachable.

On the Students. Again a challenge for the organizers was how to come to terms with the wide range of student background and interests. We anticipated this, and we again gave out a survey to measure the backgrounds in geometry, analysis and partial differential equations before the workshop. Though there were only twenty-seven students this summer (last summer the school was enrolled in the low to mid-forties), the range of student backgrounds was almost as widespread as it was at MSRI in the preceding summer, but fewer students (both absolutely and as a percentage) did not meet the clearly advertised pre-requisite of a one-semester course in Riemannian geometry. For those who did not have the pre-requisite material, we suggested targeted problems and readings in order to optimize what they could take away from the program. It felt like there were more students interested in physics this summer. We note that the size of the school—twenty-seven students—worked quite well in the Palazzone, and in particular in the sweltering heat. An optimal number for a summer school there is from about twenty-five, say, to mid-thirties.

The student responses, both in person and via the survey, were by-and-large quite positive. Here are a few samples:

"The lecturers fostered discussion and further thought without being overbearing."

"There was a nice balance between focusing in on a subtopic of GR (the positive mass theorem) and exhibiting many perspectives on this area, namely the Penrose inequality, the isoperimetric problem, and Ricci flow. Not too broad, not too specific."

"The intro was extremely well presented, it set up the other material very well, as did the first

weeks problem sessions. The topics lectures complemented each other generally..."

The Venue. Everyone agrees that Il Palazzone in Cortona is a marvelous place for a mathematical meeting. The staff is headed by Silvana Boscherini, who along with the rest of the staff is a joy to work with. (Corvino, who is preparing this report, notes his possible bias, as his Italian relatives are from Abruzzo, as is Boscherini; this engendered many discussions in Italian!) Silvana and the staff speak English, though it is nice to be able to speak some Italian, or in lieu of that, to have an Italian colleague, an Italian TA, and all the Italian students available in case there is any misunderstanding!

We note that the grand lecture hall (Sala Papacello) is spectacular, though we used it sparingly because the lecturers largely chose to give talks on the blackboard; one of the other rooms available was set up with three blackboards for this purpose; this worked quite well, with the smaller room giving a more intimate setting than the bigger hall. Furthermore, discussion following the talks could be more freely flowing: the coffee breaks were held next to the smaller lecture room, and also discussions following lectures were discouraged in the big lecture hall, which is located next to the tower where the Contessa lives. One great aspect of Il Palazzone is that the TA sessions could be held across several rooms inside, as well as outside (in the courtyard). This worked really well for the students to break themselves up into small groups working on different problems or papers, and at different levels.

The lecturers, TAs and several students stayed at Il Palazzone, while the majority of the students stayed in a very nearby hotel, the Oasi Neumann, minutes by foot from Il Palazzone. Lunches were served at Il Palazzone, and dinners at the Oasi. Though some participants sometimes chose to avail themselves of the wonderful restaurants in the town of Cortona, most people ate together at the Oasi, which helped foster interaction and a great group dynamic. We note that some students felt that an organized social activity or two would have been beneficial; last year at MSRI, we organized an outing to a baseball game, and there was the Director's hike to a BBQ lunch. Many students walked up into the town together, and also organized weekend trips to Florence and other places.

The weather was extremely hot in late July and early August. The thick walls of Il Palazzone provided some relief, though by mid-afternoon it was quite hot there (no air conditioning). No one melted, and many availed themselves of the several gelato establishments up in the town of Cortona. The size of the workshop—twenty-seven students—was perfect given the weather. The smaller lecture room with the chalkboards is not huge, so even in milder weather, having more than thirty-five students might be less than optimal.

Conclusion. The organizers feel that the workshop was indeed a success. Many students were excited about the material, and about meeting the lecturers and their peers, and they by and large seemed to be engaged with the lectures, problem sets, and readings. Corvino notes having received several follow up emails. We hope there will be future opportunities for summer schools in mathematical general relativity at venues similar to MSRI and Cortona: the success of the past two summers shows the great interest and enthusiasm of the students, and the possibility of a successful program; on the other hand, the field is much broader than what we presented (which we noted to the students), and other schools can successfully be modeled either with another focused topic in the field or with a broader scope.

Organizers* and Speakers		
First Name	**Last Name**	**Institution**
Justin	Corvino*	Lafayette College
Michael	Eichmair	ETH Zurich
Lan-Hsuan	Huang	University of Connecticut
Pengzi	Miao*	University of Miami
Giorgio	Patrizio*	Istituto Nazionale di Alta Matematica
Fernando	Schwartz	University of Tennessee

Attending Students		
First Name	**Last Name**	**Institution**
Adam	Afandi	San Francisco State University
Scott	Gensler	University of Nebraska
Colin	Grove	University of Iowa
Alexi	Hoeft	Virginia Commonwealth University
Nathan	Lanfear	Arizona State University
Jeremy	Leach	Stanford University
Raquel	Perales Aguilar	SUNY
Michael	Pinkard	Lafayette College

Graduate Student Statistics

Participants		**8**

Gender		**8**
Male	75.00%	6
Female	25.00%	2
Declined to state	0.00%	0

Ethnicity*		**8**
White	62.50%	5
Asian	12.50%	1
Hispanic	12.50%	1
Pacific Islander	0.00%	0
Black	0.00%	0
Native American	0.00%	0
Declined to state	12.50%	1

* ethnicity specifications are not exclusive

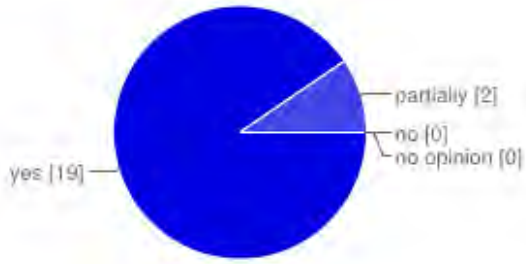
21 responses

Please note, survey includes some responses from students not supported by NSF funds.

Summary See complete responses

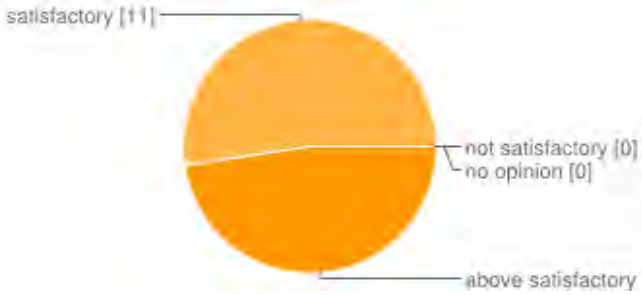
Topic presentation and organization

Did the various topics within the workshop integrate into a coherent picture?



yes	**19**	90%
partially	**2**	10%
no	**0**	0%
no opinion	**0**	0%

Were the speakers generally clear and well organized in their presentation?



above satisfactory	**10**	48%
satisfactory	**11**	52%
not satisfactory	**0**	0%
no opinion	**0**	0%

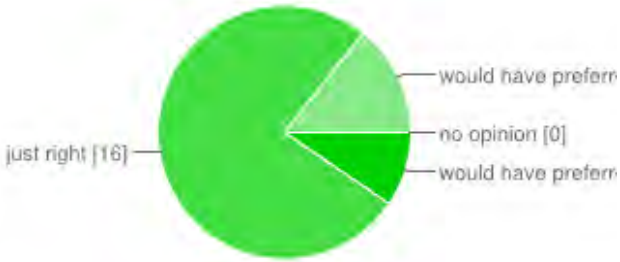
Was there too much material presented; was the school too ambitious?

too much	**2**	10%
just right	**16**	76%
not enough	**3**	14%
no opinion	**0**	0%

Was the problem session helpful?

yes	**18**	86%
partially	**3**	14%
no	**0**	0%
no opinion	**0**	0%

What were your thoughts on the structure of the problem sessions?



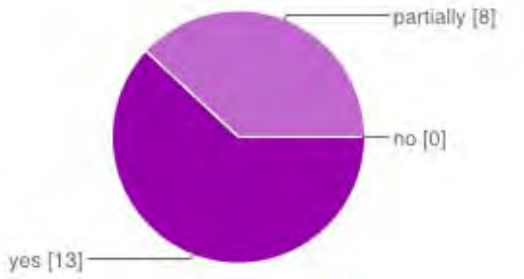
would have preferred a looser structure	**2**	10%
just right	**16**	76%
would have preferred a more rigid structure	**3**	14%
no opinion	**0**	0%

Additional comment on the topic presentation and organization

Corvino's course and problem sessions were really great! The intro was extremely well presented, it set up the other material very well, as did the first weeks problem sessions. The topics lectures ...

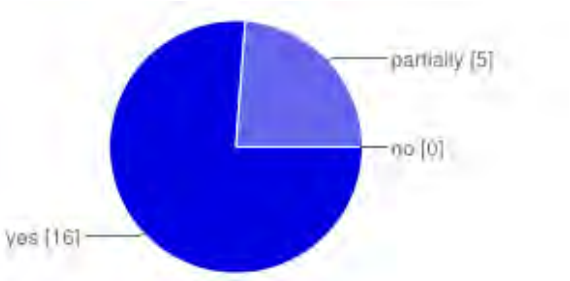
Personal assessment

Was your background adequate to access a reasonable portion of the material?



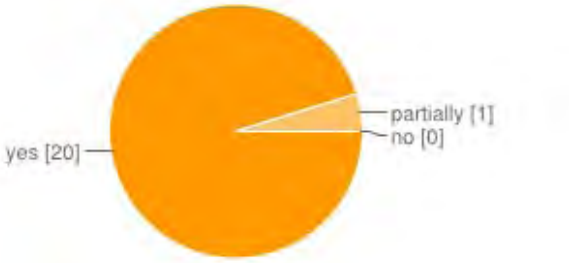
yes	**13**	62%
partially	**8**	38%
no	**0**	0%

Did the workshop increase your interest in the subject?



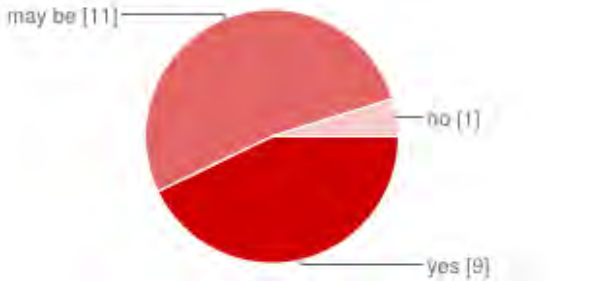
yes	**16**	76%
partially	**5**	24%
no	**0**	0%

Was the school worth your time and effort?



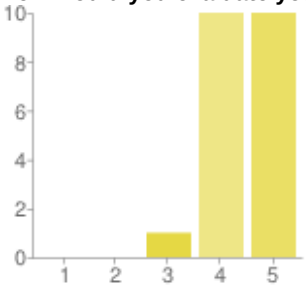
yes	**20**	95%
partially	**1**	5%
no	**0**	0%

Is it likely that you will work in the area of the workshop subject in the future?



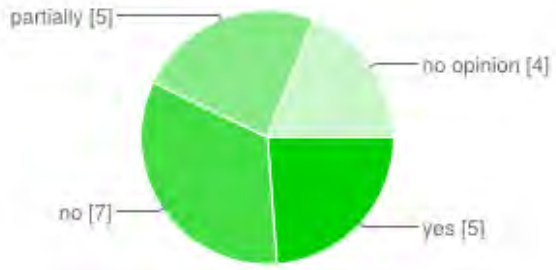
yes	**9**	43%
may be	**11**	52%
no	**1**	5%

How would you evaluate your interaction with other participants?



1 -not satisfactory	**0**	0%
2	**0**	0%
3	**1**	5%
4	**10**	48%
5 -above satisfactory	**10**	48%

Would you have liked there to be more organized social activities?



yes	**5**	24%
no	**7**	33%
partially	**5**	24%
no opinion	**4**	19%

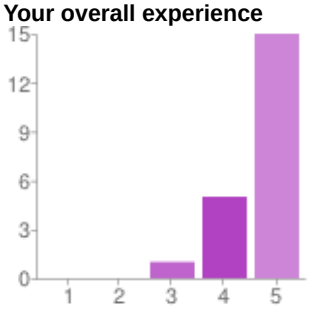
Additional comments on your personal assessment

I have not had a PDE's course, and that made accessing many of the advanced subject matter more difficult. However, my general geometry background was sufficient. I gained a lot, including a lot of ...

Venue

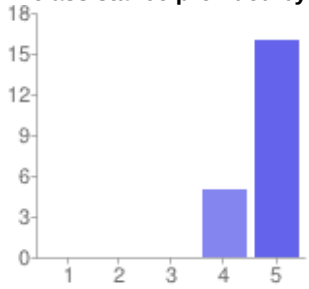
Please rate the different categories

Your overall experience



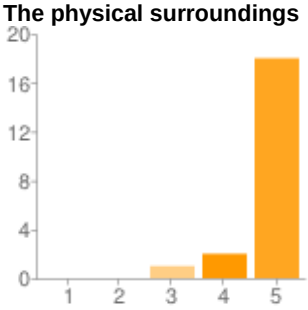
1 -not satisfactory	**0**	0%
2	**0**	0%
3	**1**	5%
4	**5**	24%
5 -above satisfactory	**15**	71%

The assistance provided by staff



1 -not satisfactory	**0**	0%
2	**0**	0%
3	**0**	0%
4	**5**	24%
5 -above satisfactory	**16**	76%

The physical surroundings



1 -not satisfactory	**0**	0%
2	**0**	0%
3	**1**	5%
4	**2**	10%
5 -above satisfactory	**18**	86%

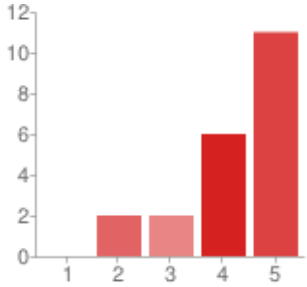
Additional comments on the venue

Too hot! In August, in Italy, air conditioner is mandatory. It was a beautiful place to stay, and I had a wonderful experience in the school and meeting the other participants. Phenomenal! Venue was a ...

Accommodation and Food

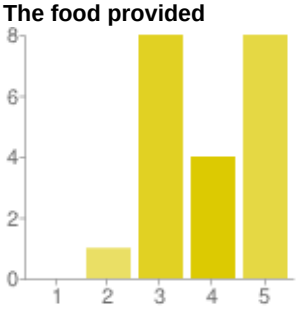
Please rate the different categories

The summer school accommodation



1 -not satisfactory	**0**	0%
2	**2**	10%
3	**2**	10%
4	**6**	29%
5 -above satisfactory	**11**	52%

The food provided



1 -not satisfactory	**0**	0%
2	**1**	5%
3	**8**	38%
4	**4**	19%
5 -above satisfactory	**8**	38%

Additional comments on accommodation and food

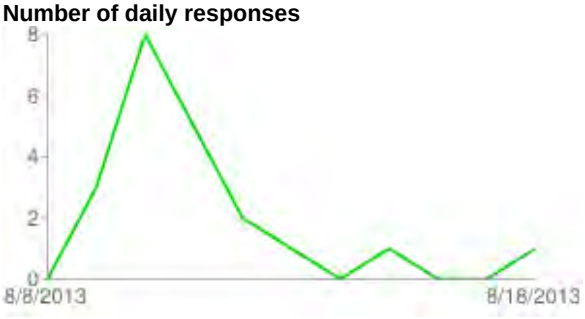
too much salt (e.g. in salad) The Palazzone was beautiful. But the food was repetitive and not always good. I would have preferred more variety. Moreover, I'm vegetarian and sometimes the vegetarian ...

Thank you for completing this survey

We welcome any additonal comments or suggestions you may have to improve the overall experience for future participants.

I think that if the second week would be spent explaining in details some mathematics tools instead of go deeper in some sectorial argument it would be more useful, specially thinking about the spirit of the summer school. Overall a great experience. I learned a lot, I enjoyed meeting the other participants, and loved being in Tuscany. I would certainly do this again and will continue to work in the field. This certainly helped prepare me for the future. Thank you! I enjoyed the program immensely, but I think I might have gotten a bit more out of it if the designated problem/study sessions wer ...

Number of daily responses



Summer Graduate School:
Mathematical General Relativity in Cortona, Italy
July 29 – August 9, 2013

Additional Survey Responses

****Please note, survey includes some responses from student not supported by NSF funds****

Additional comments on your personal assessment:

- I have not had a PDE's course, and that made accessing many of the advanced subject matter more difficult. However, my general geometry background was sufficient. I gained a lot, including a lot of ideas about to visualize ideas in the field and how to think about them, and I want to work in the field.
- What a fantastic group of people! Couldn't have asked for better.
- Very nice environment. The people were not boating knowledge, but at the same time had solib background.

Additional comments on the venue:

- Too hot! In August, in Italy, air conditioner is mandatory.
- It was a beautiful place to stay, and I had a wonderful experience in the school and meeting the other participants.
- Phenomenal!
- Venue was amazing!
- Lack of study rooms in hotel Oasi.

We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.

- I think that if the second week would be spent explaining in details some mathematics tools instead of go deeper in some sectorial argument it would be more useful, specially thinking about the spirit of the summer school.
- Overall a great experience. I learned a lot, I enjoyed meeting the other participants, and loved being in Tuscany. I would certainly do this again and will continue to work in the field. This certainly helped prepare me for the future.
- Thank you!
- I enjoyed the program immensely, but I think I might have gotten a bit more out of it if the designated problem/study sessions were a bit longer. Maybe one or two days per week could have had a ~3.5 hour problem session in lieu of an afternoon lecture. Overall it was a great workshop, though.
- I'd really like to stress the fact that a well-structured problem session would, in my opinion, be more suitable. The idea of suggestions for paper reading was also very nice. Overall, the workshop was a very rewarding experience.

Additional comments on accommodation and food:

- too much salt (e.g. in salad)
- The Palazzone was beautiful. But the food was repetitive and not always good. I would have preferred more variety. Moreover, I'm vegetarian and sometimes the vegetarian food seemed not to be prepared with the greatest care.
- No internet in my hotel room; had to go to the lobby for access.
- Everybody complained about lack of air conditioning in the rooms, and sometimes it got pretty hot.

Additional comments on the topic presentation and organization:

- Corvino's course and problem sessions were really great!
- The intro was extremely well presented, it set up the other material very well, as did the first weeks problem sessions. The topics lectures complemented each other generally, though Professor Carfora's lectures were not so related to the other lectures.
- There was a nice balance between focusing in on a subtopic of GR (the positive mass theorem) and exhibiting many perspectives on this area, namely the penrose inequality, the isoperimetric problem, and Ricci flow. Not too broad, not too specific.
- Very nice coordination between the lecture given by Justin Corvino - Michael Eichmair - Lan-Hsuan Huang
- The lecturers fostered discussion and further thought without being overbearing