MSRI
Mathematical Sciences Research Institute

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Annual Progress Report
on the
Mathematical Sciences Research Institute
2012–2013 Activities
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Mathematical Sciences Research Institute
Annual Report for 2012–2013

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1. Overview of Activities

This annual report covers MSRI projects and activities that occurred during the third year, 2012–13, of the NSF core grant DMS #0932078.

1.1 New Developments

The year 2012–13, was a busy and exciting year. We held one yearlong program together with two (2) one-semester programs: *Commutative Algebra*, *Cluster Algebras*, and *Noncommutative Algebraic Geometry and Representation Theory*. These three programs were very popular, and their workshops well attended. All programs had stellar researchers. Four (4) of them, Karen Smith, Claudio Procesi, Corrado De Concini, and Toby Stafford were funded by the Clay Mathematics Institute ($33,000). Karen Smith is a Keeler Professor in the department of mathematics at the University of Michigan. Among the many awards she received are the AMS Satter prize in recognition of her work in Commutative Algebra, a Fullbright Fellowship, and an Alfred P. Sloan Research Fellowship. Claudio Procesi, an internationally renowned researcher is a Professor Ordinario at La Sapienza (University di Roma). In the early 1980s he received the Medal of the Accademia dei Mathematics Lincei, of which he is now a member; he also received the Feltrinelli Prize in mathematics. De Concini, an equally renowned professor Ordinario at La Sapienza, is a member of the two Italian Academy of Sciences, Accademia Nazionale dei Lincei (since 2009) and Socio dell'Accademia Italiana delle Scienze detta dei XL (2010). Toby Stafford is a professor of mathematics at Manchester University. From 2007-2012 he held the prestigious Royal Society-Wolfson Research Merit Award, and in 2013, he became a Fellow of the American Mathematical Society.

Another ten (10) researchers, Luchezar Avramov, Bill Crawley-Boevey, Alicia Dickenstein, Craig Huneke, Bernhard Keller, Idun Reiten, Frank-Olaf Schreyer, Michel Van den Bergh, Jerzy Weyman, and Andrei Zelevinsky, were funded by MSRI's Eisenbud Endowment and by a grant from the Simons Foundation.

The synergy between the long program and the two partner programs was particularly fruitful. The academic year started with two joint workshops: Connections for Women and Introductory Workshop: Cluster Algebras and Commutative Algebra. All three programs had striking results to report. (See the program reports in the Appendix for more details.) Here are three such results, one from each program.

In Fall 2012, K. Lee, L. Li, and A. Zelevinsky settled, in the negative, an old question posed by V. Fock and A. Goncharov: Do the extremal rays of the positive cone of a cluster algebra A (i.e., the cone of elements represented as positive Laurent polynomials in terms of any cluster) yield a basis in A? The authors show that in rank 2, the answer is no whenever A is not tame. This work was one of A. Zelevinsky's last research projects completed before his untimely death in April 2013. The results were posted on the [arXiv:1303.5806].

Among the many results obtained during the yearlong Commutative Algebra program the striking result of Herzog and Huneke on Golod rings (which are of interest as every module over a Golod ring has rational Poincar´e series) stands out. Here is how Huneke described the work and results: "I was very pleased about several things I was able to do with colleagues during the

year, but one stands out in the sense that without the MSRI program, there was probably no chance it would have been done. That is my work with Jürgen Herzog proving that higher powers, symbolic powers, saturated powers, and in many cases integral closures of higher powers of homogeneous ideals in polynomial rings define Golod rings. The process needed an inspiring talk by Adam Boocher, an ongoing discussion of an old result of Herzog which I had been looking at for another project, and of course, the fact that both Herzog and myself were present and talking with each other."

During the Spring 2013 program on Noncommutative Algebraic Geometry and Representation Theory, Sue Sierra and Chelsea Walton (a postdoctoral fellow) solved the long standing problem of whether it is possible for the universal enveloping algebra of an infinite dimensional Lie algebra to be noetherian. As part of the solution they answered a 23-year-old question of Carolyn Dean and Lance Small: they proved that the universal enveloping algebra of the Witt (or centerless Virasoro) algebra is not noetherian. This work, "The universal enveloping algebra of the Witt algebra is not noetherian" was posted on the arxiv:1304.0114.

This year, the MSRI's annual ***Hot Topics workshop*** was on *Surface subgroups and Cube Complexes*. The workshop focused on the work of Agol (building on work of many others, including Kahn-Markovic, Haglund-Wise, Wise, Agol-Groves-Manning) that had led, in the previous 12 months, to a resolution of some of the most important outstanding questions in 3-manifold topology, including the virtual Haken conjecture of Waldhausen, the virtual fibration conjecture of Thurston, and several others. This resolution depended on an a priori unlikely interplay between two distinct kinds of geometric objects -- surface subgroups, and cube complexes. These are connected in 3 dimensions by a result of Sageev: a 3-manifold group contains a surface subgroup if and only if it acts essentially on a CAT(0) cube complex. The workshop explicitly emphasized these two kinds of objects and their relationships, gathered people working on these objects from different points of view, and encouraged them to interact and to exchange techniques, insights, problems, and perspectives. The talks, many explanatory while others more technical in nature, were given by stellar mathematicians. The report can be found in the appendix. We would like to quote one of the participants and organizers, D. Calegari: "(T)o those of us who are mid-career or older it was a bit shocking to see how quickly the landscape of low-dimensional geometry/topology and geometric group theory has been transformed by the recent breakthrough work of (Kahn-Markovic-Haglund-Wise-Groves-Manning-etc.-) Agol. Incidentally, when I first started as a graduate student, I had a vague sense that I had somehow "missed the boat"; all the exciting developments in geometry due to Thurston, Sullivan, Gromov, Freedman, Donaldson, Eliashberg etc. had taken place 10-20 years earlier, and the subject now seemed to be a matter of fleshing out the consequences of these big breakthroughs. 20 years and several revolutions later, I no longer feel this way." As for all of our workshops the talks were recorded and can be seen on our website at
http://www.msri.org/web/msri/online-videos.

Funding. In 2012–13, MSRI's overall expenditures totaled $7,888,462. Of this amount, $4,529,083 (57.4%) came from the NSF, $413,857 (5.3%) from the NSA, and the rest, $2,945,522 (37.3%) 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) 88% came from the NSF, 4% from the NSA, and 12% from private funds. Of the support for workshop participants (short term visitors) 45% came from the NSF, 34% from the NSA, and 21% 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. Twenty-six (26) Postdoctoral Fellows participated in our three scientific programs. Most were funded by MSRI's NSF core grant, two, Fan Qin and Maria Chlouveraki, were partly funded by MSRI's Viterbi Endowment and one, Claudiu Raicu, was also partially funded by our new Huneke Postdoctoral Fellowship endowed by Professor Craig Huneke. 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 2012, 91 institutions nominated 258 graduate students for one of MSRI's summer schools. Of those 204 were accepted, and in the end, 174 participated in one of the five (5) offered schools. Three were held at MSRI, and the two others were held at the Park City Mathematics Institute in Boulder, and the Centre de Recherche Mathématiques in Montréal. 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 2013, the lead director was Dr. Ivelisse M. Rubio of the University of Puerto Rico, and the primary instructor and research director was Dr. Rosa Orellana of Dartmouth College. The research topics for the summer were on Algebraic Combinatorics, and the students worked in teams of three on various projects on symmetric functions, and set partitions. Students wrote technical reports and presented the results of their research at the MSRI-UP Student Colloquium the last day of the program. Fourteen of the eighteen MSRI-UP students presented their research at the 2013 SACNAS Conference at San Antonio, Texas in October, 2013. One of the projects has been submitted for publication:

• *Number of Permutations with the Same Peak Set for Signed Permutations*, F. Castro-Velez, A. Diaz-Lopez, R. Orellana, J. Pastrana, R. Zevallos.

Please note that since MSRI-UP is funded by two independent grants, one from the NSF and the other one by the NSA, the detailed reports have been filed independently with both these two agencies.

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 2012–13 year, two events were supported by the Initiative: *Modern Math Workshop*, held in Seattle, Washington organized

by the NIMBioS; and *the Blackwell-Tapia Conference*, held in Providence Rhodes Island, and organized by the ICERM. The reports for those two workshops are part of the ICERM and NIMBioS annual reports.

Critical Issues in Mathematics Education. The Critical Issues in Mathematics Education (CIME) series of workshops addresses key problems in education today. They are designed to engage professional mathematicians in discussions with education researchers, teachers, and policy makers to improve mathematics education. This year topic was on *Assessment of Mathematical Proficiencies in the Age of the Common Core*. The workshop was heavily subscribed, with approximately 149 attendees all very engaged in the discussions. It was funded through grants from the Division of Education at the NSF and from the private foundation Math for America.

Circle on the Road and the National Association of Math Circles. The 2013 *Circle on the Road* Workshop took place at the University of Puerto Rico, Mayaguez, March 8–10, and included a mathematics festival that was open to the public. This event was part of the *National Association of Math Circles* (NAMC), whose website includes a wide variety of materials designed to help mathematicians across the US to start math circles. Videos, lesson plans, problems, and solutions can be found on the NAMC website (www.mathcircles.org). MSRI and the AMS continue their partnership co-publishing books for the Mathematical Circles Library. During the 2012–13 year, the library welcomed four (4) new volumes:

- Volume 9, *Euclidean Geometry, A Guided Inquiry Approach,* David M. Clark, 2012
- Volume 10, *Integers, Fractions and Arithmetic, A Guide for Teachers*, Judith D. Sally, Paul J. Sally, Jr., 2012.
- Volume 11, *Mathematical Circle Diaries*, Year 1, *Complete Curriculum for Grades 5 to 7*, Anna Burago, 2013.
- Volume 12, *Invitation to a Mathematical Festival*, Ivan Yashchenko, 2013.

Public Understanding of Mathematics. On September 4, MSRI officially welcomed the Simons Institute for the Theory of Computing, to Berkeley by jointly sponsoring a celebration of the 100th anniversary of the birth of Alan Turing, one of the pioneers of computer science and artificial intelligence. The event, Alan Turing: A Centenary Celebration, which we held in the auditorium of the Berkeley City College in downtown Berkeley, was an enormous success. It was filled to overflowing, with more than one hundred people standing, for a presentation by Andrew Hodges, the author of the acclaimed Turing biography, *Alan Turing: The Enigma*. The presentation was followed by a panel discussion moderated by Richard Karp, the director of the Simons Institute for the Theory of Computing, that featured Hodges together with luminaries of the fields in which Turing worked: Martin Davis, Peter Norvig, Luca Trevisan, Don Knuth, and Dana Scott.

Celebration of Mind, October 2012. This past October, MSRI welcomed approximately 80 puzzle-lovers of all ages to the first "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 night

opened in the Simons Auditorium with a viewing of an episode of David Suzuki's "The Nature of Things" that featured Martin Gardner. This was followed by a two-hour session in which guests explored numerous display tables distributed throughout the building. The tables presented an array of puzzles, games, activities, and a handful of books from Gardner's vast collection. There were dozens of physical puzzles, as well as over 40 books and 15 logic puzzles. Stan Isaacs, long-time officer of the Golden Section of the Mathematical Association of America, generously shared many of the puzzles and books from his personal collection.

Chicago Mercantile Exchange Prize. The seventh annual CME Group–MSRI Prize for innovation in financial mathematics and economics was awarded to Robert Shiller on October 12, 2012 at a luncheon in Chicago. Dr. Shiller is the Arthur M. Okun Professor of Economics, Department of Economics and Cowles Foundation for Research in Economics, Yale University, and Professor of Finance and Fellow at the International Center for Finance, Yale School of Management. The annual 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. Before the lunch and award presentation, a moderated discussion on "The U.S. Housing and Financial Crisis: Aftermath and Afterthoughts" was held with Congressman Barney Frank (D-Massachusetts 4th District) and Keith Hennessey, former Director of the U.S. National Economic Council. You can read more about the CME Group–MSRI Prize and find a link to video of the Frank/Hennessey discussion at
http://www.msri.org/web/msri/public-events/show/-/event/Em9750.

Math Midway Events. During the fall, MSRI collaborated on two evening activities with our friends at the Lawrence Hall of Science (LHS). Both events took advantage of the "Math Midway"—an interactive, "traveling carnival" style mathematics exhibition developed by the new Museum of Mathematics (MoMath) in New York—that was being hosted by LHS. In October, Paul Zeitz, Professor of Mathematics at the University of San Francisco and Director of the San Francisco Math Circle, led a discussion for middle school students, teachers, and parents that was followed by an exploration of the exhibit. This event was also part of the annual Bay Area Science Festival. The December event was a scavenger hunt through the exhibit organized for mathematics educators at all levels. There were numerous tasks that involved the activities displayed in the exhibit, such as locating points of symmetry on the "Monkey Mat," creating a specific tessellation using the "Miles of Tiles," and illustrating a regular hexagon in a cube in the "Ring of Fire." This event was co-sponsored by the San Francisco Math Circle and Circle for Teachers, the Oakland/East Bay Math Circle, and the Bay Area Circle for Teachers.

Mathematics of Planet Earth (MPE2013). MPE2013 brought together over 140 scientific societies, universities, research institutes and foundations from around the world to research fundamental questions about Planet Earth, nurture a better understanding of global issues, and help inform the public about the essential mathematics of the challenges facing our planet. MPE2013 activities included more than 15 long-term programs at mathematical research institutes all over the world, 60 workshops, dozens of special sessions at society meetings, summer and winter schools for graduate students, research experiences for undergraduates, an international competition for museum-quality virtual displays, an open-source MPE exhibition, and more than 60 public lectures.

MSRI's involvement with this effort was multifaceted. We participated in meetings held at AIM where the various components of this thematic year were developed. We held a summer graduate

school on the *Mathematics of Seismic Imaging* led by Professor Gunther Uhlmann. Most importantly, we led a joint effort, with the other US NSF-funded mathematical research institutes, in organizing the international *MPE2013 Simons Public Lecture Series.* To this end we secured a grant from the Simons Foundation of nearly $500,000. This Lecture series took place at nine locations, in five countries on four continents. Nearly 4000 people attended the lectures. Each lecture was hosted by one of the world's leading Mathematical Sciences Research Institutes. The speakers were leading experts in a variety of fields. They explained how the mathematical sciences play a significant role in understanding and solving Planet Earth's currently important problems.

The goal of the series was to engage our community's best expositors and champions to cover a diverse range of research topics at a level accessible to a non-mathematically sophisticated public audience. Each lecture was professionally filmed and edited and is currently available for viewing on the MPE2013 website (www.mpe2013.org). The Organizing Committee was comprised of Hélène Barcelo, Ed Bierstone, John Chadam, Robert Daverman, Jacques Hurtubise, Tony Nance, David Shmoys and Luc Vinet. The Scientific Advisory Committee for the lecture series was comprised of Douglas Arnold, Robert Calderbank, and John Guckenheimer. The Project Manager contracted for the series was Christine Marshall, Program Manager at MSRI.

MSRI and the American Institute of Mathematics cohosted one of these lectures: Dr. Emily Shuckburgh, a mathematician and climate scientist with the British Antarctic Survey, delivered the second Simons Public Lecture on "*Climate Disruption: What Math and Science Have to Say*" on March 4, 2013, at the Palace of Fine Arts in San Francisco, to an audience in the nearly packed 960-seat venue. Dr. Shuckburgh explained how mathematics is used in essential ways not only to help us model the Earth's climate, but also to make sense of the enormous amount of scientific data being collected in the effort to understand what is happening to our climate and what the consequences of those changes might be.

Math Night at PlayGround, February 25, 2013. Each year MSRI hosts the playwrights of PlayGround for a discussion of how mathematicians think about mathematics. This year, the theme was "fearful symmetry" (drawn from the famous Blake poem). One of our visiting members, Dave Benson, and I met with the playwrights to hold a discussion with them about how mathematicians think about symmetry in music, mathematics, and physics, why it is so important, and how it can be both enlightening and misleading. After that, each of the playwrights had five days to write a 10-page play using the theme, and Dave and I sat on the jury to help select the top six (of nearly 30 submissions) that would be given staged readings on February 25 at the Berkeley Repertory Theatre. The playwrights came up with some creative and fascinating ways to make use of the theme. On the night of the performance, we had one of the larger audiences that PlayGround has had (MSRI night at PlayGround is one of their most popular), and the audience's reception of the plays was very enthusiastic.

Taking the Long View, March 2013. On March 18 MSRI sponsored the public premiere at the Roxie Theater in San Francisco of the biographical film, *Taking the Long View: The Life of Shiing Shen Chern*, which was part of a small film festival featuring the mathematical films of George Csicsery. Professor Chern was MSRI's founding director, and we have been very pleased with the enthusiastic reception the film has garnered in private showings so far. Directed by George Csicsery, the film was funded by a grant from the Simons Foundation, with additional

funding from the NSF to pay for preparing it for syndication on public television. Taking the Long View is now being shown by stations around the country, providing a deep and attractive view of the life and thought of this extraordinary mathematician.

1.2 Summary of Demographic Data for 2012–13 Activities

During the academic year 2012–13, MSRI hosted 224 program members, of which 26 were Postdoctoral Fellows, and 1568 workshop participants.

The Postdoctoral program was particularly successful and is described in detail in Section 3. Of the Fellows, 27% were female, 35% were U.S. Citizens or Permanent Residents, and 54% listed a U.S. university as home institution. Of those institutions, 14% are located in the Northeast, 36% in the West, 36% in the Midwest, and the remaining 14% in the South.

MSRI had a total of 224 long-term members. Members spent an average of 76 days at MSRI, with peak attendance in November for the fall semester and April for the spring semester. Of the members, 25% were female, 43% reported being U.S. Citizens or Permanent Residents and 50% listed a U.S. university as their home institution. Of those institutions, 39% are located in the Midwest, 27% in the West, 18% in the Northeast, and 16% in the South. Of the members, 54% had received a Ph.D degree on or after 2000, 29% 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.

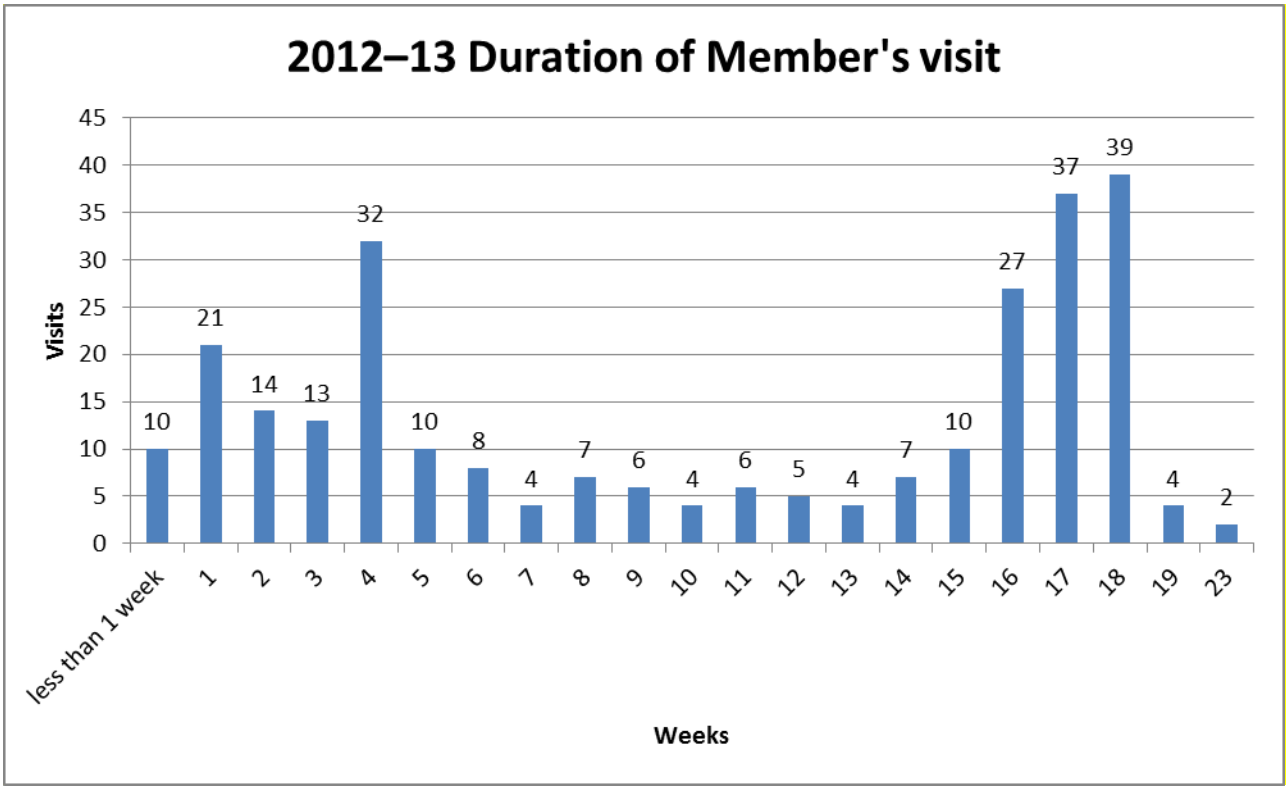
In the 2012–13 workshops, MSRI hosted 1568 separate visits (some visitors attended multiple events). Of the workshop participants, 39% were female, 56% were U.S. Citizens or Permanent Residents, of which 12% reported being a member of an under-represented minority. In addition, 71% of the 1568 participants came from a U.S. institution. Demographic data on workshop participants can be found in Sections 2 and 4.

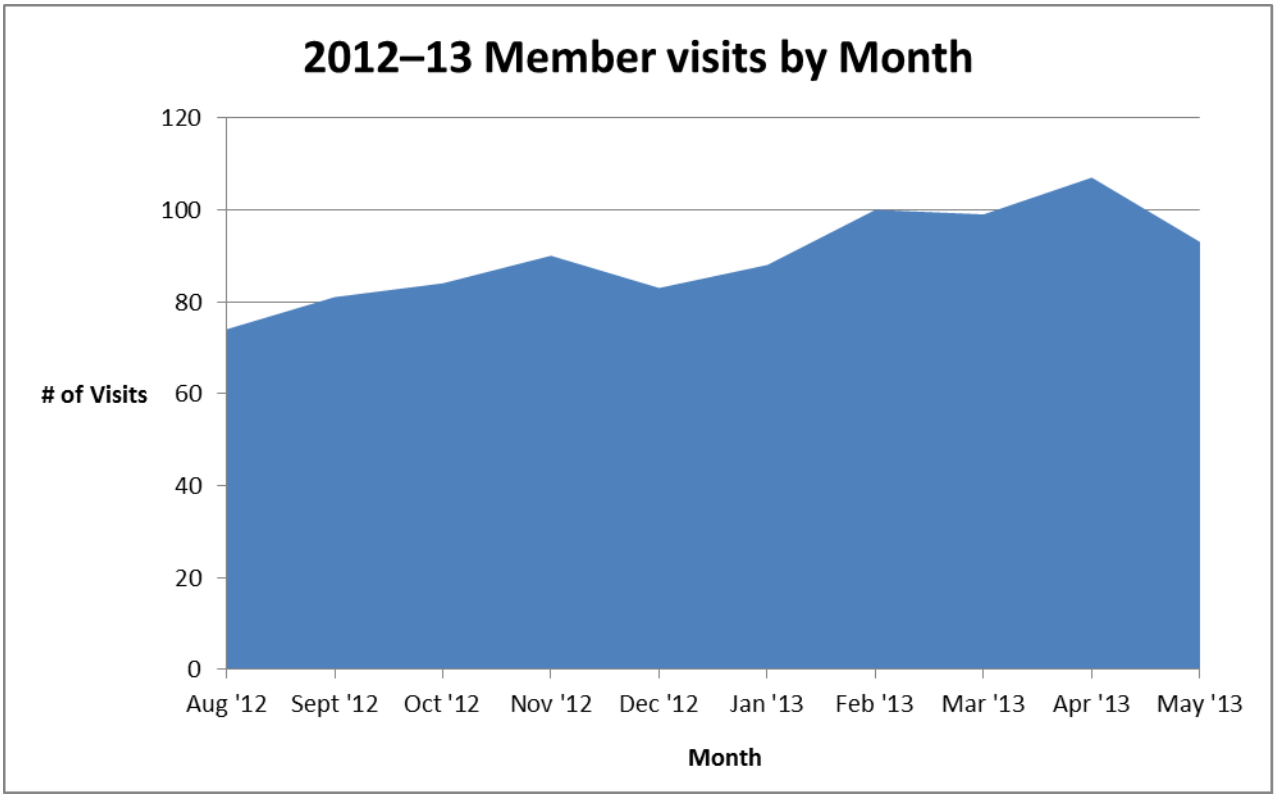
The Summer Graduate Schools of 2012 had 174 participants. Of those participants, 22% were female, 52% were U.S. Citizens or Permanent Residents and 88% students came from a U.S. institution. Demographic data on the participants of the summer graduate schools can be found in Section 4.2.

In the summer of 2012, the MSRI Undergraduate Program (MSRI-UP) hosted 18 students. This activity was reported in the 2011–12 Annual Report. Please refer to it for more details.

Member Visits Summary

All program members	Fall 2012	Spring 2013	2012–13	2004–13
Total Member Days	9244	11289	20533	149880
Total # of Visits	114	156	270	2074
Average # of Days per Visit	81.09	72.37	76.05	72.27
Average # of Months per Visit	2.7	2.4	2.5	2.4
All female program members	**Fall 2012**	**Spring 2013**	**2012–13**	**2009–13**
Total Member Days	2357	3389	5746	16503
Total # of Visits	34	44	78	230
Average # of Days per Visit	69.32	77.02	73.67	71.75
Average # of Months per Visit	2.3	2.6	2.5	2.4





1.3 Scientific Programs and their Associated Workshops

There were three major and one complementary programs for the MSRI fiscal year 2012–13, and 11 workshops were associated with them.

Note: Brief descriptions of scientific topics for each activity were reported in the Brief Report submitted in 2012. 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: Commutative Algebra
August 20, 2012 to May 24, 2013
Organized by David Eisenbud (University of California, Berkeley), Srikanth Iyengar (University of Nebraska), Ezra Miller (Duke University), Anurag Singh (University of Utah), and Karen Smith (University of Michigan)*

Workshop 1: Connections For Women: Joint Workshop on Commutative Algebra and Cluster Algebras
August 22, 2012 to August 24, 2012
Organized by Claudia Polini (University of Notre Dame), Idun Reiten (Norwegian University of Science and Technology), Karen Smith (University of Michigan), and Lauren Williams (University of California, Berkeley)*

Workshop 2: Joint Introductory Workshop: Cluster Algebras and Commutative Algebra
August 27, 2012 to September 7, 2012
Organized by David Eisenbud (University of California, Berkeley), Bernhard Keller (Universit´e Paris VII, France), Karen Smith (University of Michigan), and Alexander Vainshtein* (University of Haifa, Israel)*

Workshop 3: Combinatorial Commutative Algebra and Applications
December 3, 2012 to December 7, 2012
Organized by Winfried Bruns (Universität Osnabrück), Alicia Dickenstein (University of Buenos Aires, Argentina), Takayuki Hibi (Osaka University), Allen Knutson (Cornell University), and Bernd Sturmfels (University of California, Berkeley)*

Workshop 4: Representation Theory, Homological Algebra, and Free Resolutions
February 11, 2013 to February 15, 2013
Organized by Luchezar Avramov (University of Nebraska), David Eisenbud (University of California, Berkeley), and Irena Peeva (Cornell University))*

Workshop 5: The Commutative Algebra of Singularities in Birational Geometry: Multiplier Ideals, Jets, Valuations, and Positive Characteristic Methods
May 6, 2013 to May 10, 2013
Organized by Craig Huneke (Kansas University), Yujiro Kawamata (University of Tokyo), Mircea Mustata (University of Michigan), Karen Smith (University of Michigan), and Kei-ichi Watanabe (Nihon University)*

Program 2: Cluster Algebras
August 20, 2012 to December 21, 2012
Organized by Sergey Fomin (University of Michigan), Bernhard Keller (Université Paris Diderot - Paris 7, France), Bernard Leclerc (Université de Caen Basse-Normandie, France), Alexander Vainshtein (University of Haifa, Israel), and Lauren Williams (University of California, Berkeley)*

Workshop 1: Connections For Women: Joint Workshop on Commutative Algebra and Cluster Algebras
August 22, 2012 to August 24, 2012
Organized by Claudia Polini (University of Notre Dame), Idun Reiten (Norwegian University of Science and Technology), Karen Smith (University of Michigan), and Lauren Williams (University of California, Berkeley)*

Workshop 2: Joint Introductory Workshop: Cluster Algebras and Commutative Algebra
August 27, 2012 to September 7, 2012
Organized by David Eisenbud (University of California, Berkeley), Bernhard Keller (Universit´e Paris VII, France), Karen Smith (University of Michigan), and Alexander Vainshtein* (University of Haifa, Israel)*

Workshop 3: Cluster Algebras in Combinatorics, Algebra, and Geometry
October 29, 2012 to November 2, 2012
Organized by Claire Amiot (Université de Strasbourg), Sergey Fomin (University of Michigan), Bernard Leclerc (Université de Caen), and Andrei Zelevinsky (Northeastern University)*

Program 3: Noncommutative Algebraic Geometry and Representation Theory
January 14, 2013 to May 24, 2013
Organized by Mike Artin (Massachusetts Institute of Technology), Viktor Ginzburg (University of Chicago), Catharina Stroppel (Universität Bonn , Germany), Toby Stafford (University of Manchester, United Kingdom), Michel Van den Bergh (Universiteit Hasselt, Belgium), and Efim Zelmanov (University of California, San Diego)*

Workshop 1: Connections for Women: Noncommutative Algebraic Geometry and Representation Theory
January 24, 2013 to January 25, 2013
Organized by Georgia Benkart (University of Wisconsin), Ellen Kirkman (Wake Forest University), and Susan Sierra (Princeton University & University of Edinburgh)*

Workshop 2: Introductory Workshop: Noncommutative Algebraic Geometry and Representation Theory
January 28, 2013 to February 1, 2013
Organized by Michael Artin (Massachusetts Institute of Technology - MIT), Michel Van den Bergh (Vrije Universiteit Brussel), and Toby Stafford (University of Manchester)*

Workshop 3: Interactions between Noncommutative Algebra, Representation Theory, and Algebraic Geometry
April 8, 2013 to April 12, 2013
Organized by Victor Ginzburg (University of Chicago), Iain Gordon (University of Edinburgh, UK), Markus Reineke (Bergische Universität Wuppertal, Germany), Catharina Stroppel (University of Bonn, Germany), and James Zhang (University of Washington)*

Program 4: Complementary Program
August 20, 2012 to May 24, 2013

MSRI had a small Complementary Program comprised of four researchers, Valerio Capraro (Université de Neuchâtel), Carolyn Dean (Manchester University), Peter Selinger (Dalhousie University), and Eric Zaslow (Northwestern University).

1.4 Scientific Activities Directed at Underrepresented Groups in Mathematics

Connections for Women Workshops
During the 2012–13 academic year, MSRI hosted 3 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 2012: Enumerative Combinatorics
In an effort to report all of the activities that occurred in 2012 summer at MSRI, we would like to mention that MSRI-UP 2012 occured. This activity was already reported in the 2011–12 NSF Annual Report.

Workshop 1: Mathematics Institutes' Modern Math Workshop at SACNAS
NSF supplemental grant DMS 1126721
Location: Seattle, Washington
October 10, 2012 to October 11, 2012
Organized by NIMBioS and Jeff Brock (ICERM), Ricardo Cortez (Tulane University), Ruth Crane (ICERM), Suzanne Lenhart (University of Tennessee and NIMBioS), Ivelisse Rubio (University of Puerto Rico, Computer Science), Kelly Sturner (NIMBioS)

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

Workshop 2: Blackwell-Tapia Conference 2012
NSF supplemental grant DMS 1126721
Location: ICERM
November 9, 2012 to November 10, 2012
Organized by ICERM and Alejandro Aceves (Southern Methodist University), Edray Goins (Purdue University), Trachette Jackson (University of Michigan), Juan Meza (University of California at Merced), Jill Pipher (ICERM), Bjorn Sandstede (ICERM)

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

1.5 Summer Graduate Schools (Summer 2012)

SGS 1: Noncommutative Algebraic Geometry
June 18, 2012 to June 29, 2012
Organized by Dan Rogalski (University of California, San Diego), Travis Schedler (Massachusetts Institute of Technology), and Michael Wemyss (The University of Edinburgh, United Kingdom)*

SGS 2: Mathematical General Relativity
July 9, 2012 to July 20, 2012
Organized by Justin Corvino (Lafayette College) and Pengzi Miao (University of Miami)*

SGS 3: Model Theory
July 23, 2012 to August 3, 2012
Organized by David Marker (University of Illinois, Chicago), Thomas Scanlon (University of California, Berkeley), and Carol Wood (Wesleyan University)*

SGS 4: Seminaire de Mathematiques Superieures 2012: Probabilistic Combinatorics
Location: Montreal, Canada
June 25, 2012 to July 6, 2012
Organized by Louigi Addario-Berry (McGill University), Luc Devroye (McGill University), and Bruce Reed (McGill University)*

SGS 5: IAS/PCMI Summer 2012: Geometric Group Theory
Location: Park City, Utah
July 1, 2012 to July 21, 2012
Organized by Mladen Bestvina (University of Utah), Michah Sageev (Technion – Israel Institute of Technology), and Karen Vogtmann (Cornell University)

1.6 Other Scientific Workshops

Workshop 1: Pacific Rim Mathematical Association (PRIMA) Congress 2013
Location: Shanghai Jiao Tong University, China
June 24, 2013 to June 28, 2013
Organized by Alejandro Adem (University of British Columbia, Canada), Federico Ardila (San Francisco State University, USA), Marston Conder (University of Auckland, New Zealand), David Eisenbud (UC Berkeley, USA), Yasha Eliashberg (Stanford University, USA), Nassif Ghoussoub (University of British Columbia, Canada), Tony Guttmann (University of Melbourne, Australia), Le Minh Ha (Vietnam National University, Vietnam), Shi Jin (Shanghai Jiao Tong University and University of Wisconsin-Madison, China/USA), Alejandro Jofre (Universidad de Chile, Chile), Yujiro Kawamata (University of Tokyo, Japan), JongHae Keum (Korea Institute for Advanced Study, Korea), Doug Lind (University of Washington, USA), Kyewon Koh Park (Ajou University, Korea), Shige Peng (Shandong University, China), Jose Seade (Universidad Nacional Autónoma de México, México), Gang Tian (Princeton University and Peking University, USA/China), and Tatiana Toro (University of Washington, USA)

Workshop 2: Bay Area Differential Geometry Seminar (BADGS) 2012–13
Location: Berkeley, Santa Cruz and Stanford, California
June 2, 2012, October 6, 2012 and March 9, 2013
Organized by David Bao (San Francisco State University), Robert Bryant (Mathematical Sciences Research Institute), Joel Hass (University of California, Davis), David Hoffman (Stanford University), Rafe Mazzeo (Stanford University), and Richard Montgomery (University of California, Santa Cruz)*

Workshop 3: Hot Topics: Surface subgroups and cube complexes
March 18, 2013 to March 22, 2013
Organized by Ian Agol (University of California, Berkeley), Danny Calegari (University of Chicago), Ursula Hamenstädt (University Bonn), Vlad Markovic (California Institute of Technology)*

1.7 Education & Outreach Activities

Workshop 1: Bay Area Circle for Teachers (BACT) Summer 2012
June 18, 2012 to June 22, 2012
Organized by Sage Moore and BACT Director

Workshop 2: Bay Area Circle for Teachers (BACT) Winter 2013
January 26, 2013
Organized by Sage Moore and BACT Director

Workshop 3: Mathematics Professional Development Institute 2012 (Wu Summer Institute)
July 9, 2012 to July 27, 2012
Organized by Hung-Hsi Wu (University of California, Berkeley)

Workshop 4: UC Berkeley Julia Robinson Mathematics Festival
January 27, 2013
Location: International House of University of California, Berkeley

Workshop 5: Circle on the Road Spring 2013
NSF Supplement Grant DMS-1118532
Location: University of Puerto Rico, Mayaguez
March 8, 2013 to March 10, 2013
Organized by Amanda Serenevy (Riverbend Community Math Center), Dave Auckly (Kansas State University), Jonathan Farley (Research Institute for Mathematics), Hector Rosario (University of Puerto Rico, Mayaguez), Mark Saul (John Templeton Foundation), Diana White (University of Colorado Denver)

Workshop 6: Critical Issues in Mathematics Education 2013: Assessment of Mathematcial Proficiencies in the Age of the Common Core
NSF Supplement Grant DMS-1118532
April 3, 2013 to April 5, 2013
Organized by Mark Thames (University of Michigan), Kristin Umland* (University of New Mexico), Noah Heller (Math for America) and Alan Schoenfeld (University of California, Berkeley)*

1.8 Program Consultants List

Consultant Name(s)	Consultant Disciplinary Specialty	Consultant Employer	Activity Title
David Bao	Differential geometry	San Francisco State University	Differential geometry seminar
Mathias Beck	Discrete geometry	San Francisco State University	Bay Area Circle for Teachers
Philip Griffith	Algebraic geometry	Institute for Advanced Study	Future program
Moris Kalka	Differential geometry	Tulane University	Summer Graduate Workshops
Jacob Lurie	Algebraic topology	Harvard University	Future program
William Macallum	Education	University of Arizona	Educational workshops
Rafe Mazzeo	Differential geometry	Stanford University	Differential geometry seminar
Donald McClure	Image processing	Brown University	AMS Open Access
Curt McMullen	Geometric Topology	Harvard University	Future program
Robert Megginson	Fuctional Analysis	University of Michigan	Diversity Recruitment
Juan Meza	Computational mathematics	Lawrence Berkeley National Laboratory	MSRI - UP
Richard Montgomery	Differential geometry	University of California, Santa Cruz	Differential geometry seminar
Assaf Naor	Probability	New York University	Quantative Geometry
Jim Pitman	Statistics	University of California, Berkeley	Vmath
Bjorn Poonen	Model theory	Technology	Future program
Perter Sarnak	Number theory	University of Princeton	Future program
Mark Saul	Education	Education Development Center	Great Circles
Tatiana Shubin	Number theory	San Jose State University	Bay Area Circle for Teachers
Ted Slaman	Logic	University of California, Berkeley	Future program
Zvesda Stankova	Algebraic geometry	Mill College	Math Circles
Sam Vandervelde	Number theory	St. Lawrence University	Math Circles
Hung-Hsi Wu	Differential geometry	University of California, Berkeley	Math. Professional Dev. Instiute (Wu Summer Institute)
Educational Advisory Committee (EAC)	See Section 10: Committee Membership		Using Partnerships to Strengthen Elementary Mathematics Teacher Education
Human Resources Advisory Committee (HRAC)	See Section 10: Committee Membership		MSRI - UP
Scientific Advisory Committee (SAC) & HRAC	See Section 10: Committee Membership		Commutative Algebra Noncommutative Algebraic Geometry and Representation Theory Cluster Algebras Complementary Program

2. Program and Workshop Data

2.1 Program Participant List

(More detailed information can be found in the email attachment)

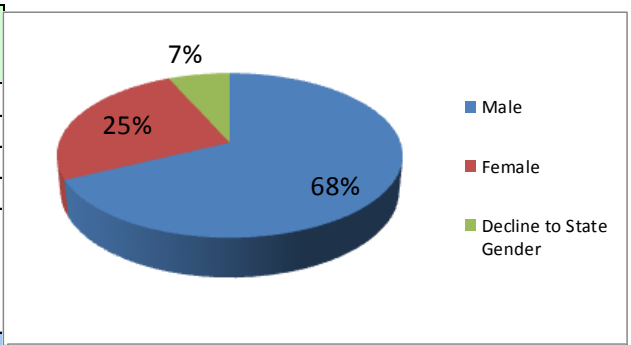
2.2 Program Participant Summary

Programs	# of Members	# of Citizens & Perm. Res.	%	# of Female	%	# of Minorities[1]	%	US Home Institution	%
Commutative Algebra	108	46	*42.6%*	30	*27.8%*	2	*5.3%*	57	52.8%
Cluster Algebras	46	20	*43.5%*	11	*23.9%*	0	*0.0%*	21	45.7%
Noncommutative Algebraic Geometry and Representation Theory	66	29	*43.9%*	15	*22.7%*	3	*12.5%*	33	50.0%
Complementary Program 2012-13	4	1	*25.0%*	1	*25.0%*	0	*0.0%*	1	25.0%
Total # of Distinct Members	**224**	**96**	***42.9%***	**57**	***25.4%***	**5**	***6.2%***	**112**	***50.0%***

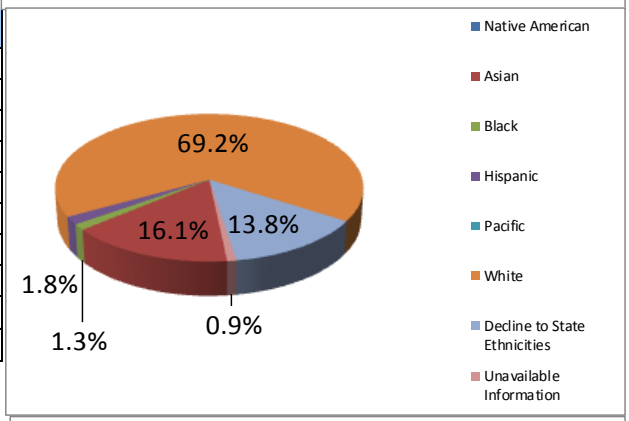
[1] *Minorities are US citizens who declare themselves American Indian, Black, Hispanic, or Pacific Islander. Minority percentage is calculated by dividing the number of Minorities by the total number of US citizens.*

2.3 Program Participant Demographic Data

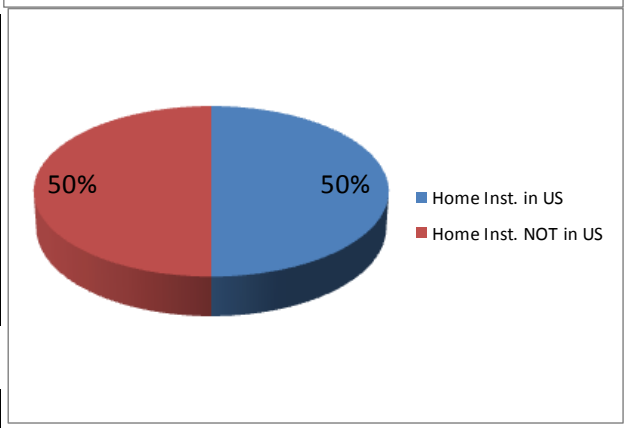
Gender	#	% (No Decl.)*	%
# of Distinct Members	224		100.0%
Male	152	72.73%	67.9%
Female	57	27.27%	25.4%
Decline to State Gender	15		6.7%



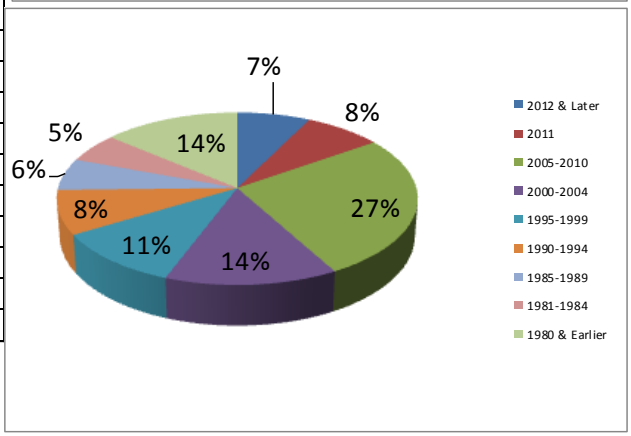
Ethnicities	#	% (No Decl.)*	%
Native American	0	0.00%	0.0%
Asian	36	18.18%	16.1%
Black	3	1.52%	1.3%
Hispanic	4	2.02%	1.8%
Pacific	0	0.00%	0.0%
White	155	78.28%	69.2%
Decline to State Ethnicities	31		13.8%
Unavailable Information	2		0.9%
Minorities	5		6.2%



Citizenships	#		%
US Citizen & Perm. Residents	96		42.9%
Foreign	120		53.6%
Unavailable information	8		3.6%
# of Distinct Members	224		100.0%
US Citizen	81		36.2%
Perm Residents	15		6.7%
Home Inst. in US	112		50.00%



Year of Ph.D	#		%
2012 & Later	16		7.1%
2011	17		7.6%
2005-2010	58		25.9%
2000-2004	30		13.4%
1995-1999	23		10.3%
1990-1994	18		8.0%
1985-1989	13		5.8%
1981-1984	12		5.4%
1980 & Earlier	30		13.4%
Unavailable Info.	7		3.1%
Total # of Distinct Members	224		100.0%



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

Programs

Commutative Algebra

Cluster Algebras

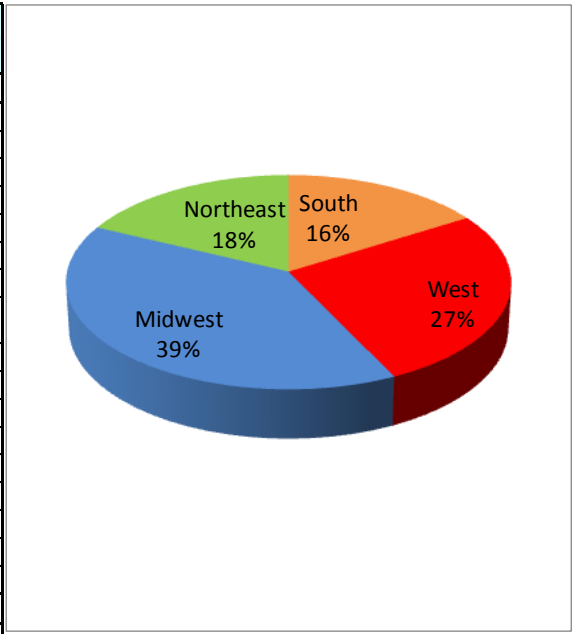
Noncommutative Algebraic Geometry and Representation Theory

Complementary Program 2012–13

2012–13 Program Members Home Institution Classified by States

**Regions based on US Census classification*

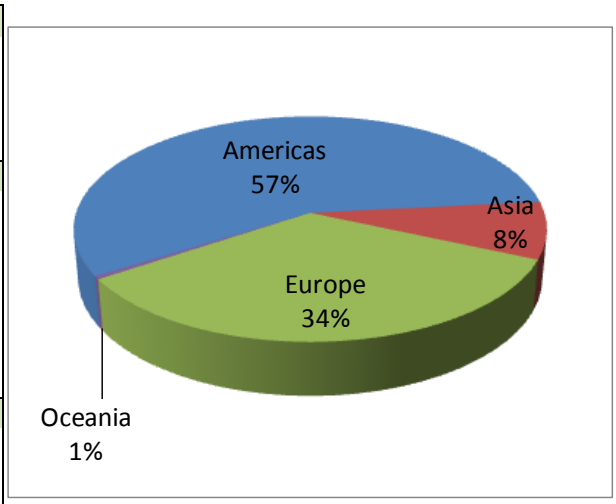
State	#	%	2007 Census Population
South	**18**	**16.1%**	**36.6%**
AL	-	0.0%	1.5%
AR	-	0.0%	0.9%
DE	-	0.0%	0.3%
DC	-	0.0%	0.2%
FL	-	0.0%	6.1%
GA	2	1.8%	3.2%
KY	-	0.0%	1.4%
LA	3	2.7%	1.4%
MD	-	0.0%	1.9%
MS	-	0.0%	1.0%
NC	5	4.5%	3.0%
OK	-	0.0%	1.2%
SC	-	0.0%	1.5%
TN	-	0.0%	2.0%
TX	7	6.3%	7.9%
VA	1	0.9%	2.6%
WV	-	0.0%	0.6%
West	**30**	**26.8%**	**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	18	16.1%	12.1%
CO	-	0.0%	1.6%
NV	-	0.0%	0.9%
NM	1	0.9%	0.7%
OR	4	3.6%	1.2%
UT	2	1.8%	0.9%
WA	5	4.5%	2.1%
WY	-	0.0%	0.2%
Midwest	**44**	**39.3%**	**22.0%**
IL	4	3.6%	4.3%
IN	12	10.7%	2.1%
IA	-	0.0%	1.0%
KS	2	1.8%	0.9%
MI	9	8.0%	3.3%
MN	6	5.4%	1.7%
MO	2	1.8%	1.9%
ND	-	0.0%	0.2%
NE	7	6.3%	0.6%
OH	-	0.0%	3.8%
SD	-	0.0%	0.3%
WI	2	1.8%	1.9%
Northeast	**20**	**17.9%**	**18.1%**
CT	-	0.0%	1.2%
ME	1	0.9%	0.4%
MA	9	8.0%	2.1%
NH	-	0.0%	0.4%
NJ	3	2.7%	2.9%
NY	6	5.4%	6.4%
PA	1	0.9%	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	**112**	**100%**	**100%**



2012–13 Program Members Home Institution Classified by Countries

**Regions based on United Nations classification*

Americas			**126**
	Central America	Mexico	1
	North America	Canada	12
		United States	112
	South America	Argentina	1
Asia			**18**
	East Asia	China	1
		Japan	10
		Korea, Republic of	1
	South-central Asia	India	3
	South-eastern Asia	Vietnam	1
	Western Asia	Israel	2
Europe			**75**
	Eastern Europe	Russia	1
	Northern Europe	England	24
		Finland	2
		Scotland	1
		Sweden	2
	Southern Europe	Italy	5
		Spain	1
	Western Europe	Austria	1
		Belgium	2
		France	13
		Germany	18
		Switzerland	5
Oceania			**1**
	Australia & NZ	Australia	1
Unavailable information			**4**
Grand Total			**224**



2.4 Workshop Participant List

(See e-mail attached file)

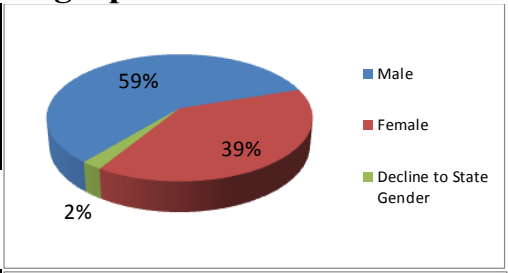
2.5 Workshop Participant Summary

Workshops	# of Participants	# of Citizens & Perm. Res.	%	# of Female	%	# of Minorities[1]	%	US Home Institution	%
10 Scientific Workshops									
Cluster Algebras in Combinatorics, Algebra, and Geometry	91	48	*52.7%*	19	*20.9%*	3	*8.6%*	57	62.6%
Combinatorial Commutative Algebra and Applications	126	65	*51.6%*	38	*30.2%*	3	*5.6%*	78	61.9%
Connections For Women: Joint Workshop on Commutative Algebra and Cluster Algebras	105	54	*51.4%*	56	*53.3%*	4	*9.5%*	70	66.7%
Connections for Women: Noncommutative Algebraic Geometry and Representation Theory	74	41	*55.4%*	49	*66.2%*	5	*14.3%*	50	67.6%
Hot Topics: Surface subgroups and cube complexes	62	38	*61.3%*	12	*19.4%*	1	*3.0%*	48	77.4%
Interactions between Noncommutative Algebra, Representation Theory, and Algebraic Geometry	125	67	*53.6%*	25	*20.0%*	3	*5.2%*	80	64.0%
Introductory Workshop: Noncommutative Algebraic Geometry and Representation Theory	118	63	*53.4%*	36	*30.5%*	3	*5.7%*	78	66.1%
Joint Introductory Workshop: Cluster Algebras and Commutative Algebra	149	72	*48.3%*	46	*30.9%*	3	*5.3%*	93	62.4%
Representation Theory, Homological Algebra, and Free Resolutions	166	80	*48.2%*	39	*23.5%*	2	*3.3%*	103	62.0%
The Commutative Algebra of Singularities in Birational Geometry: Multiplier Ideals, Jets, Valuations, and Positive Characteristic Methods	126	50	*39.7%*	23	*18.3%*	4	*9.8%*	81	64.3%
All 10 Workshops Total	**1,142**	**578**	***50.6%***	**343**	***30.0%***	**31**	***6.6%***	**738**	***64.6%***
6 Other Workshops									
AWM Research Symposium 2013	144	100	*69.4%*	142	*98.6%*	9	*10.5%*	135	93.8%
Bay Area Circle for Teachers (BACT) Summer Workshop 2013	1	0	*0.0%*	0	*0.0%*	0	*0.0%*	0	0.0%
Bay Area Differential Geometry Seminar (BADGS) Spring 2013	10	2	*20.0%*	1	*10.0%*	0	*0.0%*	10	100.0%
Circle on the Road Spring 2013	50	49	*98.0%*	31	*62.0%*	10	*20.8%*	50	100.0%
Critical Issues in Mathematics Education 2013: Assessment of Mathematical Proficiencies in the Age of the Common Core	149	143	*96.0%*	77	*51.7%*	25	*18.4%*	148	99.3%
Pacific Rim Mathematical Association (PRIMA) Congress 2013	72	13	*18.1%*	16	*22.2%*	1	*12.5%*	38	52.8%
All 6 Workshops Total	**426**	**307**	***72.1%***	**267**	***62.7%***	**45**	***23.4%***	**381**	***89.4%***
All 16 Workshops Total	**1,568**	**885**	***56.4%***	**610**	***38.9%***	**76**	***11.5%***	**1,119**	***71.4%***

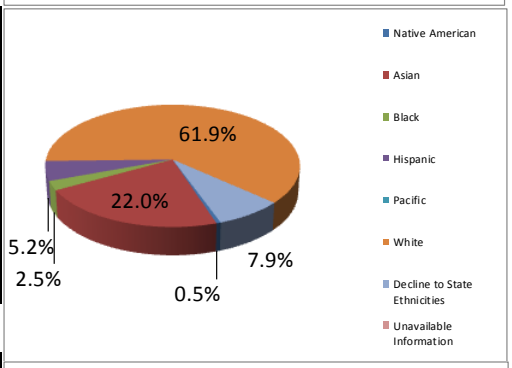
[1] *Minorities are US citizens who declare themselves American Indian, Black, Hispanic, or Pacific Islander. Minority percentage is calculated by dividing the number of Minorities by the total number of US citizens.*

2.6 Workshop Participant Demographic Data

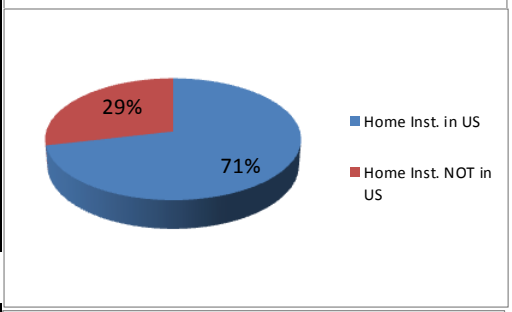
Gender	#	% (No Decl.)*	%
# of Participants	1568		100.0%
Male	923	60.21%	58.9%
Female	610	39.79%	38.9%
Decline to State Gender	35		2.2%



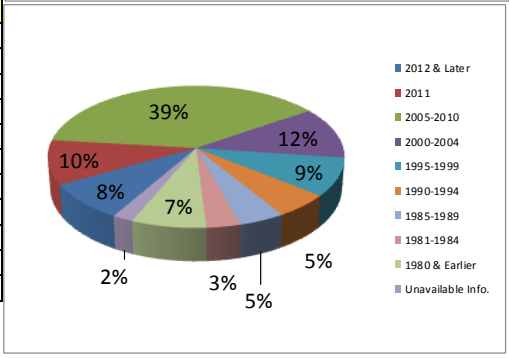
Ethnicities	#	% (No Decl.)*	%
Native American	8	0.55%	0.5%
Asian	350	23.89%	22.0%
Black	39	2.66%	2.5%
Hispanic	83	5.67%	5.2%
Pacific	0	0.00%	0.0%
White	985	67.24%	61.9%
Decline to State Ethnicities	125		7.9%
Unavailable Information	0		0.0%
Minorities	76		10.2%



Citizenships	#		%
US Citizen & Perm. Residents	885		56.4%
Foreign	651		41.5%
Unavailable information	32		2.0%
# of Particpants	1568		100.0%
US Citizen	746		47.6%
Perm Residents	139		8.9%
Home Inst. in US	1119		71.36%



Year of Highest Degree	#		%
2012 & Later	132		8.4%
2011	158		10.1%
2005-2010	604		38.5%
2000-2004	185		11.8%
1995-1999	136		8.7%
1990-1994	85		5.4%
1985-1989	70		4.5%
1981-1984	52		3.3%
1980 & Earlier	114		7.3%
Unavailable Info.	32		2.0%
Total # Participants	1568		100.0%



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

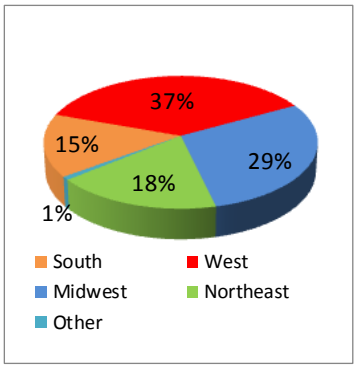
2012–13 Workshops

Cluster Algebras in Combinatorics, Algebra, and Geometry
Combinatorial Commutative Algebra and Applications
Connections For Women: Joint Workshop on Commutative Algebra and Cluster Algebras
Connections for Women: Noncommutative Algebraic Geometry and Representation Theory
Hot Topics: Surface subgroups and cube complexes
Interactions between Noncommutative Algebra, Representation Theory, and Algebraic Geometry
Introductory Workshop: Noncommutative Algebraic Geometry and Representation Theory
Joint Introductory Workshop: Cluster Algebras and Commutative Algebra
Representation Theory, Homological Algebra, and Free Resolutions
The Commutative Algebra of Singularities in Birational Geometry: Multiplier Ideals, Jets, Valuations, and Positive Characteristic Methods
AWM Research Symposium 2013
Bay Area Circle for Teachers (BACT) Summer Workshop 2013
Bay Area Differential Geometry Seminar (BADGS) Spring 2013
Circle on the Road Spring 2013
Critical Issues in Mathematics Education 2013: Assessment of Mathematical Proficiencies in the Age of the Common Core
Pacific Rim Mathematical Association (PRIMA) Congress 2013

2012–13 Workshop Participants Home Institution Classified by States

**Regions based on US Census classification*

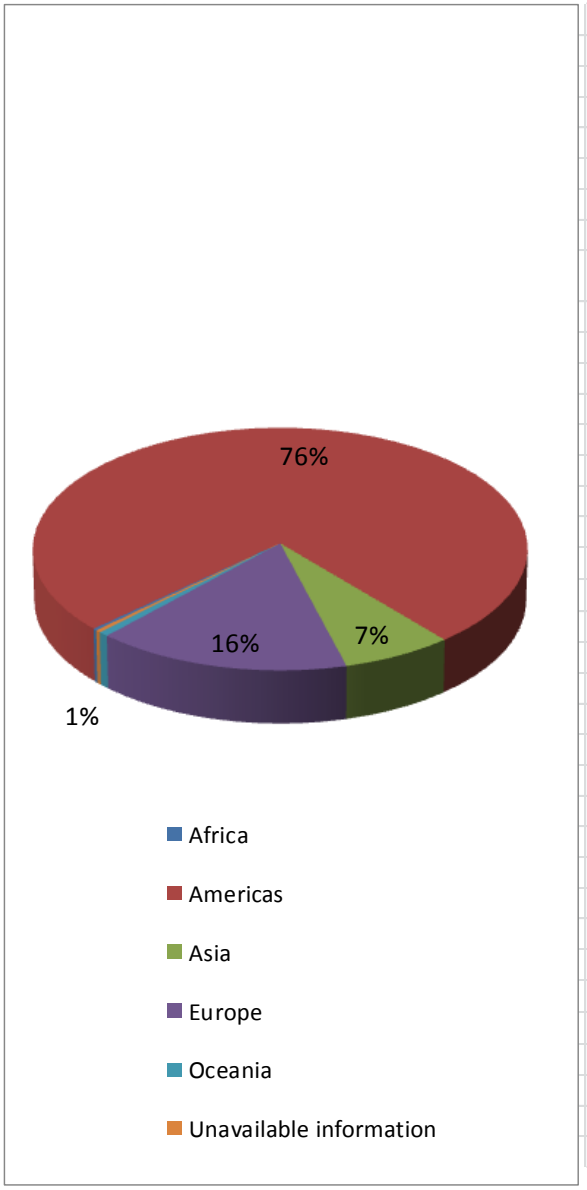
State	#	%	2007 Census Population
South	**172**	**15.4%**	**36.6%**
AL	3	0.3%	1.5%
AR	3	0.3%	0.9%
DE	-	0.0%	0.3%
DC	-	0.0%	0.2%
FL	7	0.6%	6.1%
GA	17	1.5%	3.2%
KY	10	0.9%	1.4%
LA	16	1.4%	1.4%
MD	13	1.2%	1.9%
MS	1	0.1%	1.0%
NC	28	2.5%	3.0%
OK	4	0.4%	1.2%
SC	2	0.2%	1.5%
TN	2	0.2%	2.0%
TX	58	5.2%	7.9%
VA	8	0.7%	2.6%
WV	-	0.0%	0.6%
West	**410**	**36.6%**	**23.2%**
AK	-	0.0%	0.2%
AZ	10	0.9%	2.1%
HI	-	0.0%	0.4%
ID	-	0.0%	0.5%
MT	-	0.0%	0.3%
CA	291	26.0%	12.1%
CO	10	0.9%	1.6%
NV	1	0.1%	0.9%
NM	11	1.0%	0.7%
OR	19	1.7%	1.2%
UT	33	2.9%	0.9%
WA	34	3.0%	2.1%
WY	1	0.1%	0.2%
Midwest	**327**	**29.2%**	**22.0%**
IL	41	3.7%	4.3%
IN	65	5.8%	2.1%
IA	1	0.1%	1.0%
KS	23	2.1%	0.9%
MI	62	5.5%	3.3%
MN	39	3.5%	1.7%
MO	19	1.7%	1.9%
ND	3	0.3%	0.2%
NE	46	4.1%	0.6%
OH	8	0.7%	3.8%
SD	-	0.0%	0.3%
WI	20	1.8%	1.9%
Northeast	**201**	**18.0%**	**18.1%**
CT	11	1.0%	1.2%
ME	3	0.3%	0.4%
MA	66	5.9%	2.1%
NH	-	0.0%	0.4%
NJ	20	1.8%	2.9%
NY	63	5.6%	6.4%
PA	31	2.8%	4.1%
RI	6	0.5%	0.4%
VT	1	0.1%	0.2%
Other	**9**	**0.1%**	**0%**
PR	8	0.0%	0%
Unavailable	1	0.1%	0%
Total	**1,119**	**99%**	**100%**



2012–13 Workshop Participants Home Institution Classified by Countries

**Regions based on United Nations classification*

Africa			**4**
	Middle Africa	Cameroon	1
		Congo, Republic	1
	Northern Africa	Egypt	1
	Southern Africa	South Africa	1
Americas			**1190**
	Central America	Mexico	6
	North America	Canada	58
		United States	1119
	South America	Argentina	4
		Brazil	2
		Chile	1
Asia			**109**
	Eastern Asia	China	5
		Japan	38
		Korea, Republic	20
		Taiwan	1
	South-central Asia	India	19
		Iran	8
		Pakistan	1
	South-eastern Asia	Malaysia	1
		Philippines	2
		Vietnam	2
	Western Asia	Israel	8
		Lebanon	2
		Saudi Arabia	2
Europe			**250**
	Eastern Europe	Czech Republic	6
		Poland	2
		Russia	2
	Northern Europe	Denmark	4
		England	50
		Estonia	3
		Ireland	1
		Norway	9
		Sweden	8
	Southern Europe	Greece	1
		Italy	23
		Portugal	2
		Slovenia	2
		Spain	15
	Western Europe	Austria	5
		Belgium	5
		France	36
		Germany	62
		Luxembourg	1
		Netherlands	1
		Switzerland	12
Oceania			**10**
	Australia & NZ	Australia	9
		New Zealand	1
Unavailable information			**5**
Grand Total			**1568**



2.7 Program Publication List

(See e-mail attached file)

2.8 Program Publication Work-In-Progress List

(See e-mail 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 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 2012–13 academic year, MSRI selected 26 postdoctoral scholars with research interests in the programs that MSRI offered. Of those postdocs, 21 were funded by the NSF Core Grant, 2 by the NSA, 2 by Viterbi Endowment and 1 by the Huneke Endowment. Each postdoctotal fellow completed the Responsible Conduct of Research (RCR) training through UC Berkeley.

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 six members who had earned their PhDs no more than five years ago. Those members were called "Postdoc Research Members" (PD/RMs as opposed to 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 26 Postdoctoral Fellows at MSRI, seven (27%) were female, nine (35%) were a U.S. Citizen or Permanent Resident, and 14 (54%) 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.

Cluster Algebras

Fontaine, Bruce

Name: Bruce Fontaine
Year of Ph.D: 2012
Institution of Ph.D.: University of Toronto
Dissertation title: Bases for invariant spaces and geometric representation theory
Ph.D. advisor: Joel Kamnitzer

Institution prior to obtaining the MSRI PD fellowship: University of Toronto
Position at that institution: PhD Student
Mentor (if applicable): Joel Kamnitzer

Institution (or company) where you are going after the MSRI PD fellowship: Cornell University
Position: Assistant Professor
Anticipated length: (if it is a tenure track position just write tenure-track) 2.5 years
Mentor (if applicable): Allen Knutson

Fellow's comments:

While at MSRI I attempted to understand the links between geometric models associated to representation theory, for instance via the geometric Satake correspondence and cluster algebras. I have had some success with the program of research and hope to continue it with Allen Knutson at Cornell. I found the available of people associated with cluster algebras and geometry (Dylan Thurston, Sergy Fomin and Andrei Zelevinsky) was very useful. While there, I submitted the following work with Joel Kamnitzer to Selecta Mathematica: Cyclic sieving, rotation, rotation and representation theory.

Glick, Max

Name: Max Glick
Year of Ph.D: 2012
Institution of Ph.D. : University of Michigan
Dissertation title: The pentagram map: combinatorial and geometric perspectives
Ph.D. advisor: Sergey Fomin

Institution prior to obtaining the MSRI PD fellowship: University of Michigan
Position at that institution: Graduate student
Mentor (if applicable): Sergey Fomin

Institution (or company) where you are going after the MSRI PD fellowship: Berkeley
Position: Visiting postdoc
Anticipated length: (if it is a tenure track position just write tenure-track) 1 semester
Mentor (if applicable): Lauren Williams

Fellow's comments:

I worked on trying to better understand how geometrically defined discrete dynamical systems can be understood in terms of cluster algebras. Towards the end of the semester, I started a related project, consulting with Pavlo Pylyavskyy, which I am hopeful will lead to a publication eventually. My time at MSRI was quite beneficial. I plan to continue working in the field of cluster algebras, and I am sure the people I met and the new ideas I encountered will help to this end.

Plamondon, Pierre-Guy

Name: Pierre-Guy Plamondon
Year of Ph.D: 2011
Institution of Ph.D.: Université Paris Diderot - Paris 7
Dissertation title: Catégories amassées aux espaces de morphismes de dimension infinie, applications.
Ph.D. advisor: Bernhard Keller

Institution prior to obtaining the MSRI PD fellowship: Université de Caen
Position at that institution: Postdoc
Mentor (if applicable): Bernard Leclerc

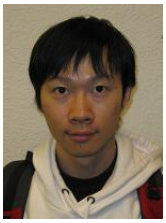
Institution (or company) where you are going after the MSRI PD fellowship: Université Paris Sud
Position: Maître de conférences
Anticipated length: (if it is a tenure track position just write tenure-track) permanent.
Mentor (if applicable): ---

Fellow's comments:

The semester on cluster algebras at MSRI has provided me with a unique opportunity to discuss with the many experts in the field that were gathered there. The institute was constantly busy with seminars, and I had the opportunity to give several talks, including one at the MSRI-Evans lectures.

During my stay at MSRI, I have worked on several subjects related to cluster algebras. Firstly, I had the chance to work with Idun Reiten, as she was my mentor during my stay. One of the main questions we discussed is whether rigid modules over a cluster-tilted algebras are determined by their dimension vector - this question is still open. Secondly, I had the chance to study the concept of friezes (after Coxeter-Conway), and worked on the question of counting their total number in different types. Discussions with Dylan Thurston led to a (still conjectural) method to count friezes. Finally, work with Bernhard Keller and Fan Qin on cluster characters led to a result concerning "generic bases" for cluster algebras. None of these results is published (yet) in any form.

My experience was enormously beneficial. The proximity of many experts in the field is a unique chance to work and to stay up to date with the recent developments.



Qin, Fan

Name: Fan Qin
Year of Ph.D: 2012
Institution of Ph.D.: University Paris 7
Dissertation title: Algebres amassees quantiques acycliques
Ph.D. advisor: Bernhard Keller

Institution prior to obtaining the MSRI PD fellowship: University Paris 7
Position at that institution: Ph.D. student
Mentor (if applicable): Bernhard Keller

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

Fellow's comments:

The main result of the following preprint is obtained while I was in MSRI.
Paper in preparation:
"Triangular and tropical properties of dual canonical bases of quantum cluster algebras"
Abstract:
Assume that a quantum cluster algebra admits a monoidal categorification by quantum affine algebras or quantum unipotent subgroups of simply-laced type. We show that, for any chosen cluster, the dual canonical basis is a triangular basis with respect to certain linearly independent set, and the basis elements are naturally parametrized by the extended g-vectors.

Was your experience at MSRI beneficial? Yes.

Rupel, Dylan

Name: Dylan Rupel
PhD: University of Oregon, 2012
Dissertation: Quantum Cluster Characters
PhD Advisor: Arkady Berenstein

Prior Institution (Graduate school): University of Oregon
Position: Graduate Teaching Fellow

Current Institution: Northeastern University
Position: Postdoctoral Teaching Associate
Mentor: Andrei Zelevinsky

Fellow's comments:

My experience at MSRI was extremely beneficial and productive. During this time I began a collaboration with Andrei Zelevinsky, Kyungyong Lee, and Li Li working on defining a quantum lift of their greedy basis. We have not produced a publication yet but we do seem to be making headway on this problem. I continued work on a project with Arkady Berenstein presenting Feigin's homomorphism as a tool for establishing quantum cluster structures on quantized coordinate rings of unipotent Kac-Moody groups. This work has progressed to its final stages and should appear on the arXiv within a short time. In addition I discovered a polynomial generalization of rank two cluster recursions in the noncommutative setting along with a combinatorial construction of the resulting "cluster variables" which establishes Laurentness and positivity. I hope to finalize the proofs of these results in the coming months. Finally I completed a review of the ClusterQuiver package for the Sage math software and a refereeing request from the "Publications of the Research Institute for Mathematical Sciences" at Kyoto University.

Scherotzke, Sarah

Name: Sarah Scherotzke
Year of Ph.D: 2009
Institution of Ph.D.: University of Oxford
Dissertation title: On Auslander-Reiten Theory for Algebras and Derived Categories
Mathematics Subject Classification: 16—Associative rings and algebras
Ph.D. advisor: Karin Erdmann

Institution prior to obtaining the MSRI PD fellowship: Bonn U.
Position at that institution: Postdoc

Institutions after the MSRI PD fellowship: Bonn U.
Position: Postdoc

No comments

Taipale, Kaisa

Name: Kaisa Taipale
Year of Ph.D: 2010
Institution of Ph.D.: University of Minnesota
Dissertation title: Quantum cohomologies and the abelian-nonabelian correspondence
Ph.D. advisor: Ionut Ciocan-Fontanine

Institution prior to obtaining the MSRI PD fellowship: St. Olaf College
Position at that institution: visiting assistant professor
Mentor (if applicable):

Institution (or company) where you are going after the MSRI PD fellowship: Cornell University
Position: visiting assistant professor
Anticipated length: (if it is a tenure track position just write tenure-track) 1 semester
Mentor (if applicable): Tara Holm

Fellow's comments:

At MSRI I worked on exploring the connection between quantum cohomology of homogeneous spaces, in particular Grassmannians, and cluster algebras, particularly cluster algebras from the coordinate rings of homogeneous spaces. I have a number of problems that I am pursuing, but none have resulted in publications yet.

My experience at MSRI was beneficial in two ways: it allowed me to learn much more about cluster algebras in order to work on this connection between quantum cohomology and cluster algebras (and I learned about the Fock-Goncharov conjectures, which support the idea of a connection!) and it allowed me to get up to speed in high-level research after spending two years at an undergraduate institution that emphasizes teaching.

Commutative Algebra

Berkesch, Christine
Fall

Name: Christine Berkesch
Year of Ph.D: 2010
Institution of Ph.D.: Purdue University
Dissertation title: Euler--Koszul homology in algebra and geometry
Ph.D. advisor: Uli Walther

Institution prior to obtaining the MSRI PD fellowship:
Duke University
Position at that institution: Assistant Research Professor

Institution (or company) where you are going after the MSRI PD fellowship: same as above
Anticipated length: 1 more semester

Postdoctoral Fellow's comments:

I worked on the following publications:

(with Jens Forsgard and Mikael Passare)
Euler--Mellin integrals and A-hypergeometric functions,
19 pages. arXiv:math.CV/1103.6273

(with Stephen Griffeth and Ezra Miller)
Systems of parameters and holonomicity of A-hypergeometric systems,
4 pages. arXiv:math.AG/1302.0048

(with Laura Felicia Matusevich and Uli Walther)
Torus equivariant D-modules and hypergeometric systems, 37 pages.

(with Laura Felicia Matusevich and Uli Walther)
Singularities and binomial D-modules, 10 pages.

I also considered various aspects of toric Boij--Soederberg theory.

Was your experience at MSRI beneficial?

Yes, this experience of focused research and collaboration was extremely beneficial.

Dufresne, Emilie
Spring

Your Name: Emilie Dufresne
Year of Ph.D: 2008
Institution of Ph.D.: Queen's University at Kingston, ON, Canada
Dissertation title: Separating Invariants
Ph.D. advisor: David Wehlau

Institution prior to obtaining the MSRI PD fellowship: Universität Basel
Position at that institution: Postdoctoral Assistant
Mentor (if applicable): Hanspeter Kraft

Institution (or company) where you are going after the MSRI PD fellowship: University of Durham, UK
Position: casual/hourly paid worker (doing tutorials for undergraduate courses)
Anticipated length: 1 semester (for now)

Postdoctoral fellow's comments:

While at MSRI, I got reacquainted with the commutative algebra community. I became aware of the progress and change of orientation which happenned in the last five years. I started learning more homological algebra, which is something I intended to do. I also started talking to new people and think in new ways. I had many conversations with Daniel Hernández, Emily Witt, Claudia Miller, Peter Symonds and Jack Jeffries. Not all these conversations turned into actual new collaborations. But one did. I have started a common project with Jack Jeffries. Already while at MSRI we obtain some very interesting results. We are in the process of writing up, but there is room for more research in that direction. I would say my experience was beneficial.

Fink, Alexander
Fall

Your Name: Alex Fink
Year of Ph.D: 2010
Institution of Ph.D.: UC Berkeley
Dissertation title: Matroid polytope subdivisions and valuations
Ph.D. advisor: jointly, Bernd Sturmfels and Federico Ardila (at San Francisco State)

Institution prior to obtaining the MSRI PD fellowship: North Carolina State
Position at that institution: postdoc
Mentor (if applicable): Seth Sullivant

Institution (or company) where you are going after the MSRI PD fellowship: proximally, back to NC State. Thereafter, Queen Mary, University of London (which I'll answer the following questions with respect to)
Position: Lecturer (~= assistant professor)
Anticipated length: tenure-track (in effect; the UK has abolished tenure)
Mentor (if applicable): n/a

Fellow's comments:

finished a joint paper with Luca Moci, _Matroids over rings_ arXiv:1209.6571, submitted for publication;
completed the key argument in a long-running joint project with Andrew Berget, on equivariant K-classes of certain orbits of matrices, whose writeup is in progress;
computed the Boij-Söderberg coefficients of matroid Stanley-Reisner ideals, writing up a short document which I hope to expand on and publish in short order;
various other collaborations started.

Was your experience at MSRI beneficial? Certainly.

Hernandez, Daniel
Spring

Your Name: Daniel Hernandez
Year of Ph.D: 2011
Institution of Ph.D.: University of Michigan, Ann Arbor
Dissertation title: F-purity of hypersurfaces
Ph.D. advisor: Karen E Smith

Institution prior to obtaining the MSRI PD fellowship:
Position at that institution: University of Minnesota, Twin Cities
Mentor (if applicable): Gennady Lyubeznik

Institution (or company) where you are going after the MSRI PD fellowship: University of Utah, Salt Lake City
Position: NSF Postdoc
Anticipated length: 1 year
Mentor (if applicable): Anurag Singh

Postdoctoral fellow's comments:

No comment

Kummini, Manoj
Fall

Name: Manoj Kummini
Year of Ph.D: 2008
Institution of Ph.D.: University of Kansas, Lawrence, KS
Dissertation title: Homological Invariants of Monomial and Binomial Ideals
Ph.D. advisor: Craig Huneke

Institution prior to obtaining the MSRI PD fellowship:
Chennai Mathematical Institute, Siruseri Tamilnadu, India
Position at that institution: Assistant Professor
Mentor: N/A

Institution after the MSRI PD fellowship:
Chennai Mathematical Institute, Siruseri Tamilnadu, India
Position: Assistant Professor
Anticipated length: Tenure-track

Postdoctoral fellow's comments:

Collaborated with Giulio Caviglia and Steven Sam and Sabine El Khoury (who visited me during the joint introductory workshop in Fall 2012). Began some discussion with Christine Berkesch and Matteo Varbaro.

Submitted papers:
El Khoury, Kummini and Srinivasan: Bounds for the Multiplicity of Gorenstein algebras. arXiv:1211.1316 [math.AC].

Caviglia and Kummini: Poset embeddings of Hilbert functions and Betti numbers. arXiv:1210.5562 [math.AC]},

Caviglia and Kummini: Betti tables of p-Borel-fixed ideals}. arXiv:1212.2201 [math.AC]

Kummini and Sam: The cone of Betti tables over a rational normal curve. arXiv:1301.7005 [math.AC].

Was your experience at MSRI beneficial?

Yes.

McCullough, Jason
Fall

Your Name: Jason McCullough
Year of Ph.D: 2009
Institution of Ph.D.: University of Illinois
Dissertation title: On the strong direct summand conjecture
Ph.D. advisor: Sankar Dutta

Institution prior to obtaining the MSRI PD fellowship: University of California Riverside
Position at that institution: Visiting Assistant Professor

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

Postdoctoral fellow's comments:

In addition to all of the beneficial workshops and seminars, I worked with a number of other people. My work with Craig Huneke, Paolo Mantero and Alexandra Seceleanu has led to perhaps 4 papers, 2 of which have already been submitted. I had a chance to finish a project with Kuei-Nuan Lin, started previously while at UCR. I also had several opportunities to meet and work with people I had not known personally before, including Aldo Conca, Mats Boij, Giulio Caviglia, and Frank Schreyer. My time at MSRI was invaluable and I am grateful to have had a chance to attend.

Murfet, Daniel
Spring

Name: Daniel Murfet
Year of Ph.D: 2008
Institution of Ph.D.: Australian National University
Dissertation title: The Mock Homotopy Category of Projectives and Grothendieck Duality
Ph.D. advisor: Amnon Neeman

Institution prior to obtaining the MSRI PD fellowship: UCLA
Position at that institution: Faculty/postdoc

Institution after the MSRI PD fellowship: USC
Position: Assistant Professor

No comments

Raicu, Claudiu
Spring

Your Name: Claudiu Raicu
Year of Ph.D.: 2011
Institution of Ph.D.: U.C. Berkeley
Dissertation title: Secant varieties of Segre-Veronese varieties
Ph.D. advisor: David Eisenbud

Institution prior to obtaining the MSRI PD fellowship: Princeton University
Position at that institution: Instructor of Mathematics
Mentor (if applicable): Janos Kollar

Institution (or company) where you are going after the MSRI PD fellowship: Princeton University
Position: Instructor of Mathematics
Anticipated length: 2011-2014
Mentor (if applicable): Janos Kollar

Postdoctoral fellow's comments:

I have written and submitted for publication a joint paper with Jerzy Weyman and Emily Witt, titled "Local cohomology with support in ideals of maximal minors and sub-maximal Pfaffians". This is the beginning of a long term project whose goal is to determine local cohomology with support in more general equivariant ideals.

My visit at MSRI was extremely helpful in expanding my research directions, I learned a lot from the researchers in residence at the institute, and had the chance to interact with the people at U.C. Berkeley as well.

Stevenson, Gregory
Spring

Your Name: Greg Stevenson
Year of Ph.D: 2011
Institution of Ph.D.: Australian National University
Dissertation title: Tensor actions and locally complete intersections
Ph.D. advisor: Amnon Neeman

Institution prior to obtaining the MSRI PD fellowship: Bielefeld U.
Position at that institution: Humboldt postdoctoral fellow

Institution where you are going after the MSRI PD fellowship: Bielefeld
Position: Humboldt postdoctoral fellow
Anticipated length: Until Nov. 2014

Postdoctoral fellow's comments:
I worked on a number of subjects with a variety of people during my semester at MSRI. Jesse Burke, who was present at one of the workshops and was able to visit during the semester, and I are collaborating on various extensions on a theorem of Orlov connecting graded singularity categories to noncommutative projective schemes. Our results are currently being written up and we plan to submit them to the proceedings volume for the commutative algebra program.
Benjamin Antieau and I have a joint project studying derived categories of various small categories, including path categories of quivers, over arbitrary noetherian rings. We have been able to prove several results, for instance giving a classification of localising subcategories of derived categories of ADE quivers over any noetherian ring, and are currently in the process of writing an article.
My mentor for the semester, Srikanth Iyengar, and I are working on multiple projects as a result of the time we spent together. We made significant progress during the semester on some questions involving actions of Hochschild cohomology and its differential-graded avatars on derived categories and their dg-models. This project is related to previous work by myself and by Benson, Iyengar, and Krause, and will hopefully clarify the connections between our approaches. We have also initiated a project studying suitable notions of the new intersection theorem in the context of derived categories of dg-categories.I also have ongoing projects, started during my semester at MSRI, with Adam-Christiaan van Roosmalen and with Kenneth Chan and Colin Ingalls. The former, with van Roosmalen, concerns the structure of the collection of (higher) triangles in a triangulated category. The latter, with Chan and Ingalls, consists of studying rigidity of derived categories of Fano and anti-Fano orders on smooth projective schemes and reconstruction, up to Morita equivalence, of the order given the derived category.I had a very positive experience at MSRI and my stay at the institute was very fruitful. It was an excellent opportunity to meet with a number of people with whom I had existing collaborations or research links as well as to begin a number of new collaborations and connect with a number of researchers in neighbouring fields. I also learned a great deal of mathematics and was exposed to several interesting questions. I look forward to a long, and productive, period of fully digesting the mathematics and problems I was fortunate enough to come into contact with at MSRI.

Varbaro, Matteo
Fall

Name: Matteo Varbaro
Year of Ph.D.: 2011
Institution of Ph.D.: Università degli Studi di Genova (Italy)
Dissertation title: Cohomological and Combinatorial Methods in the Study of Symbol Powers and Equations defining Varieties
Ph.D. advisor: Aldo Conca

Institution prior to obtaining the MSRI PD fellowship: Università degli Studi di Genova
Position at that institution: Postdoc
Mentor (if applicable): Aldo Conca

Institution (or company) where you are going after the MSRI PD fellowship: Università degli Studi di Genova
Position: Ricercatore (not the same as a tenure-track, which in Italy does not exist, but close to)
Anticipated length: 3 years

Postdoctoral fellow's comments:

At MSRI I mainly worked on four topics:
- On the F-pure threshold of a determinantal ideal, ended up with the paper entitled "The F-pure threshold of a determinantal ideal" joint with Lance Edward Miller and Anurag Singh, submitted.
- On a conjecture of Stanley on the shape of the h-vector of a matroid, continuing a line of research started with Alexandru Constantinescu, ended up with the paper "Generic and special constructions of pure O-sequences" joint with Alexandru Constantinescu and Thomas Kahle, submitted.
- On a conjecture of Kalai on the f-vector of Cohen-Macaulay flag complexes, ended up with the paper entitled "On a conjecture by Kalai" joint with Giulio Caviglia and Alexandru Constantinescu, submitted.
- On the study of the algebraic ralations between minors of a fixed size of a generic matrix, continuing a line of research started with Winfried Bruns and Aldo Conca, ended up with the preprint entitled "Diagrams of single exterior type" joint with Winfried Bruns.

The first three papers are available on the arXiv. I also started a collaboration with Jack Jeffries and Jonathan Montano, that is going on now, about the j-multiplicity of determinantal ideals.

Witt, Emily
Spring

Your Name: Emily Witt
Year of Ph.D: 2011
Institution of Ph.D.: University of Michigan
Dissertation title: Local cohomology and group actions
Ph.D. advisor: Mel Hochster

Institution prior to obtaining the MSRI PD fellowship: University of Minnesota
Position at that institution: Dunham Jackson Assistant Professor
Mentor (if applicable): Gennady Lyubeznik

Institution (or company) where you are going after the MSRI PD fellowship: University of Minnesota
Position: Dunham Jackson Assistant Professor
Anticipated length: 1-2 more years
Mentor (if applicable): Gennady Lyubeznik

Postdoctoral fellow's comments:

-Preprint (submitted) with Claudiu Raicu and Jerzy Weyman, "Local cohomology with support in ideals of maximal minors and submaximal Pfaffians"
-Preprint with Daniel Hernandez, Luiz Nunez-Betancourt, and Wenliang Zhang, "F-pure thresholds of quasi-homogeneous polynomials" completed
-Multiple projects progressed with Luis Nunez-Betancourt and/or Daniel Hernandez

Zhang, Yi
Spring

Your Name: Yi Zhang
Year of Ph.D: 2012
Institution of Ph.D.: University of Minnesota
Dissertation title: Local cohomology modules over polynomial rings of prime characteristic
Ph.D. advisor: Gennady Lyubeznik

Institution prior to obtaining the MSRI PD fellowship: Purdue University
Position at that institution: Visiting Assistant Professor
Mentor (if applicable): Uli Walther

Institution (or company) where you are going after the MSRI PD fellowship: University of Illinois at Urbana-Champaign
Position: Visiting Assistant Professor
Anticipated length: one year
Mentor (if applicable): Sankar Dutta

Postdoctoral fellow's comments:

I continued my research on local cohomology and module decomposition theory. I submitted a paper on the criterion of indecomposability. The stay at MSRI is very beneficial to my career.

NONCOMMUTATIVE ALGEBRAIC GEOMETRY AND REPRESENTATION THEORY

Chan, Kenneth

Your Name: Kenneth Chan
Year of Ph.D: 2010
Institution of Ph.D.: University of New South Wales (Australia)
Dissertation title: Resolving Singularities of Orders on Surfaces
Ph.D. advisor: Daniel Chan

Institution prior to obtaining the MSRI PD fellowship: University of Washington
Position at that institution: Acting Assistant Professor
Mentor (if applicable): James Zhang

Institution (or company) where you are going after the MSRI PD fellowship: University of Washington
Position: Acting Assistant Professor
Anticipated length: 2 years
Mentor (if applicable): James Zhang

Postdoctoral fellow's comments:

My coauthors (James Zhang and Chelsea Walton) and I finished a paper titled "Quantum binary polyhedral groups and their actions on quantum planes". I began a project with Colin Ingalls and Greg Stevenson on generalising the well known Bondal-Orlov reconstruction theorem to the setting of noncommutative algebraic geometry. I also began a project with Colin Ingalls on studying the relationship between the derived categories of a terminal order and its associated Brauer-Severi variety. Our aim is to generalise Kuznetsov's results on the relationship between the derived categories of a standard conic bundle and the associated sheaf of Clifford algebras.

Was your experience at MSRI beneficial?

Yes.

Chlouveraki, Maria

Your Name: Maria Chlouveraki
Year of Ph.D: 2007
Institution of Ph.D.: Université Paris 7 - Denis Diderot
Dissertation title: On the cyclotomic Hecke algebras of complex reflection groups
Ph.D. advisor: Prof. Michel Broué

Institution prior to obtaining the MSRI PD fellowship: University of Edinburgh
Position at that institution: Postdoctoral fellow
Mentor (if applicable): Prof. Iain Gordon

Institution (or company) where you are going after the MSRI PD fellowship: Université de Versailles
Position: Maître de conférences
Anticipated length: Permanent

Postdoctoral fellow's comments:

My participation to the MSRI program "Noncommutative Algebraic Geometry and Representation Theory" was very beneficial to me. I had the opportunity to discuss on an every-day-basis with experts in the topics that I am interested in, such as, for example, Dr. Gwyn Bellamy or Prof. Toby Stafford. I attended all workshops of the program, and also of the "Commutative Algebra" program, thus expanding my horizons. There was a lot of interaction with the other postdoctoral fellows, none of whom I had met before, and this could lead to fruitful future collaborations. I also had the opportunity to present my results to a broader audience at the Introductory Workshop and at the Postdoc Seminar. Finally, MSRI gave me the opportunity to visit UCLA, where I also gave a talk and discussed with Prof. Raphaël Rouquier, who gave me many ideas about the research topics that I am working on.

During my stay at the MSRI, I mostly collaborated with Dr. Guillaume Pouchin, who was visiting MSRI for 3 months. We are at the process of writing up our article on the representation theory and the determination of a basis for the Yokonuma-Temperley-Lieb algebra, which is a generalisation of the classical Temperley-Lieb algebra. MSRI's wonderful work environment also allowed me to finish up an article that I was already working on, together with Dr. Loïc Poulain d'Andecy, on the representation theory of the Yokonuma-Hecke algebra. Finally, I worked on the preparation of an article for the proceedings of the Introductory Workshop at the MSRI on the connections between Kazhdan-Lusztig theory and the theory of rational Cherednik algebras.

Morrison, Andrew

Your Name: Andrew Morrison
Year of Ph.D: 2012
Institution of Ph.D.: UBC
Dissertation title: Computing Motivic DT invariants
Ph.D. advisor: Jim Bryan

Institution prior to obtaining the MSRI PD fellowship: ETH Zurich
Position at that institution:
Mentor (if applicable): Rahul Pndharipande

Institution (or company) where you are going after the MSRI PD fellowship:
Position: ETH Zurich
Anticipated length: 2.5-3 years
Mentor (if applicable): Rahul Pndharipande

Postdoctoral fellow's comments:

I wrote one paper, and started at least one more. Very helpful to me was the mentor system as a younger postdoc. This was friendly and encouraging as well as mathematically sportive. Being at MSRI was great professionally,

In retrospect, it was a little hard to get to know people in the short + busy space of time. All in all the tie was great and I would love to be back again some day in the future.

Pecharich, Jeremy

Your Name: Jeremy Pecharich
Year of Ph.D: 2011
Institution of Ph.D.: University of California, Irvine
Dissertation title: Deformations of vector bundles on coisotropic subvarieties
Ph.D. advisor: Vladimir Baranovsky

Institution prior to obtaining the MSRI PD fellowship: Mount Holyoke College
Position at that institution: Visiting Assistant Professor
Mentor (if applicable): N/A

Institution (or company) where you are going after the MSRI PD fellowship: Pomona College
Position: Visiting Assistant Professor
Anticipated length: 1 year
Mentor (if applicable): N/A

Postdoctoral fellow's comments:

While at MSRI I was working on two independent projects. The first project was to study the virtual fundamental class and the moment map in symplectic geometry; this work was submitted for publication while at MSRI. I also continued work on deformation quantization of modules on symplectic varieties with Vladimir Baranovsky, part of this work is currently being written up and will appear by the end of the summer. This work also branched out into a joint project with Kai Behrend and Barbara Fantechi while I was at MSRI; part of the travel for this research was supported by the Postdoc travel grant provided by MSRI. The time I spent at MSRI was extremely beneficial to my research program from the numerous seminars to talking with other faculty in residence to time spent in the office. I would love to come back at some point in the future.

Rizzardo, Alice

Your Name: Alice Rizzardo
Year of Ph.D: 2012
Institution of Ph.D.: Columbia University
Dissertation title: On Fourier-Mukai type functors
Ph.D. advisor: Aise Johan de Jong

Institution prior to obtaining the MSRI PD fellowship: SISSA
Position at that institution: Postdoctoral fellow
Mentor (if applicable): Ugo Bruzzo

Institution (or company) where you are going after the MSRI PD fellowship: back to SISSA
Position: Postdoctoral fellow
Anticipated length: (if it is a tenure track position just write tenure-track) 2 years (one of them being 2012-2013), renewable for another two
Mentor (if applicable): Ugo Bruzzo

Postdoctoral fellow's comments:

Final draft of a paper: Representability of cohomological functors over extension fields
Worked on a project concerning Homological Projective Duality for Lagrangian Grassmannian 3,6.

Was your experience at MSRI beneficial? Very much so!

Stadnik, Theodore

Your Name: Theodore Stadnik, Jr.
Year of Ph.D: 2012
Institution of Ph.D.:Northwestern University
Dissertation title: Constructions using differential operators in positive characteristic.
Ph.D. advisor: David Nadler

Institution prior to obtaining the MSRI PD fellowship: University of California, Berkeley
Position at that institution: Postdoc (on NSF RTG)
Mentor (if applicable):

Institution (or company) where you are going after the MSRI PD fellowship: I was unable to secure an academic position for next year.

Postdoctoral fellow's comments:

I spent the majority of my time researching methods for proving derived localization theorems in arbitrary characteristics. I was successful in using these methods to prove there are entire families of spaces where localization holds. This result generalizes results about (underived) localization in characteristic zero and results about specific spaces in characteristic $p > 0$. A working title for the publication resulting from this research is "Methods for Derived Localization in Arbitrary Characteristics".

Was your experience at MSRI beneficial?
Yes, it was extremely beneficial.

Van Roosmalen, Adam-Christiaan

Your Name: Adam-Christiaan van Roosmalen
Year of Ph.D: 2008
Institution of Ph.D.: Hasselt University
Dissertation title: On the Classification of Hereditary Categories
Ph.D. advisor: Michel Van den Bergh

Institution prior to obtaining the MSRI PD fellowship: U. of Regina
Position at that institution: Postdoctoral researcher

Institution (or company) where you are going after the MSRI PD fellowship: Bielefeld University
Position: Postdoctoral Researcher
Anticipated length: Three months

Postdoctoral fellow's comments:

During my postdoctoral position at the MSRI, I continued work on the classification of hereditary categories. This led to a paper classifying hereditary categories with Serre duality which are numerically finite (the last condition means that the numerical Grothendieck group has finite rank) up to derived equivalence. The conditions on these categories are all geometrical: the bounded derived category of coherent sheaves on a smooth projective varieties satisfy Serre duality, and Hirzebruch-Riemann-Roch implies that these categories are numerically finite. The classification can thus be seen as a classification of noncommutative curves. (A preprint is available at http://arxiv.org/abs/1304.0257).

While Guillaume Pouchin (University of Edinburgh) was visiting, we worked on Hall algebras of directed categories. We proved that some hereditary categories which are not derived equivalent might have isomorphic (as algebras) derived Hall algebras. A preprint, joint with Guillaume Pouchin and Qunhua Liu, is in preparation.

In joint work with Donald Stanley, we investigate the role of the Serre functor in the theory of t-structures. We ask the following question:
Let A be an abelian category over a field, and let S: Db A --> Db A be a Serre functor. Let (U,V) be a t-structure on Db A with heart H. Is it true that the heart H is derived equivalent with A if and only if
a) (U,V) is bounded, and
b) S U \subseteq U ?

While I was a postdoctoral researcher at the MSRI, we answered this question positively when A is the category of finite dimensional modules over a finite dimensional hereditary algebra. We hope to upload the preprint shortly.

As part of still ongoing research, Greg Stevenson and I considered the stable module category of a small triangulated category C. We show that such a category can be interpreted as the homotopy category of triangles in C; this category is an algebraic triangulated category. We wish to investigate this further. One possible way is to generalise this construction and try to construct similar categories corresponding to (homotopy categories) of higher triangles (in the sense of Heller).

Was your experience at MSRI beneficial?

I believe my time at the MSRI was beneficial. I was able to benefit from talking to experts in my (and related) fields. I was also able to present some recent results, and received valuable feedback and many ideas on interesting directions to continue. I appreciate the many opportunities at the MSRI for such interactions (such as the postdoc talks, the five-minute introductions, and a joint coffee/tea-time), and the general atmosphere and openness among the members.

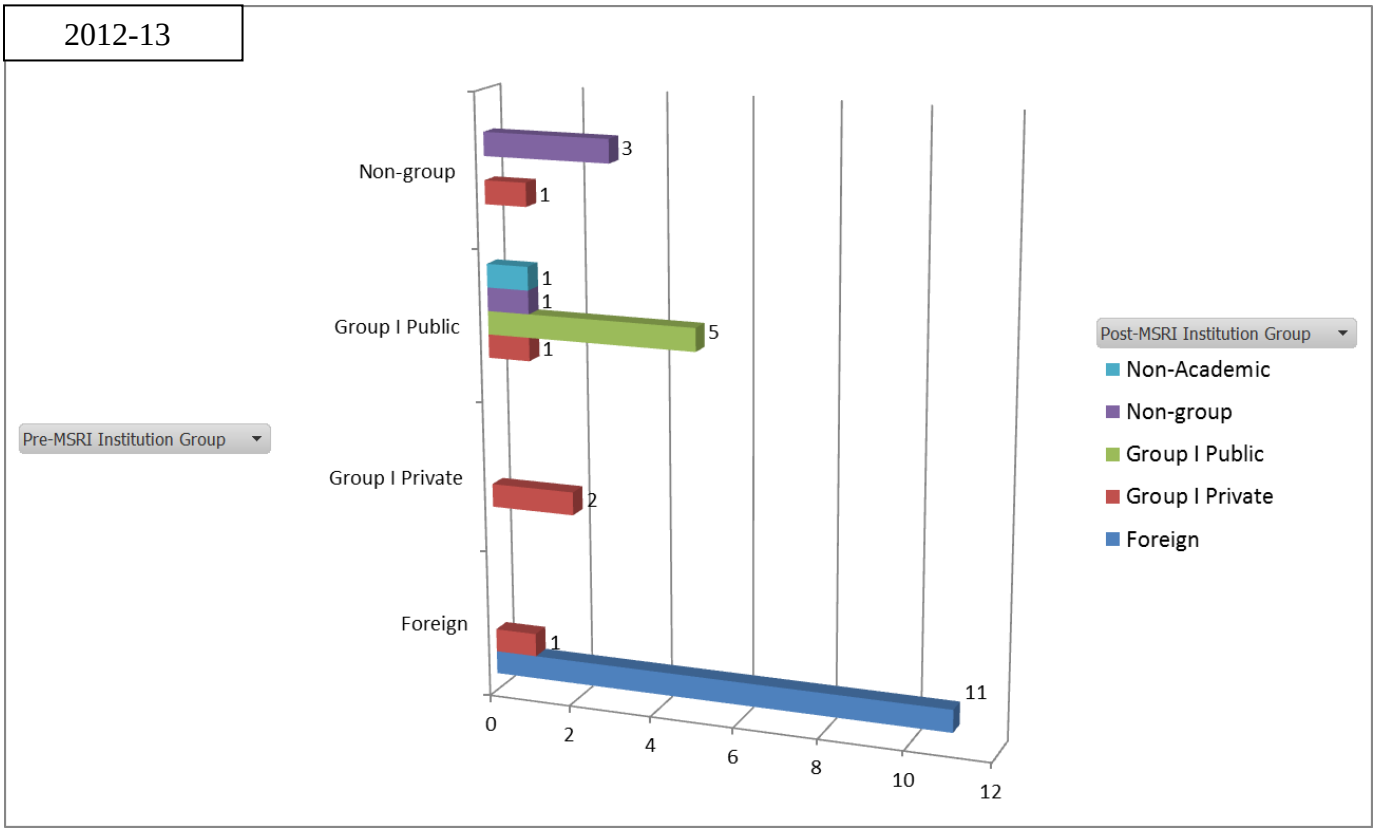
I also wish to express my gratitude to my mentor Sarah Witherspoon, who gave valuable feedback on my application material, and many suggestions when I presented (early) preprints. I value her help in suggesting interesting references and, when possible, introducing me to the authors.

I also want to mention the high quality of the workshops and conferences. I found the given introductory talks very informative and useful, and the topics to be relevant to having a bigger picture of the ongoing research.

3.2 Postdoctoral Fellow Placement List

Family Name	First Name	Pre-MSRI Institution Group	Post-MSRI Institution Group	Home Institution Name	Placement Institution Name
Berkesch	Christine	Group I Private	Group I Private	Duke University	Duke University
Chan	Kenneth	Group I Public	Group I Public	University of Washington	University of Washington
Chlouveraki	Maria	Foreign	Foreign	University of Edinburgh	Universite Versailles/Saint Quentin-en-Yvelines
Dufresne	Emilie	Foreign	Foreign	Universitat Basel	University of Durham, UK
Fink	Alexander	Non-group	Non-group	North Carolina State University	North Carolina State University
Fontaine	Bruce	Foreign	Group I Private	University of Toronto	Cornell University
Glick	Max	Group I Public	Group I Public	University of Michigan	UC Berkeley
Hernandez	Daniel	Group I Public	Group I Public	University of Minnesota Twin Cities	University of Utah
Kummini	Manoj	Foreign	Foreign	Chennai Mathematical Institute	Chennai Mathematical Institute
McCullough	Jason	Non-group	Non-group	UC Riverside	Rider University
Morrison	Andrew	Foreign	Foreign	ETH Zurich	ETH Zurich
Murfet	Daniel	Group I Public	Group I Private	UCLA	USC
Pecharich	Jeremy	Non-group	Non-group	Mt. Holyoke College	Pomona College
Plamondon	Pierre-Guy	Foreign	Foreign	Universite de Caen	Universite de Paris XI (Paris-Sud)
Qin	Fan	Foreign	Foreign	Universite de Paris VII (Denis Diderot)	Tsinghua University
Raicu	Claudiu	Group I Private	Group I Private	Princeton University	Princeton University
Rizzardo	Alice	Foreign	Foreign	International School for Advanced Studies (SISSA/ISAS)	International School for Advanced Studies (SISSA/ISAS)
Rupel	Dylan	Group I Public	Non-group	University of Oregon	Northeastern University
Scherotzke	Sarah	Foreign	Foreign	University of Bonn	University of Bonn
Stadnik	Theodore	Group I Public	Non-Academic	UC Berkeley	No employement
Stevenson	Gregory	Foreign	Foreign	Universitat Bielefeld	Universitat Bielefeld
Taipale	Kaisa	Non-group	Group I Private	Olaf College	Cornell University
van Roosmalen	Adam-Christiaan	Foreign	Foreign	University of Regina	Bielefeld University
Varbaro	Matteo	Foreign	Foreign	Universita di Genova	Universita di Genova
Witt	Emily	Group I Public	Group I Public	University of Minnesota Twin Cities	University of Minnesota Twin Cities
Zhang	Yi	Group I Public	Group I Public	Purdue University	U. of Illinois at Urbana-Champaign

Postdoctoral Fellow Placement Institution
(based on AMS Groupings)



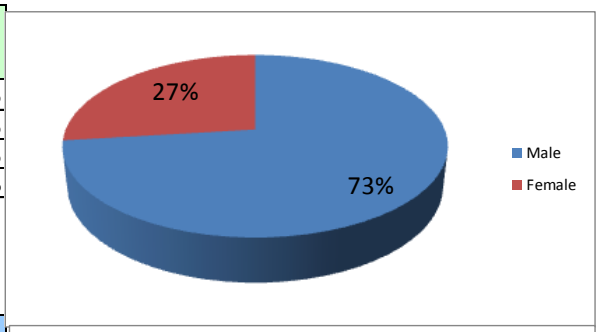
3.3 Postdoctoral Fellow Participant Summary

Programs	# of Postdocs	# of Citizens & Perm. Res.	%	# of Female	%	# of Minorities[1]	%	US Home Institution	%
Commutative Algebra	12	4	*33.3%*	3	*25.0%*	1	*25.0%*	8	66.7%
Cluster Algebras	7	3	*42.9%*	2	*28.6%*	0	*0.0%*	3	42.9%
Noncommutative Algebraic Geometry and Representation Theory	7	2	*28.6%*	2	*28.6%*	0	*0.0%*	3	42.9%
Total # of Distinct Postdocs	**26**	**9**	***34.6%***	**7**	***26.9%***	**1**	***11.1%***	**14**	***53.8%***

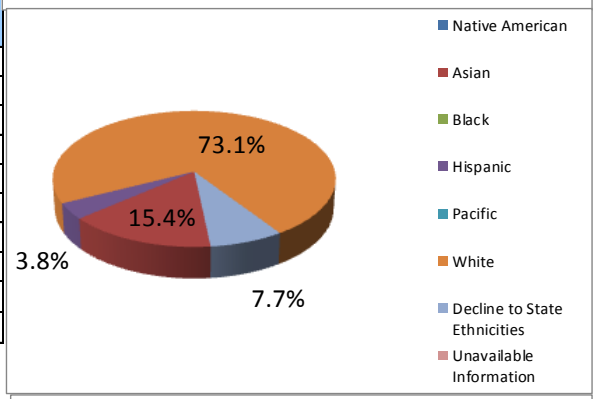
[1] *Minorities are US citizen who declare themselves American Indian, Black, Hispanic, or Pacific Islander. Minority percentage is calculated by dividing the number of Minorities by the total number of US citizens.*

3.4 Postdoctoral Fellow Demographic Data

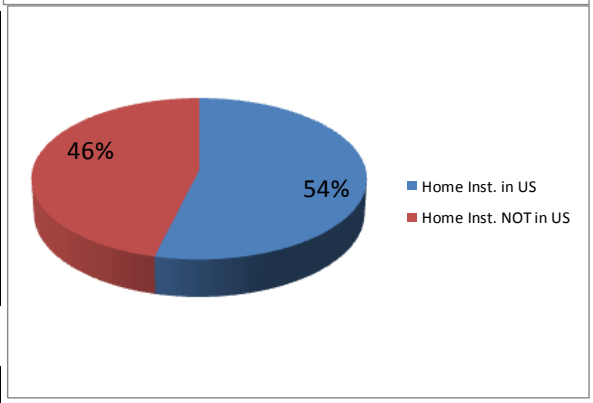
Gender	#	% (No Decl.)*	%
# of Distinct Members	26		100.0%
Male	19	73.08%	73.1%
Female	7	26.92%	26.9%
Decline to State Gender	0		0.0%



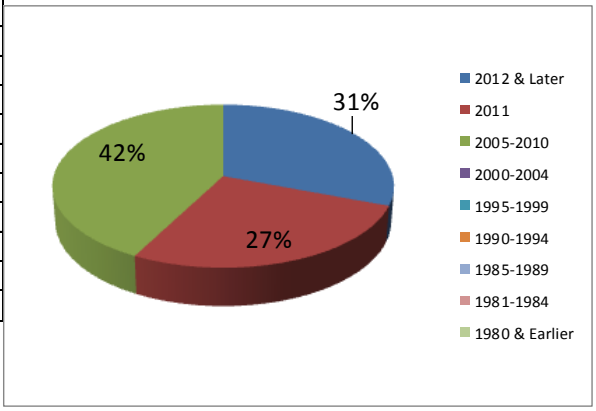
Ethnicities	#	% (No Decl.)*	%
Native American	0	0.00%	0.0%
Asian	4	16.67%	15.4%
Black	0	0.00%	0.0%
Hispanic	1	4.17%	3.8%
Pacific	0	0.00%	0.0%
White	19	79.17%	73.1%
Decline to State Ethnicities	2		7.7%
Unavailable Information	0		0.0%
Minorities	1		11.1%



Citizenships	#		%
US Citizen & Perm. Residents	9		34.6%
Foreign	17		65.4%
Unavailable information	0		0.0%
# of Distinct Members	26		100.0%
US Citizen	9		34.6%
Perm Residents	0		0.0%
Home Inst. in US	14		53.85%



Year of Ph.D	#		%
2012 & Later	8		30.8%
2011	7		26.9%
2005-2010	11		42.3%
2000-2004	0		0.0%
1995-1999	0		0.0%
1990-1994	0		0.0%
1985-1989	0		0.0%
1981-1984	0		0.0%
1980 & Earlier	0		0.0%
Unavailable Info.	0		0.0%
Total # of Distinct Members	26		100.0%



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

Programs

Commutative Algebra

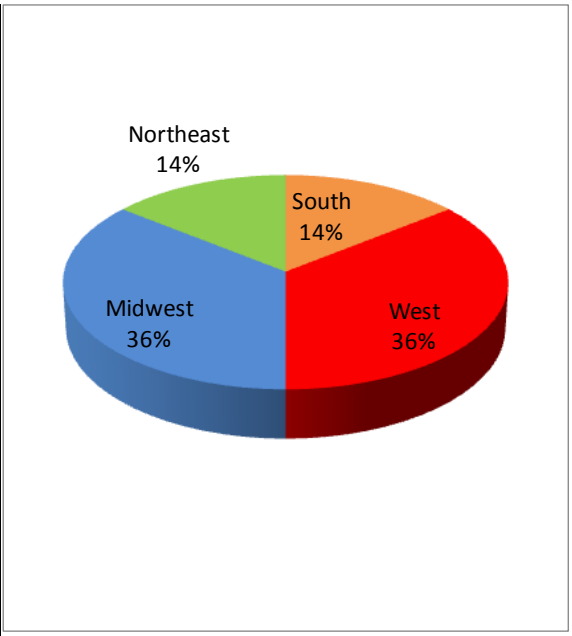
Cluster Algebras

Noncommutative Algebraic Geometry and Representation Theory

2012–13 Postdoctoral Fellows Home Institution Classified by States

**Regions based on US Census classification*

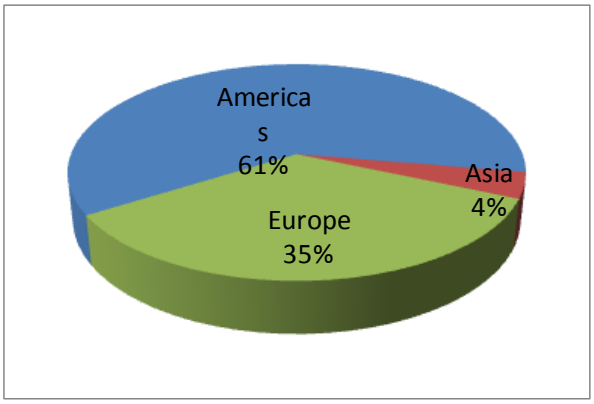
State	#	%	2007 Census Population
South	**2**	**14.3%**	**36.6%**
AL	-	0.0%	1.5%
AR	-	0.0%	0.9%
DE	-	0.0%	0.3%
DC	-	0.0%	0.2%
FL	-	0.0%	6.1%
GA	-	0.0%	3.2%
KY	-	0.0%	1.4%
LA	-	0.0%	1.4%
MD	-	0.0%	1.9%
MS	-	0.0%	1.0%
NC	2	14.3%	3.0%
OK	-	0.0%	1.2%
SC	-	0.0%	1.5%
TN	-	0.0%	2.0%
TX	-	0.0%	7.9%
VA	-	0.0%	2.6%
WV	-	0.0%	0.6%
West	**5**	**35.7%**	**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	3	21.4%	12.1%
CO	-	0.0%	1.6%
NV	-	0.0%	0.9%
NM	-	0.0%	0.7%
OR	1	7.1%	1.2%
UT	-	0.0%	0.9%
WA	1	7.1%	2.1%
WY	-	0.0%	0.2%
Midwest	**5**	**35.7%**	**22.0%**
IL	-	0.0%	4.3%
IN	1	7.1%	2.1%
IA	-	0.0%	1.0%
KS	-	0.0%	0.9%
MI	1	7.1%	3.3%
MN	3	21.4%	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	**2**	**14.3%**	**18.1%**
CT	-	0.0%	1.2%
ME	-	0.0%	0.4%
MA	1	7.1%	2.1%
NH	-	0.0%	0.4%
NJ	1	7.1%	2.9%
NY	-	0.0%	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	**14**	**100%**	**100%**



2012–13 Postdoctoral Fellows Home Institution Classified by Countries

**Regions based on United Nations classification*

Americas			**16**
	North America	Canada	2
		United States	14
Asia			**1**
	South-central Asia	India	1
Europe			**9**
	Northern Europe	Scotland	1
	Southern Europe	Italy	2
	Western Europe	France	2
		Germany	2
		Switzerland	2
Grand Total			**26**



3.5 Postdoctoral Research Member Placement List

Family Name	First Name	Pre-MSRI Institution Group	Post-MSRI Institution Group	Home Institution Name	Placement Institution Name
Faber	Eleonore	Foreign	Foreign	University of Toronto	University of Toronto
Geiss	Florian	Foreign	Foreign	Universität des Saarlandes	Universität des Saarlandes
Kahle	Thomas	Foreign	Foreign	ETH Zurich	Universität Magdeburg
Mantero	Paolo	Group II	Group II	University of California, Riverside	University of California, Riverside
Seceleanu	Alexandra	Group II	Group II	University of Nebraska, Lincoln	University of Nebraska, Lincoln
Ehrig	Michael	Foreign	Foreign	University of Bonn	University of Cologne

3.6 Postdoctoral Research Member Summary

Programs	# of PDRMs	# of Citizens & Perm. Res.	%	# of Female	%	# of Minorities[1]	%	US Home Institution	%
Commutative Algebra	5	0	*0.0%*	2	*40.0%*	0	*0.0%*	2	40.0%
Noncommutative Algebraic Geometry and Representation Theory	1	0	*0.0%*	0	*0.0%*	0	*0.0%*	0	0.0%
Total # of Distinct PDRMs	**6**	**-**	***0.0%***	**2**	***33.3%***	**-**	***0.0%***	**2**	***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.*

4. Graduate Program

In 2012–13, 598 graduate students visited MSRI to participate in our workshops (399 graduate students), summer graduate schools (174 graduate students), and programs (25 graduate students/program associates). 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 between 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 five Summer Graduate Schools that took place during the 2012 summer. Altogether 18 lecturers and 174 graduate students participated in these workshops. Of those graduate students, 22% 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: Noncommutative Algebraic Geometry
June 18, 2012 to June 29, 2012
Organized by Dan Rogalski (University of California, San Diego), Travis Schedler (Massachusetts Institute of Technology), and Michael Wemyss (The University of Edinburgh, United Kingdom)*

SGS 2: Mathematical General Relativity
July 9, 2012 to July 20, 2012
Organized by Justin Corvino (Lafayette College) and Pengzi Miao (University of Miami)*

SGS 3: Model Theory
July 23, 2012 to August 3, 2012
Organized by David Marker (University of Illinois, Chicago), Thomas Scanlon (University of California, Berkeley), and Carol Wood (Wesleyan University)*

SGS 4: Seminaire de Mathematiques Superieures 2012: Probabilistic Combinatorics
Location: Montreal, Canada
June 25, 2012 to July 6, 2012
Organized by Louigi Addario-Berry (McGill University), Luc Devroye (McGill University), and Bruce Reed (McGill University)*

SGS 5: IAS/PCMI Summer 2012: Geometric Group Theory
Location: Park City, Utah
July 1, 2012 to July 21, 2012
Organized by Mladen Bestvina (University of Utah), Michah Sageev (Technion – Israel Institute of Technology), and Karen Vogtmann (Cornell University)

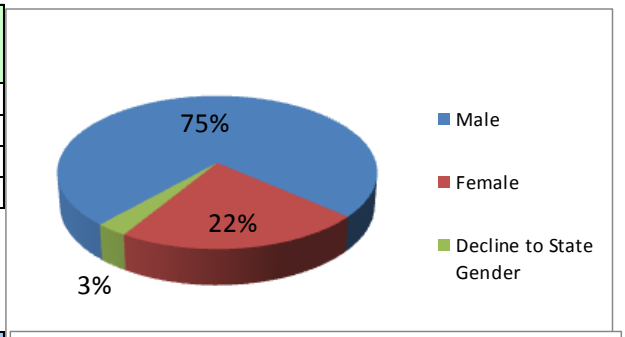
4.2 Summer Graduate School Data

Summer Graduate Schools	# of Participants	# of Citizens & Perm. Res.	%	# of Female	%	# of Minorities[1]	%	US Home Institution	%
IAS/PCMI Summer 2012: Geometric Group Theory	17	9	*52.9%*	7	*41.2%*	0	*0.0%*	15	88.2%
Mathematical General Relativity	45	23	*51.1%*	8	*17.8%*	3	*13.0%*	43	95.6%
Model Theory	40	26	*65.0%*	9	*22.5%*	3	*12.0%*	32	80.0%
Noncommutative Algebraic Geometry	54	26	*48.1%*	9	*16.7%*	2	*7.7%*	45	83.3%
Seminaire de Mathematiques Superieures 2012: Probabilistic Combinatorics	18	7	*38.9%*	6	*33.3%*	0	*0.0%*	18	100.0%
Total # of Distinct Participants	**174**	**91**	***52.3%***	**39**	***22.4%***	**8**	***9.1%***	**153**	***87.9%***

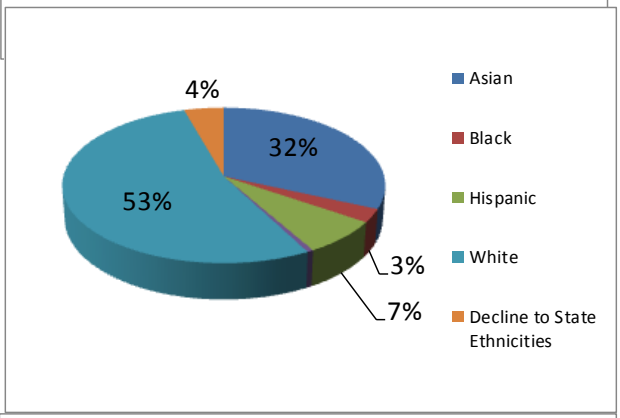
[1] *Minorities are US citizens who declare themselves American Indian, Black, Hispanic, or Pacific Islander. Minority percentage is calculated by dividing the number of Minorities by the total number of US citizens.*

Summer Graduate School Demographic Data

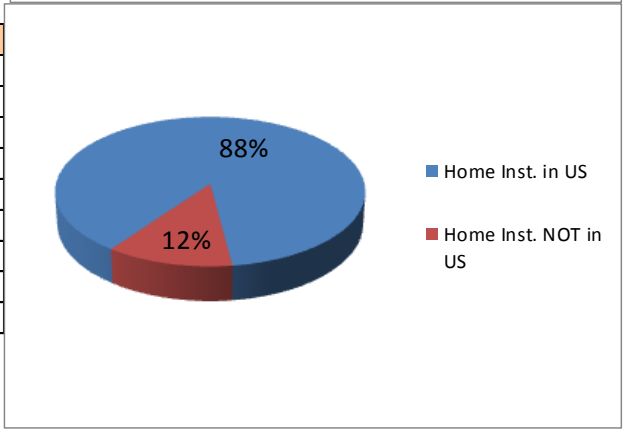
Gender	#	% (No Decl.)*	%
# of Distinct Participants	174		100.0%
Male	130	76.92%	74.7%
Female	39	23.08%	22.4%
Decline to State Gender	5		2.9%



Ethnicities	#	% (No Decl.)*	%
Native American	0	0.00%	0.0%
Asian	57	33.14%	31.7%
Black	5	2.91%	2.8%
Hispanic	13	7.56%	7.2%
Pacific	1	0.58%	0.6%
White	96	55.81%	53.3%
Decline to State Ethnicities	8		4.4%
Unavailable Information	0		0.0%
Minorities	8		9.1%



Citizenships	#		%
US Citizen & Perm. Residents	91		52.3%
Foreign	83		47.7%
Unavailable information	0		0.0%
# of Distinct Participants	174		100.0%
US Citizen	88		96.7%
Perm Residents	3		100.0%
Home Inst. in US	153		87.93%



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

Summer Graduate Schools

IAS/PCMI Summer 2012: Geometric Group Theory

Mathematical General Relativity

Model Theory

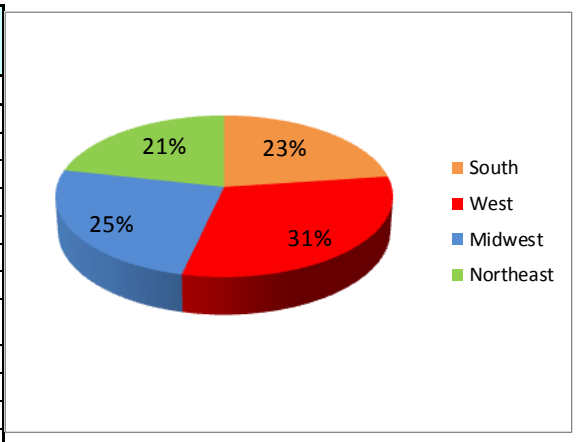
Noncommutative Algebraic Geometry

Seminaire de Mathematiques Superieures 2012: Probabilistic Combinatorics

2012 Summer Graduate Schools Home Institution Classified by States

**Regions based on US Census classification*

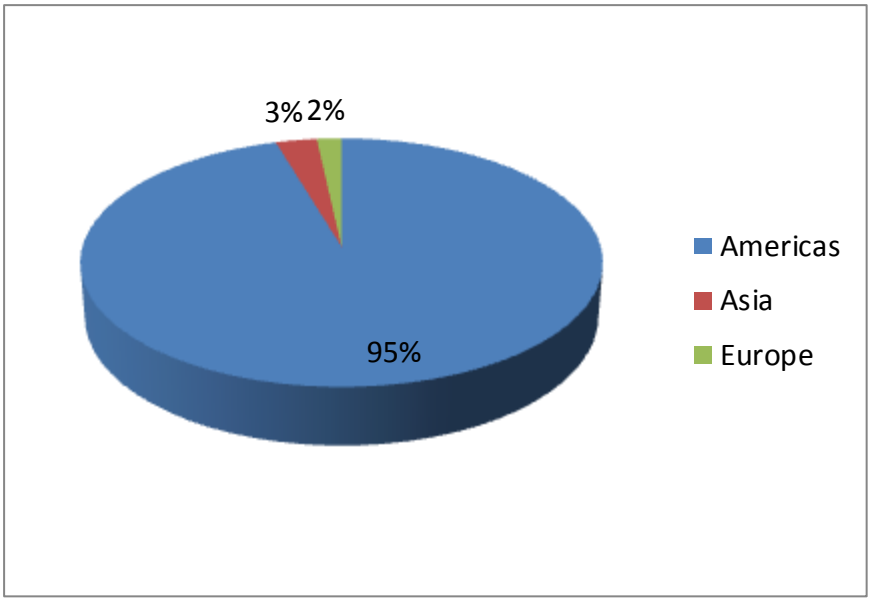
State	#	%	2007 Census Population
South	**35**	**22.9%**	**36.6%**
AL	-	0.0%	1.5%
AR	-	0.0%	0.9%
DE	2	1.3%	0.3%
DC	-	0.0%	0.2%
FL	2	1.3%	6.1%
GA	7	4.6%	3.2%
KY	-	0.0%	1.4%
LA	3	2.0%	1.4%
MD	3	2.0%	1.9%
MS	-	0.0%	1.0%
NC	6	3.9%	3.0%
OK	1	0.7%	1.2%
SC	1	0.7%	1.5%
TN	5	3.3%	2.0%
TX	5	3.3%	7.9%
VA	-	0.0%	2.6%
WV	-	0.0%	0.6%
West	**47**	**30.7%**	**23.2%**
AK	-	0.0%	0.2%
AZ	2	1.3%	2.1%
HI	1	0.7%	0.4%
ID	-	0.0%	0.5%
MT	-	0.0%	0.3%
CA	33	21.6%	12.1%
CO	2	1.3%	1.6%
NV	-	0.0%	0.9%
NM	-	0.0%	0.7%
OR	4	2.6%	1.2%
UT	1	0.7%	0.9%
WA	4	2.6%	2.1%
WY	-	0.0%	0.2%
Midwest	**38**	**24.8%**	**22.0%**
IL	12	7.8%	4.3%
IN	5	3.3%	2.1%
IA	-	0.0%	1.0%
KS	4	2.6%	0.9%
MI	2	1.3%	3.3%
MN	-	0.0%	1.7%
MO	1	0.7%	1.9%
ND	-	0.0%	0.2%
NE	3	2.0%	0.6%
OH	6	3.9%	3.8%
SD	-	0.0%	0.3%
WI	5	3.3%	1.9%
Northeast	**33**	**21.6%**	**18.1%**
CT	3	2.0%	1.2%
ME	-	0.0%	0.4%
MA	9	5.9%	2.1%
NH	3	2.0%	0.4%
NJ	4	2.6%	2.9%
NY	9	5.9%	6.4%
PA	4	2.6%	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	**153**	**100%**	**100%**



2012 Summer Graduate Schools Home Institution Classified by Countries

**Regions based on United Nations classification*

Americas			**166**
	Central America	Mexico	1
	North America	Canada	10
		United States	153
	South America	Colombia	2
Asia			**5**
	East Asia	China	1
		Korea, Republic of	3
	South-eastern Asia	Singapore	1
Europe			**3**
	Northern Europe	England	2
	Western Europe	Austria	1
Grand Total			**174**



4.3 Program Associate

Program Associates benefit greatly from the opportunity to interact with leaders of a field and postdoctoral fellows, gaining intense exposure to current ideas and trends in their area of specialization. While MSRI does not have the financial resources to fund the Program Associates, they are closely supervised and essentially benefit from all members' privileges, including shared office space. They are provided with an access card to the building which allows them to use the premises at any time. They receive a bus pass, and a library and sports facilities access pass. There were 25 graduate students who resided at MSRI for an extended

period of time during the academic year 2012–13. See the table in section 4.4 for a detailed description of the demographic data.

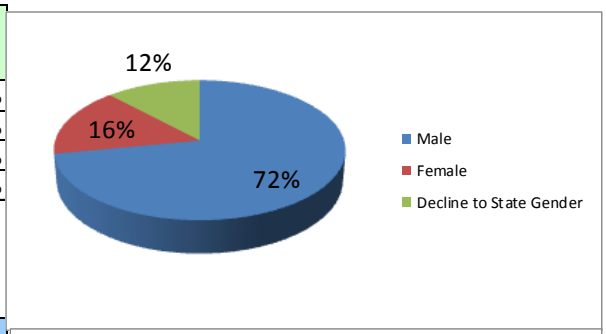
4.4 Program Associate Data

Programs	# of PAs	# of Citizens & Perm. Res.	%	# of Female	%	# of Minorities[1]	%	US Home Institution	%
Commutative Algebra	13	4	*30.8%*	3	*23.1%*	0	*0.0%*	6	46.2%
Cluster Algebras	5	0	*0.0%*	0	*0.0%*	0	*0.0%*	2	40.0%
Noncommutative Algebraic Geometry and Representation Theory	7	3	*42.9%*	1	*14.3%*	1	*33.3%*	3	42.9%
Total # of Distinct Program Associates	**25**	**7**	***28.0%***	**4**	***16.0%***	**1**	***14.3%***	**11**	***44.0%***

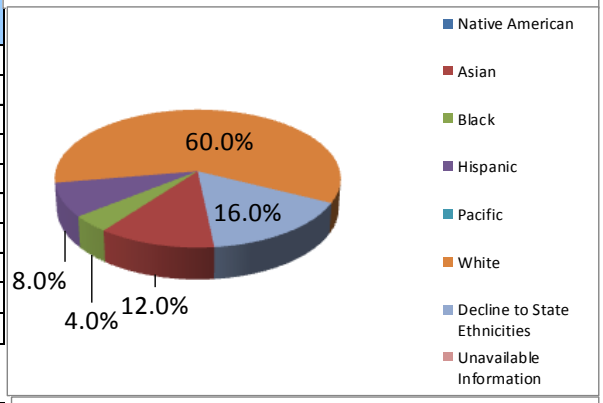
[1] *Minorities are US citizens who declare themselves American Indian, Black, Hispanic, or Pacific Islander. Minority percentage is calculated by dividing the number of Minorities by the total number of US citizens.*

Program Associate Demographic Data

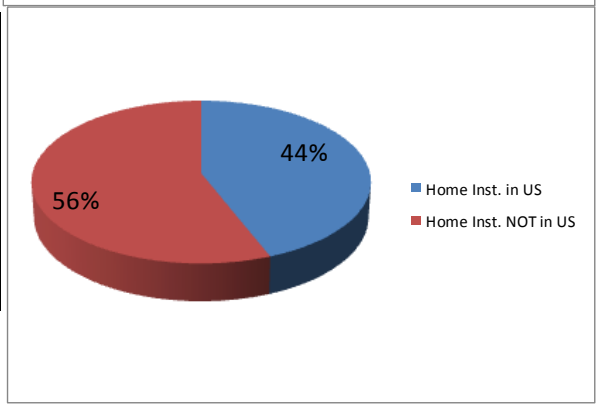
Gender	#	% (No Decl.)*	%
# of Distinct Associates	25		100.0%
Male	18	81.82%	72.0%
Female	4	18.18%	16.0%
Decline to State Gender	3		12.0%



Ethnicities	#	% (No Decl.)*	%
Native American	0	0.00%	0.0%
Asian	3	14.29%	12.0%
Black	1	4.76%	4.0%
Hispanic	2	9.52%	8.0%
Pacific	0	0.00%	0.0%
White	15	71.43%	60.0%
Decline to State Ethnicities	4		16.0%
Unavailable Information	0		0.0%
Minorities	1		14.3%



Citizenships	#		%
US Citizen & Perm. Residents	7		28.0%
Foreign	18		72.0%
Unavailable information	0		0.0%
# of Distinct Members	25		100.0%
US Citizen	7		28.0%
Perm Residents	0		0.0%
Home Inst. in US	11		44.00%



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

Programs

Commutative Algebra

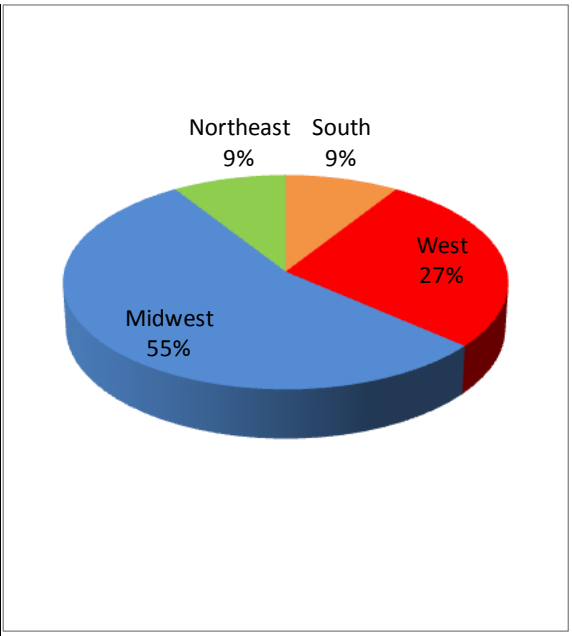
Cluster Algebras

Noncommutative Algebraic Geometry and Representation Theory

2012–13 Program Associates Home Institution Classified by States

**Regions based on US Census classification*

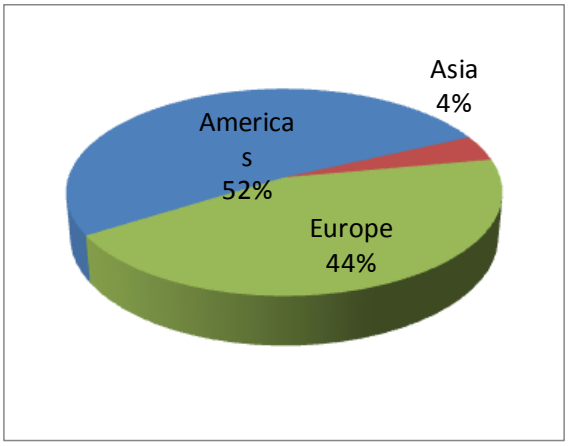
State	#	%	2007 Census Population
South	**1**	**9.1%**	**36.6%**
AL	-	0.0%	1.5%
AR	-	0.0%	0.9%
DE	-	0.0%	0.3%
DC	-	0.0%	0.2%
FL	-	0.0%	6.1%
GA	-	0.0%	3.2%
KY	-	0.0%	1.4%
LA	-	0.0%	1.4%
MD	-	0.0%	1.9%
MS	-	0.0%	1.0%
NC	-	0.0%	3.0%
OK	-	0.0%	1.2%
SC	-	0.0%	1.5%
TN	-	0.0%	2.0%
TX	1	9.1%	7.9%
VA	-	0.0%	2.6%
WV	-	0.0%	0.6%
West	**3**	**27.3%**	**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	9.1%	12.1%
CO	-	0.0%	1.6%
NV	-	0.0%	0.9%
NM	-	0.0%	0.7%
OR	-	0.0%	1.2%
UT	1	9.1%	0.9%
WA	1	9.1%	2.1%
WY	-	0.0%	0.2%
Midwest	**6**	**54.5%**	**22.0%**
IL	-	0.0%	4.3%
IN	4	36.4%	2.1%
IA	-	0.0%	1.0%
KS	-	0.0%	0.9%
MI	1	9.1%	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	9.1%	1.9%
Northeast	**1**	**9.1%**	**18.1%**
CT	-	0.0%	1.2%
ME	-	0.0%	0.4%
MA	1	9.1%	2.1%
NH	-	0.0%	0.4%
NJ	-	0.0%	2.9%
NY	-	0.0%	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	**11**	**100%**	**100%**



2012–13 Program Associates Home Institution Classified by Countries

**Regions based on United Nations classification*

Americas			**13**
	North America	Canada	2
		United States	11
Asia			**1**
	Western Asia	Israel	1
Europe			**11**
	Northern Europe	England	1
		Sweden	1
	Western Europe		
		Belgium	1
		France	2
		Germany	6
Grand Total			**25**



4.5 Graduate Student List

(Participants who attended 2012–13 workshops, excluding Summer Graduate Schools)
(See e-mail attached file)

4.6 Graduate Student Data

(Participants who attended 2012–13 workshops, excluding Summer Graduate Schools)

Workshops	# of Participants	# of Citizens & Perm. Res.	%	# of Female	%	# of Minorities[1]	%	US Home Institution	%
10 Scientific Workshops									
Cluster Algebras in Combinatorics, Algebra, and Geometry	23	12	*52.2%*	4	*17.4%*	2	*20.0%*	15	65.2%
Combinatorial Commutative Algebra and Applications	32	16	*50.0%*	9	*28.1%*	0	*0.0%*	24	75.0%
Connections For Women: Joint Workshop on Commutative Algebra and Cluster Algebras	37	17	*45.9%*	18	*48.6%*	2	*14.3%*	26	70.3%
Connections for Women: Noncommutative Algebraic Geometry and Representation Theory	27	14	*51.9%*	18	*66.7%*	2	*15.4%*	18	66.7%
Hot Topics: Surface subgroups and cube complexes	23	13	*56.5%*	4	*17.4%*	0	*0.0%*	19	82.6%
Interactions between Noncommutative Algebra, Representation Theory, and Algebraic Geometry	32	17	*53.1%*	4	*12.5%*	1	*6.7%*	27	84.4%
Introductory Workshop: Noncommutative Algebraic Geometry and Representation Theory	40	20	*50.0%*	12	*30.0%*	1	*5.3%*	28	70.0%
Joint Introductory Workshop: Cluster Algebras and Commutative Algebra	43	19	*44.2%*	14	*32.6%*	1	*6.3%*	31	72.1%
Representation Theory, Homological Algebra, and Free Resolutions	41	16	*39.0%*	7	*17.1%*	1	*6.3%*	33	80.5%
The Commutative Algebra of Singularities in Birational Geometry: Multiplier Ideals, Jets, Valuations, and Positive Characteristic Methods	36	10	*27.8%*	4	*11.1%*	1	*12.5%*	28	77.8%
All 10 Workshops Total	**334**	**154**	***46.1%***	**94**	***28.1%***	**11**	***8.0%***	**249**	***74.6%***
3 Other Workshops									
AWM Research Symposium 2013	29	17	*58.6%*	29	*100.0%*	2	*11.8%*	28	96.6%
Critical Issues in Mathematics Education 2013: Assessment of Mathematical Proficiencies in the Age of the Common Core	13	11	*84.6%*	10	*76.9%*	0	*0.0%*	13	100.0%
Pacific Rim Mathematical Association (PRIMA) Congress 2013	23	5	*21.7%*	6	*26.1%*	1	*25.0%*	16	69.6%
All 3 Workshops Total	**65**	**33**	***50.8%***	**45**	***69.2%***	**3**	***21.4%***	**57**	***87.7%***
All 13 Workshops Total	**399**	**187**	***46.9%***	**139**	***34.8%***	**14**	***9.2%***	**306**	***76.7%***

[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)

In an effort to report all activities that occurred in the 2012 at MSRI, we would like to mention that MSRI-UP did take place during this time, however, this activity was already reported in the 2011–12 NSF Annual Report. For more details on the MSRI-UP 2012, please refer to our 2011–12 NSF Annual Report.

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.

6. Brief Report of Activities in 2013–14

OVERVIEW OF ACTIVITIES 2013–14

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: 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)*

The study of Einstein's general relativistic gravitational field equation, which has for many years played a crucial role in the modeling of physical cosmology and astrophysical phenomena, is increasingly a source for interesting and challenging problems in geometric analysis and PDE. In nonlinear hyperbolic PDE theory, the problem of determining if the Kerr black hole is stable has sparked a flurry of activity, leading to outstanding progress in the study of scattering and asymptotic behavior of solutions of wave equations on black hole backgrounds. The spectacular recent results of Christodoulou on trapped surface formation have likewise stimulated important advances in hyperbolic PDE. At the same time, the study of initial data for Einstein's equation has generated a wide variety of challenging problems in Riemannian geometry and elliptic PDE theory. These include issues, such as the Penrose inequality, related to the asymptotically defined mass of an astrophysical systems, as well as questions concerning the construction of non constant mean curvature solutions of the Einstein constraint equations. This semester-long program aims to bring together researchers working in mathematical relativity, differential geometry, and PDE who wish to explore this rapidly growing area of mathematics.

Workshops associated with the Mathematical General Relativity Program:

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)*

Ever since the epic work of Yvonne Choquet-Bruhat on the well-posedness of Einstein's equations initiated the mathematical study of general relativity, women have played an important role in many areas of mathematical relativity. In this workshop, some of the leading women researchers in mathematical relativity present their work.

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)*

Mathematical relativity is a very widely ranging area of mathematical study, spanning differential geometry, elliptic and hyperbolic PDE, and dynamical systems. We introduce in this workshop 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.

The introductory workshop serves as an overview to the overlying programmatic theme. It aims to familiarize graduate students, postdocs, and non-experts to major and new topics of the current program. Though the audience is expected to have a general mathematical background, knowledge of technical terminology and recent findings is not assumed.

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)*

This workshop discusses recent developments both in the study of the properties of initial data for Einstein's equations, and in the study of solutions of the Einstein evolution problem. Cosmic censorship, the formation and stability of black holes, the role of mass and quasi-local mass, and the construction of solutions of the Einstein constraint equations are focus problems for the workshop. We highlight recent developments, and examine major areas in which future progress is likely.

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)*

Cluster algebras were conceived in the Spring of 2000 as a tool for studying dual canonical bases and total positivity in semisimple Lie groups. They are constructively defined commutative algebras with a distinguished set of generators (cluster variables) grouped into overlapping subsets (clusters) of fixed cardinality. Both the generators and the relations among them are not given from the outset, but are produced by an iterative process of successive mutations. Although this procedure appears counter-intuitive at

first, it turns out to encode a surprisingly widespread range of phenomena, which might explain the explosive development of the subject in recent years.

Cluster algebras provide a unifying algebraic/combinatorial framework for a wide variety of phenomena in settings as diverse as quiver representations, Teichmueller theory, invariant theory, tropical calculus, Poisson geometry, Lie theory, and polyhedral combinatorics.

Workshops associated with the Optimal Transport: Geometry and Dynamics Program:

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)

This two-day event aims to connect women graduate students and beginning researchers with more established female researchers who use optimal transportation in their work and can serve as professional contacts and potential role-models. As such, it will showcase a selection of lectures featuring female scientists, both established leaders and emerging researchers.

These lectures will be interspersed with networking and social events such as lunch or tea-time discussions led by successful researchers about (a) the particular opportunities and challenges facing women in science---including practical topics such as work-life balance and choosing a mentor, and (b) promising new directions in optimal transportation and related topics. Junior participants will be paired with more senior researchers in mentoring groups, and all participants will be encouraged to stay for the Introductory Workshop the following week, where they will have the opportunity to propose a short research communication.

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)*

The workshop is 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.

As such, it will feature some survey lectures or minicourses by distinguished visitors and/or a few of the organizers of the theme semester, amounting to a kind of summer school. These will be 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 aims to familiarize graduate students, postdocs, and non-experts to major and new topics of the current program. Though the audience is expected to have a general mathematical background, knowledge of technical terminology and recent findings is not assumed.

Workshop 3: Fluid Mechanics, Hamiltonian Dynamics, 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)*

The workshop will be devoted to emerging approaches to fluid mechanical, geophysical and kinetic theoretical flows based on optimal transportation. It will also explore numerical approaches to optimal transportation problems.

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)*

The program aims to further the flourishing interaction between model theory and other parts of mathematics, especially number theory and arithmetic geometry. At present the model theoretical tools in use arise primarily from geometric stability theory and o-minimality. Current areas of lively interaction include motivic integration, valued fields, diophantine geometry, and algebraic dynamics.

Workshops associated with the Model Theory, Arithmetic Geometry and Number Theory Program:

Workshop 1: Introductory Workshop: Model Theory, Arithmetic Geometry and 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)*

Model theory is a branch of mathematical logic whose structural techniques have proven to be remarkably useful in arithmetic geometry and number theory. We will introduce in this workshop some of the main themes of the program.

In particular, we will be offering the following tutorials:
1. An Introduction to Stability-Theoretic Techniques, by Pierre Simon.
2. Model Theory and Diophantine Geometry, by Antoine Chambert-Loir, Ya'acov Peterzil, and Anand Pillay.
3. Valued Fields and Berkovich Spaces, by Deirdre Haskell and Martin Hils.
4. Model Theory and Additive Combinatorics, by Lou van den Dries.

In addition to the tutorials there will be several "state of the art" lectures on the program topics, indicating recent results as well as directions for future work. Speakers include Ekaterina Amerik, Ehud Hrushovski, Alice Medvedev, Terence Tao, and Margaret Thomas.

The introductory workshop aims to familiarize graduate students, postdocs, and non-experts to major and new topics of the current program. Though the audience is expected to have a general mathematical background, knowledge of technical terminology and recent findings is not assumed.

Workshop 2: Connections for Women: Model Theory and Its Interactions with 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)

The development of model theory has always been influenced by its potential applications. Recent years have seen a remarkable flowering of that development, with many exciting applications of model theory in number theory and algebraic geometry. The introductory workshop will aim to increase these interactions by exposing the techniques of model theory to the number theorists and algebraic geometers, and the problems of number theory and algebraic geometry to the model theorists. The Connections for Women workshop will focus on presenting current research on the borders of these subjects, with particular emphasis on the contributions of women. In addition, there will be some social occasions to allow young women and men to make connections with established researchers, and a panel discussion addressing the challenges faced by all young researchers, but especially by women, in establishing a career in mathematics.

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)*

The workshop will feature talks in a range of topics where model theory interacts with other parts of mathematics, especially number theory and arithmetic geometry, including: motivic integration, algebraic dynamics, diophantine geometry, and valued fields

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)*

Algebraic topology uses techniques of algebra to describe and solve problems in geometry and topology. From its inception with Poincare's work on the fundamental group and homology, the field has exploited natural ways to associate numbers, groups, rings, and modules to various spaces. As the field evolved, two dominant themes emerged: "what are the invariants we can construct, and how do we compute them?" and "what is the general framework in which we can do algebraic topology?".

As people grew to better understand the invariants and computations techniques, they saw that they enjoy extra structure and sit in natural families similar to those seen in algebraic geometry. They suffer from the drawback that cohomology theories are not quite as rigid as rings. Here various cooperations with those studying the framework of homotopy theory has allowed ways to make precise the connections with algebraic geometry. This has culminated in the Hopkins-Miller theory of topological modular forms, which records information about elliptic curves and integral modular forms. Lurie's derived algebraic geometry naturally associates ring spectra to deeply signicant objects in algebraic geometry and number theory. This has lead to striking cross-overs in which algebraic topologists and number theorists focus on the same objects: abelian varieties and their moduli.

Algebraic topology on the whole has enjoyed several exciting advances of late, and all of them arise from blending the computational and foundational techniques. These hybridized results harken back to Poincare: algebraic topology should illuminate the geometry, and the interactions of the schools allows a brighter picture. The solution of Hill-Hopkins-Ravenel to the Kervaire Invariant One problem, where a panoply of computations techniques blended with very elementary geometry to solve this 40 year old problem. Lurie's proof of the Cobordism Hypothesis, synthesizing decades of work on topological quantum field theories and intuition about the geometry of manifolds.

The MSRI program will build on this cooperative narrative. A primary goal of the MSRI program is to draw together algebraic topologists of all stripes, reintroducing each to the tools of the others and providing a synergistic research forum. Algebraic topologists, both those focused on the families of invariants and those focused on the framework, will have the opportunity to explore the descriptive language employed by the other. This leads to ferreting out underlying commonalities and grappling with the deeper structures inherent to the subject.

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)*

This two-day workshop will consist of short courses given by prominent female mathematicians in the field. These introductory courses will be appropriate for graduate students, post-docs, and researchers in related areas. The workshop will also include a panel discussion featuring successful women at various stages in their mathematical careers.

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)*

Algebraic topology is a rich, vibrant field with close connections to many branches of mathematics. This workshop will describe the state of the field, focusing on major programs, open problems, exciting new tools, and cutting edge techniques.

The introductory workshop serves as an overview to the overlying programmatic theme. It aims to familiarize graduate students, postdocs, and non-experts to major and new topics of the current program. Though the audience is expected to have a general mathematical background, knowledge of technical terminology and recent findings is not assumed.

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)*

Recent innovations in higher category theory have unlocked the potential to reimagine the basic tools and constructions in algebraic topology. This workshop will explore the interplay between these higher and $infty$-categorical techniques with classical algebraic topology, playing each off of the other and returning the field to conceptual, geometrical intuition.

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).

1.2 Scientific Activities Directed at Underrepresented Groups in Mathematics

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)*

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.

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.

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

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)

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.

Keynote Speaker: Federico Ardila, Associate Professor of Mathematics, San Francisco State University

Spring Opportunities Workshop for Women in the Mathematical Sciences
NSF supplemental grant DMS 1126721
Location: NIMBioS, University of Tennessee, Knoxville
April 9, 2013 to April 11, 2013

Organized by NIMBioS Ruth Charney (Brandeis University and President of AWM) Snehalata Huzurbazar (University of Wyoming, North Carolina State University and SAMSI), Suzanne Lenhart (University of Tennessee and NIMBioS), Joan Lind (University of Tennessee), Kelly Sturner (NIMBioS)

This workshop will familiarize women in the mathematical sciences with professional opportunities in academics, industry and government labs and help them thrive in mathematics-related fields.

Graduate students and PhD's in the early stages of their post-graduate careers are invited to apply to attend. Support is available for travel and lodging to the workshop, and registration is free. The workshop is expected to start at 3 p.m. on April 9 and end in the afternoon of April 11.

Speakers, panelists and discussion leaders will be women in research and management positions in industry and government labs as well as women in academia. Participants are encouraged to present a poster on their research.

1.3 Summer Graduate Schools 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)*

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 2: Seminaire de Mathematiques Superieures 2013: Physics and Mathematics of Link 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)

Homology theories of knots and links is a burgeoning field at the interface of mathematics with theoretical physics. The 2013 edition of the SMS will bring together leading researchers in mathematics and mathematical physics working in this area, with the aim to educate a new generation of scientists in this exciting subject. The school will provide a pedagogical review of the current state of the various constructions of knot homologies, and also encourage interactions between the communities in order to facilitate development of the unified picture.

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)

The Graduate Summer School bridges the gap between a general graduate education in mathematics and the specific preparation necessary to do research on problems of current interest. In general, these students will have completed their first year, and in some cases, may already be working on a thesis. While a majority of the participants will be graduate students, some postdoctoral scholars and researchers may also be interested in attending.

We strongly recommend that graduate students have already had the equivalent of rigorous first year graduate-level courses in topology, algebra and analysis.

The main activity of the Graduate Summer School will be a set of intensive short lectures offered by leaders in the field, designed to introduce students to exciting, current research in mathematics. These lectures will not duplicate standard courses available elsewhere. Each course will consist of lectures with problem sessions. Course assistants will be available for each lecture series. The participants of the Graduate Summer School meet three times each day for lectures, with one or two problem sessions scheduled each day as well.

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)*

The branches of number theory most directly related to automorphic forms have seen enormous progress over the past five years. Techniques introduced since 2008 have made

it possible to prove many new arithmetic applications. The purpose of the current workshop is to drow the attention of young students or researchers to new questions that have arisen in the course of bringing several chapters in the Langlands program and related algebraic number theory to a close. We will focus especially on some precise questions of a geometric nature, or whose solutions seem to require new geometric insights. A graduate level in Number Theory is expected.

This two-week workshop will be devoted to the following subjects: Automorphy lifting theorems, p-adic local Langlands program, Characters of categorical representations and Hasse-Weil zeta function. During the first week, the lecturers present an open question and related mathematical objects. The first exercice sessions serve to direct the participants to an appropriate subject depending on their level. During the second week, the lecturers give some more advanced lectures on the field.

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

In this two week program we will develop some of the mathematical foundations of seismic imaging that is a basic tool used in ``Imaging the Earth Interior". This is one of the components of the Mathematics of Planet Earth 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 mathematics of seismic imaging involves solving inverse problems for the wave equation. No previous experience on inverse problems will be assumed.

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))

In cooperation with INdAM (Istituto Nazionale di Alta Matematica) and the CMI (Clay Mathematical Institute), MSRI will sponsor a summer graduate workshop on Mathematical General Relativity in Cortona during the summer of 2013; the school will reprise the very successful school of Mathematical General Relativity held at MSRI in 2012.

Mathematical general relativity is the study of mathematical problems related to Einstein's theory of gravitation. There are interesting connections between the physical theory and problems in differential geometry and partial differential equations.

The purpose of the summer school is to introduce graduate students to some fundamental aspects of mathematical general relativity, with particular emphasis on the geometry of

the Einstein constraint equations and the Positive Mass Theorem. These topics will comprise a component of the upcoming semester program at MSRI in Fall 2013.

There will be mini-courses, as well as several research lectures. each day for lectures, with one or two problem sessions scheduled each day as well.

1.4 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)*

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 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)

The seminar will take place from 10AM to 5PM on Saturday, and 9:15AM to 1PM on Sunday. Participants and their significant others are invited to a dinner to be arranged at a local restaurant on Saturday evening. The cost of the dinner will be reduced for students and postdocs. There is a signup link on the interactive program.

Location: Stanford University Department of Mathematics, Room 380C

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)*

Since their introduction just two years ago, perfectoid spaces have played a crucial role in a number of striking advances in arithmetic algebraic geometry: the proof of Deligne's weight-monodromy conjecture for complete intersections in toric varieties; the development of p-adic Hodge theory for rigid analytic spaces; a p-adic analogue of Riemann's classification of abelian varieties over the complex numbers; and the construction of Galois representations for torsion classes in the cohomology of many

locally symmetric spaces (for instance arithmetic hyperbolic 3-manifolds). We will start the week with an exposition of the foundations of the theory of perfectoid spaces, with the aim of teaching novices to work with them. Then we will discuss their current and potential applications.

1.5 Education & Outreach Workshops

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

The BACT Summer Workshop supports teachers in their development of problem solving skills as well as supporting the incorporation of problem solving into their teaching curriculum. During the earlier part of the week teachers will gain experience with a variety of problem solving techniques such as symmetry, mathematical patterns, and parity. Subsequent sessions will focus on particular topics such as geometry, sequences, counting, and number theory.

A major theme throughout the week will be finding creative answers to the question of how to incorporate a problem-solving approach to math education into the existing curriculum. To this end leaders will supply participants with handouts or short modules based on the material covered during their sessions. They will also work with teachers to share ideas for enlivening any math class and to develop lesson plans. Focused discussions will be held regularly to determine what obstacles exist to incorporating this style of teaching into the present curriculum, what resources would be most helpful to teachers, and other related topics.

Daily Schedule
The summer workshop consists of daily sessions Monday through Friday, June 17 - June 21, 2013. The sessions will meet at Clark Kerr Campus in Berkeley, CA, with daily meetings 9:00am -5:00pm. Evenings will be reserved for related, informal activities including further exploration of the day's problems and discussions of other mathematical fun and games.

We ask that all participants remain on site, even those within commuting distance, since collegial interaction and evening activities form an important part of the workshop.

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

This is a three-week institute on algebra for middle school teachers, to be conducted by Hung-Hsi Wu with the assistance of Winnie Gilbert, Stefanie Hassan, and Sunil Koswatta.

The goal of the institute is to provide middle school teachers with the mathematical knowledge for teaching algebra according to the Common Core State Standards in Mathematics (CCSSM). There are basic flaws in the usual algebra curriculum and the CCSSM have corrected most of them. This is especially true with regard to the sequencing of middle school geometry and algebra topics as well as the presentation of basic concepts such as “algebraic expressions”, “variables”, and “solving equations”. In order to successfully implement these changes, we need teachers with the requisite content knowledge. At the moment there seems to be little awareness of this need in the education establishment. This institute will provide teachers with the needed content knowledge.

The twin pillars supporting the learning of algebra are rational numbers and the geometry of similar triangles. Unique among national and state standards, the CCSSM outline the correct sequencing of these topics to properly prepare students for the study of algebra. The Institute of 2012 was devoted to these preparatory materials, and the present Institute will be a direct continuation. However, for those who did not attend the 2012 institute, an effort will be made to smooth the transition.

The proposed schedule of the institute is as follows:

2 days: use of symbols

4 days: linear equations and simultaneous equations

3 days: linear functions and inequalities

3 days: rational exponents and exponential functions

3 days: quadratic functions and equations

The proper use of symbols may be the most basic of all skills in algebra. When students learn to use symbols correctly, they will know that the concept of a variable, promoted so highly in textbooks, is completely unnecessary except as mathematical slang. The heart of the discussion of linear equations in two variables is the theorem that the graph of such an equation is a line, and every line is the graph of such an equation. The proof of this theorem hinges on a correct definition of the slope of a line, which in turn brings in the angle-angle criterion for similar triangles. A brief review of similar triangles will be given before going into the details of the proof. Understanding the proof of this theorem about the graph of a linear equation is critical to students’ ability to handle all problems related to writing down the equation of a line when certain geometric data of the line are given. An important component of the discussion of linear equations is the relationship between the slopes of lines and the parallelism or perpendicularity of the lines, a topic poorly done in textbooks and the source of much confusion.

The next major topic is the introduction of the concept of a function. Why is it necessary? This institute will focus on the bread-and-butter issues of school algebra: linear,

quadratic, and exponential functions. It is only when exponential functions are discussed that the laws of exponents are put in the proper context and become learnable. The last part of the institute will be devoted to an analysis of the graphs of quadratic functions (they are parabolas, which will be precisely defined, for a change) and to showing how this knowledge helps make sense of quadratic functions, in much the same way that knowing that the graphs of linear functions are lines helps make sense of the study of linear functions.

In addition to the three weeks from July 8 to July 26, there will be five follow-up Saturday sessions during the 2013-2014 school year (with the precise dates yet to be determined). Each of the 15 weekdays of the institute will begin promptly at 8:30 am and end at 4:30 pm. There will be a total of four to five hours of lectures and seat work (with breaks and lunch); the lectures will be on mathematics (not pedagogical strategies). Material on which the lectures are based will be handed out during the first days; it will be a revised version of the following: http://math.berkeley.edu/~wu/Algebrasummary.pdf

Teachers will be asked to give short presentations (as if in a school classroom) on topics already discussed in the institute. Each day of the institute will end with small group discussions on pedagogy or on the homework assignment from the day before.

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)*

The 2014 CIME workshop will focus on the role played by mathematics departments in preparing future teachers. As part of this focus, the workshop will consider two broad questions: What mathematics should teachers know, and how should they come to know this mathematics?

The Conference Board of the Mathematical Sciences publication, The Mathematical Education of Teachers II, recommends that, at institutions that prepare teachers, teacher education should be "an important part of a mathematics department's mission" (p.19). Certainly, at some universities, mathematicians are significantly involved in the mathematical experiences of students who are planning become teachers. But there are many other departments where this is not true. Future mathematics teachers are enrolled in the department's mathematics classes, but no one is attending to the fact that this is where they are developing mathematical knowledge and (from watching their instructors) ideas about how teach mathematics. This role – whether deliberate or latent — is vitally important for the mathematical preparation of beginning teachers.

The CIME workshop has 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 known about effective mathematical preparation of teachers, including curriculum, instructional approaches, and assessments?
2. What supports do mathematicians and mathematics departments need to carry out this important role effectively? What are examples of successful models and what evidence exists about their effects?
3. What are some of the persistent problems or challenges and what are promising examples of addressing these?

and (C) to identify possible action steps to provide more collective capacity for math departments to contribute to teachers' mathematical education.

2. 2013-14 PROGRAM AND WORKSHOP PARTICIPANT SUMMARY

Time	*Activity Type*	*Activity Title*	*No. of registered participants*	*MSRI Postdocs*	*PD/RMs*
Fall 2013	Scientific Program	Mathematical General Relativity	71	Semyon Dyatlov Boris Ettinger Nick Haber Davi Maximo (OT) Kristen Moore (OT) Anna Sakovich Volker Schlue Carlos Vega Haotian Wu Xin Zhou	Shabnam Beheshti Mihaela Ifrim Caleb Meier Shiwu Yang
9/3/2013 to 9/4/2013	Programmatic Workshop	Connections for Women: Mathematical General Relativity	56		
9/9/2013 to 9/13/2013	Programmatic Workshop	Introductory Workshop: Mathematical Relativity	131		
11/18/2013 to 11/22/2013	Programmatic Workshop	Initial Data and Evolution Problems in General Relativity	147		
Fall 2013	Scientific Program	Optimal Transport: Geometry and Dynamics	58	Shibing Chen Matthias Erbar Jun Kitagawa Davi Maximo (MGR) Kristen Moore (MGR) Zahra Sinaei Ling Xiao	Sajjad Lakzian Brendan Pass Stephanie Somersille YI WANG Jinxin Xue Yongsheng Zhang
8/22/2013 to 8/23/2013	Programmatic Workshop	Connections for Women on Optimal Transport: Geometry and Dynamics	58		
8/26/2013 to 8/30/2013	Programmatic Workshop	Introductory Workshop on Optimal Transport: Geometry and Dynamics	168		
10/14/2013 to 10/18/2013	Programmatic Workshop	Fluid Mechanics, Hamiltonian Dynamics, and Numerical Aspects of Optimal Transportation	119		

Time	*Activity Type*	*Activity Title*	*No. of registered participants*	*MSRI Postdocs*	*PD/RMs*
Spring 2014	Scientific Program	Model Theory, Arithmetic Geometry and Number Theory	75	Uri Andrews Martin Bays Artem Chernikov Taylor Dupuy James Freitag Cameron Hill Holly Krieger Margaret Thomas Adam Topaz	Maryanthe Malliaris
2/3/2014 to 2/7/2014	Programmatic Workshop	Introductory Workshop: Model Theory, Arithmetic Geometry and Number Theory	188		
2/10/2014 to 2/11/2014	Programmatic Workshop	Connections for Women: Model Theory and Its Interactions with Number Theory and Arithmetic Geometry	78		
5/12/2014 to 5/16/2014	Programmatic Workshop	Model Theory in Geometry and Arithmetic	has not occurred yet		
Spring 2014	Scientific Program	Algebraic Topology	70	David Ayala Anna Marie Bohmann Ilya Grigoriev Joseph Hirsh Angelica Osorno Emily Riehl Vesna Stojanoska Hiro Tanaka Sean Tilson	none
1/23/2014 to 1/24/2014	Programmatic Workshop	Connections for Women: Algebraic Topology	107		
1/27/2014 to 1/31/2014	Programmatic Workshop	Introductory Workshop: Algebraic Topology	245		
4/7/2014 to 4/11/2014	Programmatic Workshop	Reimagining the Foundations of Algebraic Topology	176		
Whole Year 2013-14	Scientific Program	Complementary Program 2013-14	8		
6/15/2013 to 7/28/2013	Scientific Activities Directed at Underrepresented Groups in Mathematics	MSRI-UP 2013: Algebraic Combinatorics	18		
10/2/2013 to 10/3/2013	Scientific Activities Directed at Underrepresented Groups in Mathematics	Modern Math Workshop (ICERM)	off site		
4/9/2014 to 4/11/2014	Scientific Activities Directed at Underrepresented Groups in Mathematics	Spring Opportunities Workshop for Women in the Mathematical Sciences (NIMBioS)	off site		
6/17/2013 to 6/28/2013	Summer Graduate School (2013)	Algebraic Topology	60		
6/24/2013 to 7/5/2013	Summer Graduate School (2013)	Seminaire de Mathematiques Superieures 2013: Physics and Mathematics of Link Homology	23		
6/30/2013 to 7/20/2013	Summer Graduate School (2013)	IAS/PCMI Summer 2013: Geometric Analysis	15		
7/1/2013 to 7/12/2013	Summer Graduate School (2013)	New Geometric Techniques in Number Theory	62		
7/29/2013 to 8/9/2013	Summer Graduate School (2013)	Introduction to the Mathematics of Seismic Imaging	49		
7/29/2013 to 8/9/2013	Summer Graduate School (2013)	Mathematical General Relativity in Cortona, Italy	11		

Time	*Activity Type*	*Activity Title*	*No. of registered participants*	
10/19/2013 to 10/19/2013	Other Scientific Workshop	Bay Area Differential Geometry Seminar (BADGS) Fall 2013	off site	
2/8/2014 to 2/9/2014	Other Scientific Workshop	Pacific Northwest and Bay Area Differential Geometry Seminar (BADGS) Winter 2014	off site	
2/17/2014 to 2/21/2014	Other Scientific Workshop	Hot Topics: Perfectoid Spaces and their Applications	210	

06/17/13 to 06/21/13	Education & Outreach Workshop	Bay Area Circle for Teachers Summer 2013	off site	
07/08/13 to 07/26/13	Education & Outreach Workshop	Mathematics Professional Development Institute 2013	21	
3/26/2014 to 3/28/2014	Education & Outreach Workshop	Critical Issues in Mathematics Education 2014: The role of the mathematics department in the mathematical preparation of teachers	242	

7. Appendix – Final Reports of Activities in 2012–13

MSRI
Mathematical Sciences Research Institute

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Commutative Algebra

August 20, 2012 to May 24, 2013
MSRI, Berkeley, CA
USA

Organizers:

David Eisenbud* (University of California, Berkeley)
Srikanth Iyengar (University of Nebraska)
Ezra Miller (Duke University)
Anurag Singh (University of Utah)
Karen Smith (University of Michigan)

PROGRAM REPORT
COMMUTATIVE ALGEBRA, 2012–13

DAVID EISENBUD, SRIKANTH B. IYENGAR, EZRA MILLER,
ANURAG K. SINGH, AND KAREN E. SMITH

INTRODUCTION

A year-long program in Commutative Algebra was held at the Mathematical Sciences Research Institute, Berkeley, organized by Eisenbud (Berkeley), Iyengar (Lincoln), Miller (Chapel Hill), Singh (Salt Lake City), and Smith (Ann Arbor). Eisenbud, Iyengar, and Singh were in residence for the entire duration of the program.

Commutative Algebra has been witnessing an extraordinary transformation in the past few years. This is being driven by a new crop of researchers in the subject, who have brought to bear novel techniques and perspectives on many long-standing problems, and opened exciting new directions of research. A remarkable aspect is that many of the key researchers are still in postdoctoral positions or starting tenure-track positions as of Fall 2013. We were fortunate to have attracted many of these to MSRI during the special year in commutative algebra; they brought tremendous amounts of enthusiasm and energy to the program. The success of the program was, in a large measure, thanks to them.

Another critical factor contributing to the vitality of the program was the choice of the partner programs, Cluster Algebras (Fall 2012) and Noncommutative Algebraic Geometry and Representation Theory (Spring 2013). There was a lively interaction between researchers in Commutative Algebra and the partner programs, especially among the postdocs and early career faculty. This has led to a number of new collaborations across these disciplines, and is sure to have an impact on each of the three fields in the years to come.

SELECTED BREAKTHROUGHS

There were numerous serendipitous developments during the Special Year, through collaborations new and old. Perhaps one that best illustrates this is work of **Herzog** and **Huneke**, who proved a striking result on Golod rings; these rings are of interest as every module over a Golod ring has rational Poincaré series. Speaking about their work, Huneke writes: "I was very pleased about several things I was able to do with colleagues during the year, but one stands out in the sense that without the MSRI program, there was probably no chance it would have been done. That is my work with Jürgen Herzog proving that higher powers, symbolic powers, saturated powers, and in many cases integral closures of higher powers of homogeneous ideals in polynomial rings define Golod rings. The process needed an inspiring talk by Adam Boocher, on ongoing discussion of an old result of Herzog which I had been looking at for another project, and of course, the fact that both Herzog and myself were present and talking with each other." This work will appear in *Advances in Mathematics*.

Here are some of the other highlights of the special year, many of which again highlight the charm of a being part of a program at MSRI:

1. **Benson**, **Krause**, and **Iyengar** formulated a new approach to stratification of triangulated categories. This provides a substantially shorter and more pleasant proof of stratification in the case of finite groups than the one in their recent paper in the *Annals of Mathematics*. It also opens up the way for work on the much harder case of finite group schemes. The latter is now the subject of an ongoing collaboration that also includes Julia Pevtsova.
2. **Bhatt**, **Blickle**, **Lyubeznik**, **Singh**, and **W. Zhang** proved that the local cohomology of a smooth $\mathbb{Z}$-algebra, e.g., the polynomial ring $\mathbb{Z}[x_1,\dots,x_n]$ has only finitely many associated prime ideals. This is notable since many problems (in particular, several homological conjectures) are unresolved for rings of mixed characteristic, though the equicharacteristic versions have been settled for decades. Their paper will appear in *Inventiones Mathematicae*.
3. **Brenner** proved that the Hilbert-Kunz multiplicity can be an irrational number, and thereby settled a long-standing open question. This, again, is an example of how MSRI provided the right place and the right time. Dale **Cutkosky** gave some inspiring lectures on his recent work on multiplicities associated to graded families of ideals, and related asymptotic length functions; **Dao** and **Smirnov** were also at MSRI, and working on generalized Hilbert-Kunz functions and multiplicities. The stage was set for an all-out attack on the irrationality question. Brenner first produced an example where the *generalized* Hilbert-Kunz multiplicity is irrational; his talk in the May workshop was amusingly titled *Something is irrational in Hilbert-Kunz theory*. By the end of the program, he had settled the original question as well.
4. **Chardin** and **Symonds** proved a conjecture of Derksen concerning the degrees of the syzygies of polynomial invariants of finite groups. A conversation in a hallway pointed to a crucial ingredient in their final proof, namely, some work of Aldo Conca and Satoshi Murai (who were also long-term members of the program, though not concurrently with Chardin and Symonds) on a splitting map of Koszul cycles.
5. **Eisenbud**, **Hartshorne**, and **Schreyer** used novel computational techniques to solve an outstanding problem in the theory of Gorenstein linkage, posed by Hartshorne a dozen years before. This had been seen as an obstacle to progress on the conjecture: *Every Cohen-Macaulay ideal is Gorenstein-linked to a complete intersection.* The conjecture is known for many classes of ideals, but Hartshorne had pointed out a case that could be a counter-example: the ideal of a general set of twenty points in $\mathbb{P}^3$. Because of the program, Hartshorne and Schreyer saw each other from time to time, and one day Hartshorne challenged Schreyer, asking whether there was any possible computational attack on the problem. Though others had decided "no," Schreyer had a new computational tool, developed in work with Eisenbud, and saw a possible attack. Much work and a couple of months later, the three collaborators could prove that, indeed, the ideal of a general set of twenty points in $\mathbb{P}^3$ is Gorenstein-linked to a complete intersection. Their work handles some similar cases, and points to an approach to still more.
6. **Eisenbud** and **Peeva** made a breakthrough towards a full understanding of minimal free resolutions over complete intersection rings of arbitrary codimension c, a subject often referred to by its main tool, *matrix factorizations*. The case $c = 1$ had been done by Eisenbud some 35 years before, and has many applications in representation theory and singularities that were discussed in the partner Cluster Algebras and Noncommutative Algebraic Geometry and Representation Theory (NAGRT) programs. In addition, it has recently seen many applications in mathematical physics that were addressed by MSRI postdocs Murfet and Stevenson and their collaborators, and were the

subject of joint seminars with the NAGRT program. The case of codimension 2 was partially elucidated by Avramov and Buchweitz (who were also long-term members of the program). But the general case had remained open. With time to concentrate on the problem, Eisenbud and Peeva, in culmination of years of collaborative work, were able to give a definition of "matrix factorization" in the general case that has all the good properties of the codimension 1 case. Their foundational paper on the subject has been submitted, and several further papers on particular aspects are in preparation.

7. **Kahle**, **E. Miller**, and **O'Neill** settled a 20 year old question of Eisenbud and Sturmfels on the existence of binomial irreducible decompositions. A conversation between Kahle and O'Neill (Miller's graduate student), provided an opportunity for O'Neill to detect a deficiency in a key definition from an earlier paper of Kahle and Miller. Beyond fixing the problem, this resulted in the joint project in which they answered, in the affirmative, the question on binomial irreducible decompositions.
8. **Rossi** and **Şega** proved that over a compressed Gorenstein algebra with socle degree not equal to 3, each module has rational Poincaré series with a common denominator. Şega adds that this work was inspired by Peeva's lectures on free resolutions at the MSRI Introductory Workshop in August 2012.

There were several other interesting developments coming out of the Special Year: Bhatt, Schwede, and Takagi extended to general singular spaces the results of Mustaţă and Srinivas on the connection between the action of Frobenius in prime characteristic and measures of singularities defined via the convergence of integrals over the complex numbers; Conca, De Negri, and Gorla simplified and vastly extended results of Bernstein, Sturmfels, and Zelevinsky on Gröbner bases for ideals of minors of a matrix of variables; Iyengar, Lipman, and Neeman discovered a remarkable formula for the fundamental class in Grothendieck Duality; Kummini and Sam took the first major steps in extending the theory of Eisenbud and Schreyer on cones of Betti tables, by generalizing some of their results to coordinate rings of rational normal curves.

POSTDOCTORAL FELLOWS

We assigned a senior researcher as a mentor to each Postdoctoral Fellow, and also to most early career Research Members; the mentors were charged with discussing research plans and progress, career counseling, advice on journal selection, presentations, job interviews, etc. We list below each postdoctoral fellow, their mentor, some specific research accomplishments, and professional placement beyond the program at MSRI.

1. **Christine Berkesch** (postdoc, Fall 2012), mentor: Frank-Olaf Schreyer, Saarbrücken.

Berkesch is a talented researcher in commutative algebra, specializing in connections with D-modules, combinatorics, algebraic geometry, and homological algebra. She assisted Schreyer during his lecture series in the Introductory Workshop, and is a co-author of the corresponding survey article for the MSRI volume. In addition, she worked on toric extensions of Boij-Söderberg theory, and on the following papers:

- (with Forsgård and Passare) *Euler-Mellin integrals and A-hypergeometric functions*, `arXiv:1103.6273`.
- (with Griffeth and E. Miller) *Systems of parameters and holonomicity of A-hypergeometric systems*, `arXiv:1302.0048`.
- (with Matusevich and Walther) *Torus equivariant D-modules and hypergeometric systems*.
- (with Matusevich and Walther) *Singularities and binomial D-modules*.

Berkesch returned to a postdoctoral position at Duke University for Spring 2013, and began a tenure-track position at the University of Minnesota in Fall 2013.

2. **Emilie Dufresne** (postdoc, Spring 2013), mentor: Dave Benson, Aberdeen.

Dufresne works on the invariant theory of finite groups; her expertise is the theory of separating invariants initiated by Derksen and Kemper. She has proved beautiful results using a mix of techniques from algebraic geometry, commutative algebra, and the representation theory of finite groups. At MSRI, she had fruitful interactions with Daniel Hernández, Emily Witt, Claudia Miller, Peter Symonds, and Jack Jeffries. Her paper with Jeffries, *How many invariants are needed to separate orbits?* (`arXiv:1309.6012`) gives some of the best known results on the minimal number of separating invariants for finite group actions on polynomial rings.

Following her MSRI stay, Dufresne will be at the University of Durham, UK, for Fall 2013, on a part-time position.

3. **Alex Fink** (postdoc, Fall 2012), Mentor: Olga Holtz, Berkeley.

Fink brings deep creativity and technical power to algebraic and geometric combinatorics, using techniques from commutative algebra and algebraic geometry to address combinatorial problems. At MSRI, he and Luca Moci completed the paper *Matroids over rings*, `arXiv:1209.6571`. He also completed the key argument in a long-standing joint project with Andrew Berget on equivariant K-classes of certain orbits of matrices. Other work while at MSRI includes Boij-Söderberg coefficients of matroid Stanley-Reisner ideals, and the start of several new collaborations, including those with Thomas Kahle, Matteo Varbaro, Alex Constantinescu, Daniel Erman, Kaisa Taipale, and Jenna Rajchgot.

Fink returned to a postdoctoral position at North Carolina State University; following that, he started a tenure-track position at Queen Mary College, London.

4. **Daniel Hernández** (postdoc, Spring 2013), mentor: Holger Brenner, Osnabrück.

Hernández is an expert on the topic of F-threshold. This is a subtle invariant of the singularities of a polynomial over a field of prime characteristic, defined using iterations of the Frobenius map. With roots in tight closure theory, the F-threshold is closely related to the well-known log canonical threshold of a complex polynomial. Hernández collaborated with Luis Núñez-Betancourt, Emily Witt, and Wenliang Zhang on the paper *F-pure thresholds of quasi-homogeneous polynomials*, and started a collaboration with Emilie Dufresne and Jack Jeffries on the F-purity of separating algebras.

Hernández started an NSF postdoctoral position at the University of Utah.

5. **Manoj Kummini** (postdoc, Fall 2012), mentor: Srikanth Iyengar, Lincoln.

Writing in support of Kummini's application to the MSRI postdoc program, Huneke noted his "enthusiasm, and the ability and desire to talk mathematics with people at all ages and backgrounds." Indeed, when at MSRI, Kummini was actively pursing numerous collaborations, new and old, with Christine Berkesch, Giulio Caviglia, Sabine El Khoury, Steven Sam, and Matteo Varbaro. Papers from his MSRI stay include:

- (with El Khoury and Srinivasan) *Bounds for the multiplicity of Gorenstein algebras*, `arXiv:1211.1316`.
- (with Caviglia) *Poset embeddings of Hilbert functions and Betti numbers*, `arXiv:1210.5562`.
- (with Caviglia) *Betti tables of p-Borel-fixed ideals*, `arXiv:1212.2201`.
- (with Sam) *The cone of Betti tables over a rational normal curve*, `arXiv:1301.7005`.
- (with Caviglia) *Betti tables of p-Borel-fixed ideals*, Journal of Algebraic Combinatorics.

Kummini returned to an Assistant Professorship at Chennai Math Institute, India.

6. **Jason McCullough** (postdoc Fall 2012), mentor: Aldo Conca, Genoa.

McCullough has distinguished himself by constructing striking examples in the context of Stillman's question: is there a bound on the projective dimension of a homogeneous ideal in a polynomial ring, depending only on the number and degrees of the generators, and not on the number of variables in the ring? His various discussions at MSRI with Craig Huneke, Paolo Mantero, and Alexandra Seceleanu have resulted in four papers, two of which have already been submitted. This includes a tight bound on the projective dimension of ideals generated by quadrics of height two in any polynomial ring. McCullough adds, "I also had several opportunities to meet and work with people I had not known personally before, including Aldo Conca, Mats Boij, Giulio Caviglia, and Frank Schreyer."

- (with Huneke, Mantero, and Seceleanu) *Multiple structures with arbitrarily large projective dimension on linear subspaces*, `arXiv:1301.4147`.
- (with Huneke, Mantero, and Seceleanu) *The projective dimension of codimension two algebras presented by quadrics*, `arXiv:1304.0745`.
- (with Huneke, Mantero, and Seceleanu) *Almost complete intersections of maximal multiplicity are Gorenstein*.
- (with Huneke, Mantero, and Seceleanu) *Projective dimension of ideals generated by four quadrics*.

McCullough also assisted Peeva during her lecture series in the Introductory Workshop. Following his MSRI stay, he started a tenure-track position at Rider University.

7. **Daniel Murfet** (postdoc, Spring 2013), mentor: David Eisenbud, Berkeley.

Murfet is a very original mathematician, interested in matrix factorizations. He is one of few commutative algebraists engaging with mathematical physics in a meaningful way, and in this regard he brings a totally different perspective to the subject. He contributed in myriad ways to the success of the MSRI program: he wrote an article *Matrix factorizations* in the Spring 2013 edition of the Emissary, tracing the development of the idea of matrix factorizations of a polynomial, starting with the work of Dirac, and leading up to knot homology; he invited mathematical physicists Nils Carqueville and Anna Ros Camacho to the program and, with them, gave numerous lectures on the connections between string theory and matrix factorizations; he was one of the organizers of the Focus Period on Matrix Factorizations; and he gave a beautiful presentation to the Committee of Academic Sponsors. In addition to all this, he completed, and initiated, numerous projects:

- (with Nils Carqueville), *Adjunctions and defects in Landau-Ginzburg models*, `arXiv:1208.1481`.
- (with Nils Carqueville), *A toolkit for defect computations in Landau-Ginzburg models*, `arXiv:1303.1389`.
- (with Iyengar), *Relative singularity categories*.
- *Clifford actions on DG categories*.
- *Knörrer periodicity versus Bott periodicity*.

Murfet assisted Van den Bergh during his lecture series in the Introductory Workshop. After the MSRI stay, Murfet started a three-year postdoctoral position at the University of Southern California in Los Angeles.

8. **Claudiu Raicu** (postdoc, Spring 2013), mentor: Jerzy Weyman, Boston.

Raicu was the inaugural Huneke Postdoctoral Fellow at MSRI. He has an amazing grasp of a very wide range of material from commutative algebra, algebraic geometry, and representation theory. His thesis included a novel application of representation theory to prove two well-known conjectures on the equations of secant varieties. While at MSRI, he

worked with Jerzy Weyman and Emily Witt on the paper *Local cohomology with support in ideals of maximal minors and sub-maximal Pfaffians*, arXiv:1305.1719. The authors describe the local cohomology modules of the polynomial ring of functions on the space of matrices, with support in the ideal of maximal sized minors. As an application, they characterize Cohen-Macaulay modules of covariants for the action of the special linear group on a direct sum of copies of the standard representation. The paper is the beginning of a long-term project whose goal is to determine local cohomology with support in more general equivariant ideals.

Raicu also assisted Huneke during his lecture series in the Introductory Workshop. He returned to a postdoctoral position at Princeton University, with János Kollár.

9. **Greg Stevenson** (postdoc, Spring 2013), mentor: Srikanth Iyengar, Lincoln.

Stevenson made for a remarkable presence at MSRI, equally at home in the Commutative Algebra and in the Noncommutative Algebraic Geometry and Representation Theory programs. He launched into a number of projects with researchers in both programs, and also with those just passing through! Here is a selection of collaborations that were initiated at MSRI:

- (with Antieau), *Derived categories of representations of quivers over noetherian commutative rings*.
- (with Burke), *Singularity categories and noncommutative projective schemes*.
- (with Chan and Ingalls), *Rigidity of derived categories of Fano and anti-Fano orders on smooth projective schemes*.
- (with Iyengar), *Hochschild actions on dg-categories*.
- (with van Roosmalen), *The homotopy category of triangles*.
- (with Steen), *Failure of existence of strong generators for triangulated categories*.

Stevenson returned to a postdoctoral position at the University of Bielefeld, Germany.

10. **Matteo Varbaro** (postdoc, Fall 2012), mentor: Anurag Singh, Salt Lake City.

Varbaro has an extensive and varied list of highly original publications in combinatorial commutative algebra, with surprising forays into notoriously difficult areas of local algebra. He collaborated extensively with other MSRI members, e.g., on a conjecture of Stanley on the shape of the h-vector of a matroid, and on a conjecture of Kalai on the f-vector of Cohen-Macaulay flag complexes. He assisted Brenner during his lecture series in the Introductory Workshop. The papers from his MSRI stay are:

- (with L. E. Miller and Singh) *The F-pure threshold of a determinantal ideal*, arXiv:1210.6729.
- (with Kahle and Constantinescu) *Generic and special constructions of pure O-sequences*, arXiv:1212.3426.
- (with Caviglia and Constantinescu) *On a conjecture by Kalai*, arXiv:1212.3726.
- (with Bruns) *Diagrams of single exterior type*, arXiv:1308.0220.
- (with Jeffries and Montaño) *Multiplicities of classical varieties*, arXiv:1308.0582.

After MSRI, Varbaro started on a *Ricercatore* position at the University of Genoa, Italy.

11. **Emily Witt** (postdoc, Spring 2013), mentor: Uli Walther, West Lafayette.

Witt has obtained strong results on local cohomology modules of polynomial rings over fields of characteristic zero, where the support ideals considered come from invariant theory, such as determinantal ideals. In the process, she has developed techniques for studying local cohomology that combine invariant theory and D-module methods. She made progress on multiple projects with Núñez-Betancourt and Hernández. Her seminar talk sparked discussions with Raicu and Weyman, which resulted in the first of the papers:

- (with Raicu and Weyman), *Local cohomology with support in ideals of maximal minors and submaximal Pfaffians*, arXiv:1305.1719.
- (with Hernández, Núñez-Betancourt, and W. Zhang, *F-pure thresholds of quasi-homogeneous polynomials*

Witt returned to a postdoctoral position at the University of Minnesota.

12. **Wenliang Zhang** (postdoc, Spring 2013), mentor: Anurag Singh, Salt Lake City.

Wenliang Zhang is a very active researcher in core commutative algebra, with several high quality papers treating a broad range of problems in local cohomology, prime characteristic commutative algebra, and mixed characteristic. He collaborated extensively with Lyubeznik, Schwede, Singh, and Tucker, amongst others. Specifically, the following papers were completed at MSRI:

- (with Patakfalvi and Schwede) *F-singularities in families*, arXiv:1305.1646.
- (with Katzman, Schwede, and Singh), *Rings of Frobenius operators*, arXiv:1304.6147.
- (with Bhatt, Blickle, Lyubeznik, and Singh) *Local cohomology modules of a smooth $\mathbb{Z}$-algebra have finitely many associated primes*, Inventiones Mathematicae (to appear).
- (with Katzman) *Annihilators of Artinian modules compatible with a Frobenius map*, arXiv:1301.1468.

Zhang also assisted Karen Smith during her lecture series in the Introductory Workshop. He returned to a tenure-track position at the University of Nebraska, Lincoln.

13. **Yi Zhang** (postdoc, Spring 2013), mentor: Greg Smith, Kingston.

Yi Zhang has found surprising applications for the adjoint of the Frobenius functor: these include an unexpected bound on the height of associated primes of local cohomology modules in prime characteristic; no similar bound is known in the case of characteristic zero. This has implications for a question of Stillman on uniform bounds for projective dimension in terms of degrees of generators. Another application is a striking result about grading shifts in prime characteristic local cohomology modules. He continued his collaboration with Lyubeznik and Wenliang Zhang, and has a Visiting Assistant Professorship at the University of Illinois at Urbana-Champaign, starting Fall 2013.

POSTDOCTORAL RESEARCH MEMBERS

The following early career Research Members were also assigned mentors; they were active participants in the postdoctoral seminar as well.

1. **Eleonore Faber** (Spring 2013), mentor: Ragnar Olaf-Buchweitz, Toronto.

Faber is an expert in the theory of free divisors, and has a wide range of interests that include tight closure theory. Speaking of her stay in MSRI, she writes "Although I was a postdoc in the Commutative Algebra program, I somehow got into Noncommutative Algebraic Geometry: out of an interest in resolution of singularities of free divisors, I came into contact with the topic of noncommutative desingularizations. Together with Hailong Dao and Colin Ingalls, we started a collaboration about noncommutative resolutions of commutative, possibly non-normal, rings."

Faber returned to a postdoctoral position at the University of Toronto.

2. **Florian Geiss** (Fall 2012), mentor: David Eisenbud, Berkeley.

Geiss has done subtle work exploiting computational commutative algebra techniques in the service of moduli problems in the theory of algebraic curves. During his MSRI stay, he worked with Eisenbud and Erman on the paper *Tate resolutions on Segre products*.

After MSRI, Geiss returned to a postdoctoral position in Saarbrücken. He has since taken up an industry job.

3. **Thomas Kahle** (Fall 2012), mentor: Frank-Olaf Schreyer.

Kahle has made substantial contributions to effective computation and a broad array of applications of commutative algebra, particularly primary decomposition of binomial ideals and algebraic statistics. Speaking of his MSRI visit, Kahle writes "My semester at MSRI has been very inspiring. Together with Alexandru Constantinescu and Matteo Varbaro, I have been working on our joint paper [below] that we submitted in December. Next to this tangible outcome, there are many little things that are hard to measure. The MSRI semester gave me the opportunity to meet a large group of commutative algebraists, some of whom I had never met before. I enjoyed many inspiring discussions that continue to have an impact on my work." Papers from MSRI include:

- (with Constantinescu and Varbaro) *Generic and special constructions of pure O-sequences*, `arXiv:1212.3426`.
- (with E. Miller and O'Neill) *Binomial irreducible decomposition*.

Kahle returned to a postdoctoral position at Technische Universität, Munich, and then started a Junior Professor position at Magdeburg, Germany, in August 2013.

4. **Paolo Mantero** (Fall 2012), mentor: Claudia Polini, Notre Dame.

Mantero's work includes multiplicity or length-based criteria for the almost Cohen-Macaulayness of associated graded rings; his results are among the first that work for ideals of arbitrary dimension. His extensive collaborations at MSRI resulted in the papers

- (with Huneke, McCullough, and Seceleanu) *Multiple structures with arbitrarily large projective dimension on linear subspaces*, `arXiv:1301.4147`.
- (with Huneke, McCullough, and Seceleanu) *The projective dimension of codimension two algebras presented by quadrics*, `arXiv:1304.0745`.
- (with Huneke, McCullough, and Seceleanu) *Almost complete intersections of maximal multiplicity are Gorenstein*.
- (with Huneke, McCullough, and Seceleanu) *Projective dimension of ideals generated by four quadrics*.
- (with Fouli and Xie) *A note on symbolic powers of ideals*.
- (with Johnson) *Characterizing the sum of geometrically linked ideals*.

After his MSRI visit, Mantero went to the University of California at Riverside as a Visiting Assistant Professor.

5. **Jenna Rajchgot** (Fall 2012), mentor: Craig Huneke, Charlottesville.

Rajchgot is an expert on Frobenius splitting. At MSRI, she interacted heavily with participants in the Cluster Algebra program, particularly Ryan Kinser and Greg Muller. She writes of her MSRI stay, "Kinser (whom I met at the joint introductory meetings) and I described a closed immersion from each representation space of a type A quiver with bipartite orientation to a certain opposite Schubert cell of a partial flag variety. We showed that this *bipartite Zelevinsky map* restricts to an isomorphism from each orbit closure to a Schubert variety intersected with the above-mentioned opposite Schubert cell." The preprint *Type A quiver loci and Schubert varieties* is available as `arXiv:1307.6261`.

Rajchgot went on to a postdoctoral position at the University of Michigan.

6. **Steven Sam** (Year long), mentor: Bernd Sturmfels, Berkeley.

Sam has fast become a leading expert on free resolutions and Betti numbers. His work includes impressive contributions to Boij-Söderberg theory, quiver representations, and Kalman varieties. He writes of his MSRI stay, "During the Fall 2012 semester of my stay at MSRI, Manoj Kummini and I proved some results on the cone of Betti tables of modules over the coordinate ring of a rational normal curve. Namely, we extended the results of Eisenbud and Schreyer in the case of the polynomial ring. One notable difference is that modules can have infinite length minimal free resolutions over the rational normal curve whereas that does not happen for the polynomial ring."

Sam was, and continues to be, a Miller research postdoctoral fellow at the University of California, Berkeley.

7. **Alexandra Seceleanu** (Fall 2012), mentor: Bernd Ulrich, West Lafayette.

Seceleanu has worked on a variety of topics in commutative algebra including Hilbert functions of Artin algebras, the weak Lefschetz property, and the local homological conjectures for rings of mixed characteristic. She added new research directions and new collaborations during her MSRI stay:

- (with Huneke, Mantero, and McCullough) *Multiple structures with arbitrarily large projective dimension on linear subspaces*, `arXiv:1301.4147`.
- (with Huneke, Mantero, and McCullough) *The projective dimension of codimension two algebras presented by quadrics*, `arXiv:1304.0745`.
- (with Huneke, Mantero, and McCullough) *Almost complete intersections of maximal multiplicity are Gorenstein*.
- (with Huneke, Mantero, and McCullough) *Projective dimension of ideals generated by four quadrics*.

Seceleanu returned to a postdoctoral position at the University of Nebraska, Lincoln.

DIVERSITY

Six of the 20 Postdoctoral Fellows/Postdoctoral Research Members listed above were women, as were five of the Research Professors: Dickenstein, Holtz, Miró-Roig, Polini, and Witherspoon (joint with Noncommutative Algebraic Geometry and Representation Theory). Fourteen additional Research Members were women, and one was African-American. Daniel Hernández, one of our Postdoctoral Fellows, is Mexican American.

GRADUATE STUDENTS

We had a number of enthusiastic graduate students participating in the program, and a special seminar run for and by them. Some collaborations at MSRI that included graduate students are:

- Jeffries and Montaño, *The j-multiplicity of monomial ideals*, `arXiv:1212.1419`, Mathematical Research Letters (to appear).
- Jeffries, Montaño, and Varbaro, *Multiplicities of classical varieties*, `arXiv:1308.0582`.
- Jeffries and Dufresne, *How many invariants are needed to separate orbits?* `arXiv:1309.6012`.
- E. Miller, Kahle, and O'Neill, *Binomial irreducible decomposition*.

Jack Jeffries is a graduate student from the University of Utah, and Jonathan Montaño from Purdue University. The first of the papers computes the j-multiplicity of a monomial ideal as the normalized volume of a polytopal complex; this may be viewed as an extension of Teissier's volume-theoretic interpretation of the Hilbert-Samuel multiplicity

for $\mathfrak{m}$-primary monomial ideals. Prior to their work, the result was known only for rings of dimension up to two. Their lectures on their work at MSRI caught the attention of Matteo Varbaro, an MSRI postdoc, who joined them in an effort to calculate the j-multiplicity of determinantal ideals. The answers—in the second paper above—turn out to be in the form of integrals that are central in random matrix theory. Of the third paper, Jeffries writes:

"Emilie Dufresne, an MSRI postdoc, gave a talk on her results on separating sets. One of the lemmas in her talk gave me an idea about a possible application of local cohomology to prove a lower bound on the size of separating sets. We started discussing around this idea, and soon found that these techniques provided much stronger bounds than those previously known in a wide range of examples. With the aid of discussions with Dave Benson, Anurag Singh, and Bernd Sturmfels, we were able to show that these techniques generalized and strengthened a classical result of Serre. Furthermore, we found that these techniques provided an unexpected link between the Goresky-MacPherson formula on subspace arrangements and the Shephard-Todd theorem in invariant theory. In the absence of a talented postdoc in invariant theory, and immediate access to experts in invariant theory, local cohomology, and combinatorics, I can't imagine realizing such a connection."

Ezra Miller's graduate student, Chris O'Neill, made the critical contribution to the paper on *Binomial irreducible decomposition* that was discussed previously. Miller adds "This was O'Neill's first collaboration. It wouldn't have occurred without the program's vibrant research atmosphere."

SEMINARS AND FOCUS PERIODS

During the program year, we designated seven *focus periods* on some areas of active research that were well-represented at MSRI:

1. *Linkage, multiplicities, Rees algebras, and integral closure*, September 10–October 12, 2012, organizers: Craig Huneke, Claudia Polini, and Bernd Ulrich.
2. *Boij-Söderberg theory*, October 15–November 16, 2012, organizers: David Eisenbud, Daniel Erman, and Frank-Olaf Schreyer.
3. *Combinatorics*, November 19–December 21, 2012, organizers: Alicia Dickenstein, Jürgen Herzog, Ezra Miller, and Seth Sullivant.
4. *Invariant theory*, February 4–March 1, 2013, organizers: Luchezar Avramov, David Benson, and Peter Symonds.
5. *Matrix factorizations and maximal Cohen-Macaulay modules*, March 4–29, 2013, organizers: Ragnar-Olaf Buchweitz, Srikanth Iyengar, and Daniel Murfet.
6. *Local cohomology and regularity*, April 1–26, 2013, organizers: Marc Chardin, Anurag Singh, and Wenliang Zhang.
7. *Tight closure and singularities*, April 29–May 24, 2013, organizers: Holger Brenner, Shunsuke Takagi, and Kevin Tucker.

Each week of the program year, aside from those with programmatic workshops, included a *Commutative Algebra Colloquium* and a *Focus Area Seminar*, and often an *Opportunistic Seminar*. In addition there were the following related workshops and seminars:

- Pan-American Advanced Studies Institute workshop, *Commutative Algebra and its Interactions with Algebraic Geometry, Representation Theory, and Physics*, Guanajuato, Mexico, May 14–25, 2012.
- *Tensors and their Geometry in High Dimensions*, September 26–29, 2012, organized by the Berkeley RTG on Representation Theory, Geometry, and Combinatorics.
- The *MSRI-Evans lecture* that took place bi-monthly on Mondays.
- Eisenbud's *Commutative algebra and algebraic geometry* seminar, that met on Tuesdays.

- Bernd Sturmfels taught a Graduate Course on *Combinatorial Commutative Algebra* at UC Berkeley in Fall 2012.
- *Macaulay2 Day*, Thursday, February 7, 2013.

SYNERGY

Our program benefited greatly from the partner programs in Cluster Algebras and in Noncommutative Algebraic Geometry and Representation Theory. The interaction with the Cluster Algebra program got a big boost from the Joint Introductory Workshop that opened both programs. Speaking of this, Karen Smith writes, "For me, the most exciting part of the year was the interaction with the participants in the cluster algebra program. Despite the fact Sergey Fomin is here at the University of Michigan and we interact regularly over many things professional and personal, I hadn't ever really taken the time to learn about cluster algebras. Once I did so, thanks mainly to his amazing lectures at the Introductory Workshop (having been suitably "warmed-up" by Lauren Williams's lectures at the Connections Workshop), I found that I could not only understand what they were up to, but also make a genuine contribution by injecting a commutative algebraic point of view. During my 2 week Fall stay, I began a collaboration with Greg Muller, a postdoc doing cluster algebras, who I have since hired at Michigan. We've been able to answer some questions, and point out some features that have surprised experts in cluster algebras. Most interestingly to me: we (together with my other 2 postdocs Jenna Rajchgot and Angelica Benito) proved that locally acyclic cluster algebras have canonical singularities, answering a question of Sean Keel. The special year in commutative algebra paired with the cluster algebra semester was, from my point of view, a very successful endeavor which continues to contribute to an atmosphere of communication and collaboration at Michigan."

Roger Wiegand said: "I attended the introductory workshop on cluster algebras and found the connections with representation theory fascinating. I hope to learn more about this subject and its connections with my own research."

The interaction with the NAGRT program was even more intense, with attendance "across disciplines" in many of the seminars and colloquia. There were special seminars that attracted speakers and participants from either program, noteworthy being a six-week long working seminar on matrix factorizations that surveyed the key developments in the theory of matrix factorizations, initiated by David Eisenbud in the 1980s, culminating in a "Matrix Factorization Day" (21st March 2013) that covered some of the latest developments in the field. All this led to a number of new collaborations between researchers in the two programs, and gave a boost to many already existing ones.

Sarah Witherspoon, who was partly supported by the NAGRT program, wrote "One of the things that I did was joint work with Dave Benson, starting with some informal discussions we had at MSRI in the spring: We found some counterexamples to the tensor product property for varieties for modules. That is, in many well-known contexts to which support variety theory is applied, such as representations of finite groups or finite group schemes, the variety of a tensor product of modules is the intersection of the varieties of the modules, a very useful property in applications. But this is simply not true in general of varieties for modules of a finite dimensional Hopf algebra, as the examples that Dave and I found in the spring show. The examples exhibit some other curious behavior, such as nonprojective modules having some tensor power being projective, and pairs of modules whose tensor product in one order is projective while the tensor product in the other order is not. We expect these examples will spur the community on to work to understand better the support variety theory for Hopf algebras in general."

In a different direction, David Benson gave a talk *Symmetry in music* for playwrights, and also engaged in the pre-show discussion for *Fearful symmetry*, a collection of six 10-minute plays, performed at the Berkeley Repertory Theatre, in association with MSRI.

PROGRAM WORKSHOPS

Connections for Women: Joint Workshop on Commutative Algebra and Cluster Algebras, August 22–24, 2012, organizers: Claudia Polini, Idun Reiten, Karen Smith, and Lauren Williams. The workshop include a minicourse *Basics of cluster algebras* by Lauren Williams, assisted by Kelli Talaska, as well as a poster session. The speakers were:

Karin Baur
Alicia Dickenstein
Claudia Miller
Konstanze Rietsch
Maria Evelina Rossi
Irena Swanson
Kelli Talaska
Gordana Todorov
Vijaylaxmi Trivedi
Lauren Williams

Joint Introductory Workshop: Cluster Algebras and Commutative Algebra, August 27–September 7, 2012, organizers: David Eisenbud, Bernhard Keller, Karen Smith, and Alexander Vainshtein. The workshop featured the following lecture series:

- Holger Brenner, *Vector bundles and ideal closure operations*, supporting lecture by Matteo Varbaro.
- Sergey Fomin, *Introduction to cluster algebras*, supporting lecture by Gregg Musiker.
- Craig Huneke, *Introduction to uniformity in commutative algebra*, supporting lecture by Claudiu Raicu.
- Bernhard Keller, *Quiver representations and cluster algebras*, supporting lecture by Fan Qin.
- Bernard Leclerc, *Preprojective algebras and Lie theory*, supporting lecture by Pierre-Guy Plamondon.
- Irena Peeva, *Infinite free resolutions*, supporting lecture by Jason McCullough.
- Idun Reiten, *Cluster categories*, supporting lecture by Sarah Scherotzke.
- Frank-Olaf Schreyer, *Syzygies, finite length modules, and random curves*, supporting lecture by Christine Berkesch.
- Karen Smith, *Introduction to Frobenius splitting*, supporting lecture by Wenliang Zhang.
- Dylan Thurston, *Cluster algebras and triangulated surfaces*.
- Alek Vainshtein, *Cluster algebras and Poisson geometry*, supporting lecture by Michael Gekhtman.
- Michel Van den Bergh, *Non-commutative resolutions*, supporting lecture by Daniel Murfet.

Combinatorial Commutative Algebra and Applications, December 3–7, 2012, organizers: Winfried Bruns, Alicia Dickenstein, Takayuki Hibi, Allen Knutson, and Bernd Sturmfels. Speakers:

Christine Berkesch (MSRI postdoc)
Aldo Conca
David Eisenbud
Daniel Erman
Jürgen Herzog
June Huh (graduate student)
Thomas Kahle (postdoctoral member)
Mateusz Michalek
Ezra Miller
Satoshi Murai
Uwe Nagel
Hidefumi Ohsugi

Sonja Petrovic
Claudia Polini
Jenna Rajchgot (postdoctoral member)
Tim Römer
Steven Sam (postdoctoral member)
Anne Shiu
Greg Smith
Adam Van Tuyl
Matteo Varbaro (MSRI postdoc)
Josephine Yu

Representation Theory, Homological Algebra, and Free Resolutions, February 11–17, 2013, organizers: Luchezar Avramov, David Eisenbud, and Irena Peeva. Speakers:

Lidia Angeleri Hügel
Kristen Beck
David Benson
Jennifer Biermann
Ragnar-Olaf Buchweitz
Jesse Burke
Giulio Caviglia
Olgur Celikbas
Marc Chardin
Hailong Dao
Alessandro De Stefani (graduate student)
Alexander Dugas
Tobias Dyckerhoff
Gavril Farkas
Louiza Fouli
Federico Galetto
Laura Ghezzi
Jürgen Herzog
Melvin Hochster
Osamu Iyama
Srikanth Iyengar
Leila Khatami
Henning Krause
Robert Lazarsfeld
Kuei-Nuan Lin
Jason McCullough (MSRI postdoc)
Claudia Miller
Rosa Miró-Roig
Fatemeh Mohammadi
Frank Moore
Daniel Murfet (MSRI postdoc)
Saeed Nasseh (graduate student)
Van Nguyen (graduate student)
Luis Núñez-Betancourt (graduate student)
Alexander Polishchuk
Claudiu Raicu (MSRI postdoc)
Idun Reiten
Gregory Stevenson (MSRI postdoc)
Kavita Sutar
Peter Symonds
Bernd Ulrich
Javid Validashti
Oana Veliche
Xin Zhou

The Commutative Algebra of Singularities in Birational Geometry: Multiplier Ideals, Jets, Valuations, and Positive Characteristic Methods, May 6–10, 2013, organizers: Craig Huneke, Yujiro Kawamata, Mircea Mustaţă, Karen Smith, and Kei-ichi Watanabe. The speakers were:

Angelica Benito
Bhargav Bhatt
Holger Brenner
Steven Cutkosky
Tommaso de Fernex
Lawrence Ein
Charles Favre
Nobuo Hara
Shihoko Ishii
Masayuki Kawakita
János Kollár
Gennady Lyubeznik
James McKernan
Vikram Mehta
Wenbo Niu
Claudia Polini
Jenna Rajchgot (postdoctoral member)
Akiyoshi Sannai
Karl Schwede
Takafumi Shibuta

Vasudevan Srinivas
Shunsuke Takagi
Bernard Teissier
Vijaylaxmi Trivedi
Kevin Tucker
Willem Veys
Adela Vraciu
Emily Witt (MSRI postdoc)
Yuchen Zhang (graduate student)

We conclude with a few quotes from participants:

Uli Walther: "A long term project of mine, the study of Bernstein-Sato polynomials and Milnor fibers, also benefited from my MSRI stay: I found out that some of the mysteries of Bernstein-Sato polynomials can be cleared up if one understands approximation complexes and tensor powers of certain modules. I was fortunate to have Claudia Miller and Jürgen Herzog next door; they first made me realize what I needed to be thinking about, and then proceeded to enlighten me for an entire semester."

Roger Wiegand: "The idyllic location and stimulating intellectual atmosphere were an incredible boon to my research. Thanks!"

Sylvia Wiegand: "Overall, having such a year is vital to all of us in our field. It has provided stimulation and inspiration that will keep us going for many years."

Commutative Algebra

Berkesch, Christine
Fall

Name: Christine Berkesch
Year of Ph.D: 2010
Institution of Ph.D.: Purdue University
Dissertation title: Euler--Koszul homology in algebra and geometry
Ph.D. advisor: Uli Walther

Institution prior to obtaining the MSRI PD fellowship:
Duke University
Position at that institution: Assistant Research Professor

Institution (or company) where you are going after the MSRI PD fellowship: same as above
Anticipated length: 1 more semester

Postdoctoral Fellow's comments:

I worked on the following publications:

(with Jens Forsgard and Mikael Passare)
Euler--Mellin integrals and A-hypergeometric functions,
19 pages. arXiv:math.CV/1103.6273

(with Stephen Griffeth and Ezra Miller)
Systems of parameters and holonomicity of A-hypergeometric systems,
4 pages. arXiv:math.AG/1302.0048

(with Laura Felicia Matusevich and Uli Walther)
Torus equivariant D-modules and hypergeometric systems, 37 pages.

(with Laura Felicia Matusevich and Uli Walther)
Singularities and binomial D-modules, 10 pages.

I also considered various aspects of toric Boij--Soederberg theory.

Was your experience at MSRI beneficial?

Yes, this experience of focused research and collaboration was extremely beneficial.

Dufresne, Emilie
Spring

Your Name: Emilie Dufresne
Year of Ph.D: 2008
Institution of Ph.D.: Queen's University at Kingston, ON, Canada
Dissertation title: Separating Invariants
Ph.D. advisor: David Wehlau

Institution prior to obtaining the MSRI PD fellowship: Universität Basel
Position at that institution: Postdoctoral Assistant
Mentor (if applicable): Hanspeter Kraft

Institution (or company) where you are going after the MSRI PD fellowship: University of Durham, UK
Position: casual/hourly paid worker (doing tutorials for undergraduate courses)
Anticipated length: 1 semester (for now)

Postdoctoral fellow's comments:

While at MSRI, I got reacquainted with the commutative algebra community. I became aware of the progress and change of orientation which happenned in the last five years. I started learning more homological algebra, which is something I intended to do. I also started talking to new people and think in new ways. I had many conversations with Daniel Hernández, Emily Witt, Claudia Miller, Peter Symonds and Jack Jeffries. Not all these conversations turned into actual new collaborations. But one did. I have started a common project with Jack Jeffries. Already while at MSRI we obtain some very interesting results. We are in the process of writing up, but there is room for more research in that direction. I would say my experience was beneficial.

Fink, Alexander
Fall

Your Name: Alex Fink
Year of Ph.D: 2010
Institution of Ph.D.: UC Berkeley
Dissertation title: Matroid polytope subdivisions and valuations
Ph.D. advisor: jointly, Bernd Sturmfels and Federico Ardila (at San Francisco State)

Institution prior to obtaining the MSRI PD fellowship: North Carolina State
Position at that institution: postdoc
Mentor (if applicable): Seth Sullivant

Institution (or company) where you are going after the MSRI PD fellowship: proximally, back to NC State. Thereafter, Queen Mary, University of London (which I'll answer the following questions with respect to)
Position: Lecturer (~= assistant professor)
Anticipated length: tenure-track (in effect; the UK has abolished tenure)
Mentor (if applicable): n/a

Fellow's comments:

finished a joint paper with Luca Moci, _Matroids over rings_ arXiv:1209.6571, submitted for publication;
completed the key argument in a long-running joint project with Andrew Berget, on equivariant K-classes of certain orbits of matrices, whose writeup is in progress;
computed the Boij-Söderberg coefficients of matroid Stanley-Reisner ideals, writing up a short document which I hope to expand on and publish in short order;
various other collaborations started.

Was your experience at MSRI beneficial? Certainly.

Hernandez, Daniel
Spring

Your Name: Daniel Hernandez
Year of Ph.D: 2011
Institution of Ph.D.: University of Michigan, Ann Arbor
Dissertation title: F-purity of hypersurfaces
Ph.D. advisor: Karen E Smith

Institution prior to obtaining the MSRI PD fellowship:
Position at that institution: University of Minnesota, Twin Cities
Mentor (if applicable): Gennady Lyubeznik

Institution (or company) where you are going after the MSRI PD fellowship: University of Utah, Salt Lake City
Position: NSF Postdoc
Anticipated length: 1 year
Mentor (if applicable): Anurag Singh

Postdoctoral fellow's comments:

No comment

Kummini, Manoj
Fall

Name: Manoj Kummini
Year of Ph.D: 2008
Institution of Ph.D.: University of Kansas, Lawrence, KS
Dissertation title: Homological Invariants of Monomial and Binomial Ideals
Ph.D. advisor: Craig Huneke

Institution prior to obtaining the MSRI PD fellowship:
Chennai Mathematical Institute, Siruseri Tamilnadu, India
Position at that institution: Assistant Professor
Mentor: N/A

Institution after the MSRI PD fellowship:
Chennai Mathematical Institute, Siruseri Tamilnadu, India
Position: Assistant Professor
Anticipated length: Tenure-track

Postdoctoral fellow's comments:

Collaborated with Giulio Caviglia and Steven Sam and Sabine El Khoury (who visited me during the joint introductory workshop in Fall 2012). Began some discussion with Christine Berkesch and Matteo Varbaro.

Submitted papers:
El Khoury, Kummini and Srinivasan: Bounds for the Multiplicity of Gorenstein algebras. arXiv:1211.1316 [math.AC].

Caviglia and Kummini: Poset embeddings of Hilbert functions and Betti numbers. arXiv:1210.5562 [math.AC]},

Caviglia and Kummini: Betti tables of p-Borel-fixed ideals}. arXiv:1212.2201 [math.AC]

Kummini and Sam: The cone of Betti tables over a rational normal curve. arXiv:1301.7005 [math.AC].

Was your experience at MSRI beneficial?

Yes.

McCullough, Jason Fall

Your Name: Jason McCullough
Year of Ph.D: 2009
Institution of Ph.D.: University of Illinois
Dissertation title: On the strong direct summand conjecture
Ph.D. advisor: Sankar Dutta

Institution prior to obtaining the MSRI PD fellowship: University of California Riverside
Position at that institution: Visiting Assistant Professor

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

Postdoctoral fellow's comments:

In addition to all of the beneficial workshops and seminars, I worked with a number of other people. My work with Craig Huneke, Paolo Mantero and Alexandra Seceleanu has led to perhaps 4 papers, 2 of which have already been submitted. I had a chance to finish a project with Kuei-Nuan Lin, started previously while at UCR. I also had several opportunities to meet and work with people I had not known personally before, including Aldo Conca, Mats Boij, Giulio Caviglia, and Frank Schreyer. My time at MSRI was invaluable and I am grateful to have had a chance to attend.

Murfet, Daniel Spring

Name: Daniel Murfet
Year of Ph.D: 2008
Institution of Ph.D.: Australian National University
Dissertation title: The Mock Homotopy Category of Projectives and Grothendieck Duality
Ph.D. advisor: Amnon Neeman

Institution prior to obtaining the MSRI PD fellowship: UCLA
Position at that institution: Faculty/postdoc

Institution after the MSRI PD fellowship: USC
Position: Assistant Professor

No comments

Raicu, Claudiu
Spring

Your Name: Claudiu Raicu
Year of Ph.D.: 2011
Institution of Ph.D.: U.C. Berkeley
Dissertation title: Secant varieties of Segre-Veronese varieties
Ph.D. advisor: David Eisenbud

Institution prior to obtaining the MSRI PD fellowship: Princeton University
Position at that institution: Instructor of Mathematics
Mentor (if applicable): Janos Kollar

Institution (or company) where you are going after the MSRI PD fellowship: Princeton University
Position: Instructor of Mathematics
Anticipated length: 2011-2014
Mentor (if applicable): Janos Kollar

Postdoctoral fellow's comments:

I have written and submitted for publication a joint paper with Jerzy Weyman and Emily Witt, titled "Local cohomology with support in ideals of maximal minors and sub-maximal Pfaffians". This is the beginning of a long term project whose goal is to determine local cohomology with support in more general equivariant ideals.

My visit at MSRI was extremely helpful in expanding my research directions, I learned a lot from the researchers in residence at the institute, and had the chance to interact with the people at U.C. Berkeley as well.

Stevenson, Gregory
Spring

Your Name: Greg Stevenson
Year of Ph.D: 2011
Institution of Ph.D.: Australian National University
Dissertation title: Tensor actions and locally complete intersections
Ph.D. advisor: Amnon Neeman

Institution prior to obtaining the MSRI PD fellowship: Bielefeld U.
Position at that institution: Humboldt postdoctoral fellow

Institution where you are going after the MSRI PD fellowship: Bielefeld
Position: Humboldt postdoctoral fellow
Anticipated length: Until Nov. 2014

Postdoctoral fellow's comments:
I worked on a number of subjects with a variety of people during my semester at MSRI. Jesse Burke, who was present at one of the workshops and was able to visit during the semester, and I are collaborating on various extensions on a theorem of Orlov connecting graded singularity categories to noncommutative projective schemes. Our results are currently being written up and we plan to submit them to the proceedings volume for the commutative algebra program.
Benjamin Antieau and I have a joint project studying derived categories of various small categories, including path categories of quivers, over arbitrary noetherian rings. We have been able to prove several results, for instance giving a classification of localising subcategories of derived categories of ADE quivers over any noetherian ring, and are currently in the process of writing an article.
My mentor for the semester, Srikanth Iyengar, and I are working on multiple projects as a result of the time we spent together. We made significant progress during the semester on some questions involving actions of Hochschild cohomology and its differential-graded avatars on derived categories and their dg-models. This project is related to previous work by myself and by Benson, Iyengar, and Krause, and will hopefully clarify the connections between our approaches. We have also initiated a project studying suitable notions of the new intersection theorem in the context of derived categories of dg-categories.I also have ongoing projects, started during my semester at MSRI, with Adam-Christiaan van Roosmalen and with Kenneth Chan and Colin Ingalls. The former, with van Roosmalen, concerns the structure of the collection of (higher) triangles in a triangulated category. The latter, with Chan and Ingalls, consists of studying rigidity of derived categories of Fano and anti-Fano orders on smooth projective schemes and reconstruction, up to Morita equivalence, of the order given the derived category.I had a very positive experience at MSRI and my stay at the institute was very fruitful. It was an excellent opportunity to meet with a number of people with whom I had existing collaborations or research links as well as to begin a number of new collaborations and connect with a number of researchers in neighbouring fields. I also learned a great deal of mathematics and was exposed to several interesting questions. I look forward to a long, and productive, period of fully digesting the mathematics and problems I was fortunate enough to come into contact with at MSRI.

Varbaro, Matteo
Fall

Name: Matteo Varbaro
Year of Ph.D.: 2011
Institution of Ph.D.: Università degli Studi di Genova (Italy)
Dissertation title: Cohomological and Combinatorial Methods in the Study of Symbol Powers and Equations defining Varieties
Ph.D. advisor: Aldo Conca

Institution prior to obtaining the MSRI PD fellowship: Università degli Studi di Genova
Position at that institution: Postdoc
Mentor (if applicable): Aldo Conca

Institution (or company) where you are going after the MSRI PD fellowship: Università degli Studi di Genova
Position: Ricercatore (not the same as a tenure-track, which in Italy does not exist, but close to)
Anticipated length: 3 years

Postdoctoral fellow's comments:

At MSRI I mainly worked on four topics:
- On the F-pure threshold of a determinantal ideal, ended up with the paper entitled "The F-pure threshold of a determinantal ideal" joint with Lance Edward Miller and Anurag Singh, submitted.
- On a conjecture of Stanley on the shape of the h-vector of a matroid, continuing a line of research started with Alexandru Constantinescu, ended up with the paper "Generic and special constructions of pure O-sequences" joint with Alexandru Constantinescu and Thomas Kahle, submitted.
- On a conjecture of Kalai on the f-vector of Cohen-Macaulay flag complexes, ended up with the paper entitled "On a conjecture by Kalai" joint with Giulio Caviglia and Alexandru Constantinescu, submitted.
- On the study of the algebraic ralations between minors of a fixed size of a generic matrix, continuing a line of research started with Winfried Bruns and Aldo Conca, ended up with the preprint entitled "Diagrams of single exterior type" joint with Winfried Bruns.

The first three papers are available on the arXiv. I also started a collaboration with Jack Jeffries and Jonathan Montano, that is going on now, about the j-multiplicity of determinantal ideals.

Witt, Emily
Spring

Your Name: Emily Witt
Year of Ph.D: 2011
Institution of Ph.D.: University of Michigan
Dissertation title: Local cohomology and group actions
Ph.D. advisor: Mel Hochster

Institution prior to obtaining the MSRI PD fellowship: University of Minnesota
Position at that institution: Dunham Jackson Assistant Professor
Mentor (if applicable): Gennady Lyubeznik

Institution (or company) where you are going after the MSRI PD fellowship: University of Minnesota
Position: Dunham Jackson Assistant Professor
Anticipated length: 1-2 more years
Mentor (if applicable): Gennady Lyubeznik

Postdoctoral fellow's comments:

-Preprint (submitted) with Claudiu Raicu and Jerzy Weyman, "Local cohomology with support in ideals of maximal minors and submaximal Pfaffians"
-Preprint with Daniel Hernandez, Luiz Nunez-Betancourt, and Wenliang Zhang, "F-pure thresholds of quasi-homogeneous polynomials" completed
-Multiple projects progressed with Luis Nunez-Betancourt and/or Daniel Hernandez

Zhang, Yi
Spring

Your Name: Yi Zhang
Year of Ph.D: 2012
Institution of Ph.D.: University of Minnesota
Dissertation title: Local cohomology modules over polynomial rings of prime characteristic
Ph.D. advisor: Gennady Lyubeznik

Institution prior to obtaining the MSRI PD fellowship: Purdue University
Position at that institution: Visiting Assistant Professor
Mentor (if applicable): Uli Walther

Institution (or company) where you are going after the MSRI PD fellowship: University of Illinois at Urbana-Champaign
Position: Visiting Assistant Professor
Anticipated length: one year
Mentor (if applicable): Sankar Dutta

Postdoctoral fellow's comments:

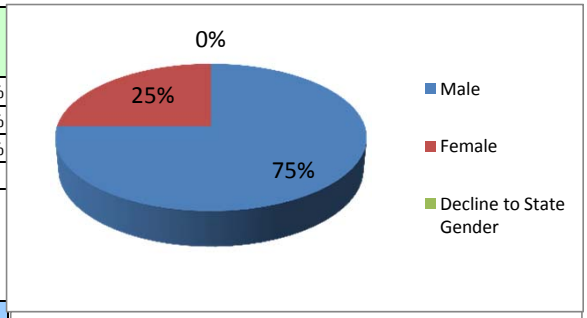
I continued my research on local cohomology and module decomposition theory. I submitted a paper on the criterion of indecomposability. The stay at MSRI is very beneficial to my career.

Postdoc Pre/Post-MSRI Institution Group

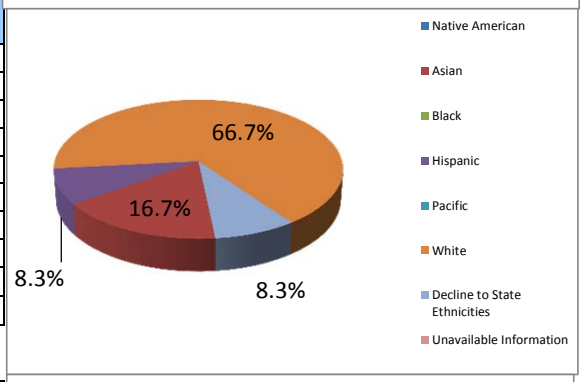
Family Name	First Name	Pre-MSRI Institution Group	Post-MSRI Institution Group	Home Institution Name	Placement Institution Name
Berkesch	Christine	Group I Private	Group I Private	Duke University	Duke University
Dufresne	Emilie	Foreign	Foreign	Universitat Basel	University of Durham, UK
Fink	Alexander	Non-group	Non-group	North Carolina State University	North Carolina State University
Hernandez	Daniel	Group I Public	Group I Public	University of Minnesota Twin Cities	University of Utah
Kummini	Manoj	Foreign	Foreign	Chennai Mathematical Institute	Chennai Mathematical Institute
McCullough	Jason	Non-group	Non-group	UC Riverside	Rider University
Murfet	Daniel	Group I Public	Group I Private	UCLA	USC
Raicu	Claudiu	Group I Private	Group I Private	Princeton University	Princeton University
Stevenson	Gregory	Foreign	Foreign	Universitat Bielefeld	Universitat Bielefeld
Varbaro	Matteo	Foreign	Foreign	Universita di Genova	Universita di Genova
Witt	Emily	Group I Public	Group I Public	University of Minnesota Twin Cities	University of Minnesota Twin Cities
Zhang	Yi	Group I Public	Group I Public	Purdue University	U. of Illinois at Urbana-Champaign

Commutative Algebra Postdoctoral Fellows Demographic Summary

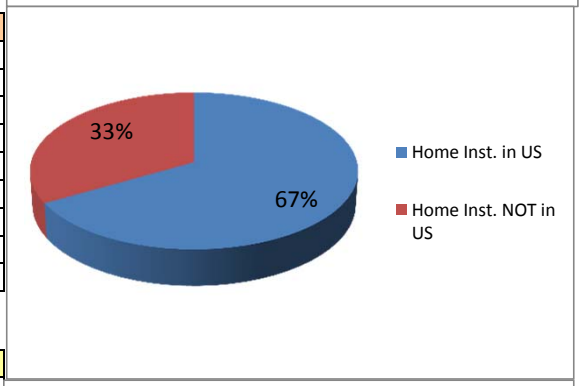
Gender	#	% (No Decl.)*	%
# of Distinct Members	12		100.0%
Male	9	75.00%	75.0%
Female	3	25.00%	25.0%
Decline to State Gender	0		



Ethnicities	#	% (No Decl.)*	%
Native American	0		0.0%
Asian	2	18.18%	16.7%
Black	0		0.0%
Hispanic	1		8.3%
Pacific	0		0.0%
White	8	72.73%	66.7%
Decline to State Ethnicities	1		8.3%
Unavailable Information	0		0.0%
Minorities	1		

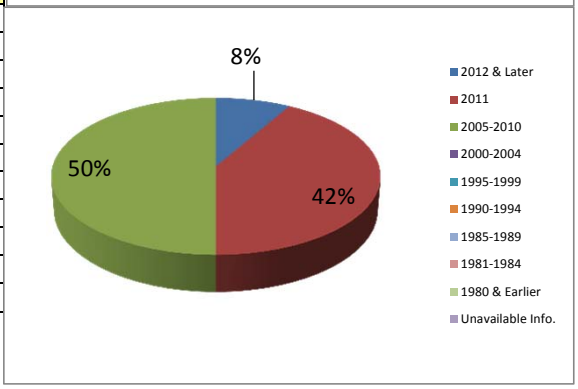


Citizenships	#		%
US Citizen & Perm. Residents	4		33.3%
Foreign	8		66.7%
Unavailable information	0		
# of Distinct Members	12		100.0%
US Citizen	4		33.3%
Perm Residents	0		0.0%
Home Inst. in US	8		66.67%



Year of Ph.D	#		%
2012 & Later	1		8.3%
2011	5		41.7%
2005-2010	6		50.0%
2000-2004	0		0.0%
1995-1999	0		0.0%
1990-1994	0		0.0%
1985-1989	0		0.0%
1981-1984	0		0.0%
1980 & Earlier	0		0.0%
Unavailable Info.	0		0.0%
Total # of Distinct Members	12		100.0%

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



Commutative Algebra

Program Summary

Role	# of Distinct Members	%	# of Citizens & Perm. Res.	%	US Citizens	# of Female	%	# of Minorities[1]	%
Organizers	5	4.6%	4	80.0%	4	1	20.0%	0	0.0%
Research Professors	20	18.5%	10	50.0%	7	5	25.0%	0	0.0%
Postdoctoral Fellows	12	11.1%	4	33.3%	4	3	25.0%	1	25.0%
NSF Postdoctoral Fellows	2	1.9%	1	50.0%	1	0	0.0%	0	0.0%
PD/RM	5	4.6%	0	0.0%	0	2	40.0%	0	0.0%
Research Members	51	47.2%	23	45.1%	18	16	31.4%	1	5.6%
Program Associates	13	12.0%	4	30.8%	4	3	23.1%	0	0.0%
Guests	0	0.0%	0	0.0%	0	0	0.0%	0	0.0%
Total # of Distinct Members	**108**		**46**	***42.6%***	**38**	**30**	***27.8%***	**2**	***5.3%***

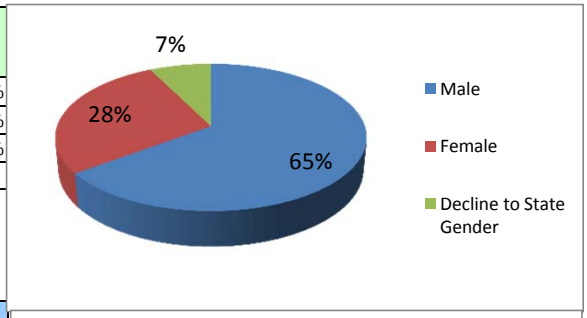
[1] *Minorities are US citizen who declare themselves American Indian, Black, Hispanic, or Pacific Islander. Minority percentage is calculated by dividing the number of Minorities by the total number of US citizens.*

Home Institute Grouping

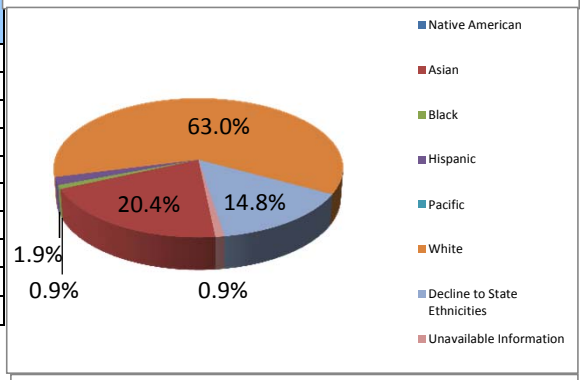
	US								
Role	**Group I Private**	**Group I Public**	**Group II**	**Group III**	**Group M**	**Group B**	**Non-Group**	**Foreign**	**Total**
Organizers	1	3	1	0	0	0	0	0	5
Research Professors	1	5	3	0	0	0	0	11	20
Postdoctoral Fellows	2	4	0	0	0	0	2	4	12
NSF Postdoctoral Fellows	0	1	1	0	0	0	0	0	2
PD/RM	0	0	2	0	0	0	0	3	5
Research Members	5	7	7	2	1	0	3	26	51
Program Associates	2	4	0	0	0	0	0	7	13
Total	**11**	**24**	**14**	**2**	**1**	**-**	**5**	**51**	**108**
%	***10.2%***	***22.2%***	***13.0%***	***1.9%***	***0.9%***	***0.0%***	***4.6%***	***47.2%***	***100.0%***

Commutative Algebra Demographic Summary

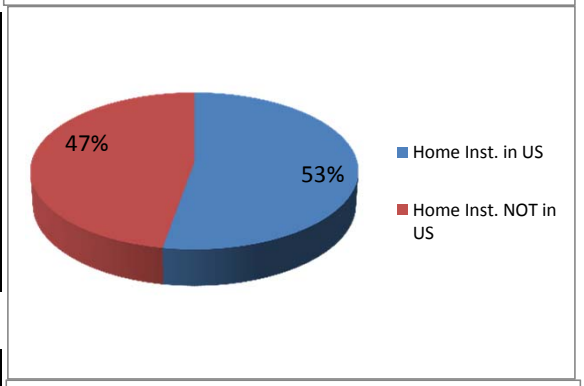
Gender	#	% (No Decl.)*	%
# of Distinct Members	108		92.6%
Male	70	70.00%	64.8%
Female	30	30.00%	27.8%
Decline to State Gender	8		



Ethnicities	#	% (No Decl.)*	%
Native American	0		0.0%
Asian	22	23.66%	20.4%
Black	1		0.9%
Hispanic	2		1.9%
Pacific	0		0.0%
White	68	73.12%	63.0%
Decline to State Ethnicities	16		14.8%
Unavailable Information	1		0.9%
Minorities	2		

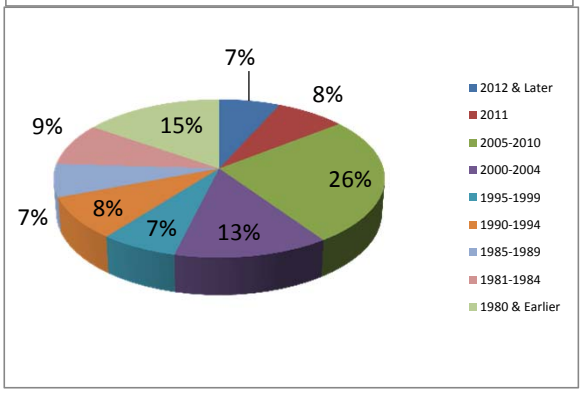


Citizenships	#		%
US Citizen & Perm. Residents	46		42.6%
Foreign	62		57.4%
Unavailable information	0		
# of Distinct Members	108		100.0%
US Citizen	38		35.2%
Perm Residents	8		7.4%
Home Inst. in US	57		52.78%



Year of Ph.D	#		%
2012 & Later	7		6.5%
2011	8		7.4%
2005-2010	27		25.0%
2000-2004	14		13.0%
1995-1999	7		6.5%
1990-1994	9		8.3%
1985-1989	7		6.5%
1981-1984	9		8.3%
1980 & Earlier	16		14.8%
Unavailable Info.	4		3.7%
Total # of Distinct Members	108		100.0%

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



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Cluster Algebras

August 20, 2012 to December 21, 2012
MSRI, Berkeley, CA
USA

Organizers:

Sergey Fomin (University of Michigan)
Bernhard Keller (Université Paris Diderot - Paris 7, France)
Bernard Leclerc (Université de Caen Basse-Normandie, France)
Alexander Vainshtein* (University of Haifa, Israel)
Lauren Williams (University of California, Berkeley)

REPORT ON THE CLUSTER ALGEBRAS PROGRAM MSRI FALL 2012

Organizers:
Sergey Fomin (Ann Arbor)
Bernhard Keller (Paris)
Bernard Leclerc (Caen)
Alek Vainshtein (Haifa)
Lauren Williams (Berkeley)

1. Introduction

The theory of cluster algebras is a young subject: the original discovery by S. Fomin and A. Zelevinsky was made in 2000. At the heart of the theory lie several discrete dynamical systems based on birational and piecewise-linear recurrences, and defined in a totally elementary way. The resulting structure is surprisingly rich, and exhibits many unexpected features. For example, there is a natural notion of cluster algebras of finite type, and their classification turns out to be completely parallel to the celebrated Cartan-Killing classification of semisimple Lie algebras.

The internal beauty of the subject does not however properly explain the explosion of interest in the theory of cluster algebras in recent years. Indeed, the key reason is external: over the last decade, cluster algebras were found to play important roles in a large number of diverse contexts throughout mathematics and theoretical physics. An incomplete list of these fields includes: Total positivity; Representation theory and geometry of semisimple Lie groups; Kac-Moody groups and quantum groups; String theory; Statistical physics and discrete probability; Quiver representations and finite-dimensional algebras; Teichmüller theory and its generalizations; Poisson and symplectic geometry; Discrete integrable systems; Tropical geometry; Combinatorial invariant theory; Classical projective geometry; and Algebraic and polyhedral combinatorics. Quite remarkably, cluster algebras provide a unifying algebraic and combinatorial framework for a wide variety of phenomena in these and other settings.

Over the dozen years that passed since its inception, the theory of cluster algebras attracted into its realm many excellent researchers from all around the world. The semester-long MSRI program on Cluster Algebras, held during August 20 – December 21, 2012, presented a broad panorama of the current state of this rapidly expanding subject, enabled many mathematicians to broaden their understanding of the roles that cluster algebras play in various active areas of research, facilitated new interactions, and more generally provided the participants an excellent opportunity to share and further develop their ideas. In addition, the program benefitted from mathematical exchanges with the participants in the companion program in Commutative Algebra.

2. Research developments

Among the many research developments that took place during the program on Cluster Algebras, we would like to single out the following ten.

Tau-tilting theory. This remarkably general theory whose foundations have been developed by T. Adachi, O. Iyama, and I. Reiten [arXiv:1210.1036] aims to build a generalization of classical tilting theory (for finite dimensional algebras) that incorporates a proper notion of (cluster) mutation. The key results were reported in Iyama's and Reiten's talks at the main topical workshop for the program.

Exotic cluster structures on SL_n. M. Gekhtman, M. Shapiro, and A. Vainshtein continued their development of an ambitious theory of cluster structures in the ring of regular functions on a simple complex Lie group G, and of respective compatible Poisson-Lie structures. Conjecturally, each class in the Belavin-Drinfeld classification of Poisson-Lie structures on G naturally gives rise to a cluster structure. The paper [arXiv:1307.1020] for the first time establishes this conjecture in a non-standard case, namely the case of the Cremmer-Gervais structure on SL_n.

Quantum nilpotent algebras and quantum cluster algebras. In [arXiv:1208.6267], K. Goodearl and M. Yakimov have found a surprising connection between cluster theory and the theory of noncommutative and Poisson unique factorization domains, by establishing the existence of a quantum cluster structure in each member of a certain axiomatically defined class of quantum nilpotent algebras. One recent application is a proof that in the case of coordinate rings of double Bruhat cells, the notions of the upper and ordinary cluster algebra coincide. This settles a conjecture of Berenstein, Fomin and Zelevinsky.

Desingularizations of quiver Grassmannians via graded quiver varieties. In the eponymous paper by B. Keller and S. Scherotzke [arXiv:1305.7502], conceived during the MSRI program and employing techniques developed by H. Nakajima and F. Qin, the authors extend earlier work of G. Cerulli Irelli, E. Feigin, and M. Reineke to construct desingularizations of a much wider class of quiver Grassmannians, and in particular Grassmannians of modules over iterated tilted algebras of Dynkin type.

Kirillov-Reshetikhin modules. B. Leclerc and D. Hernandez further developed their cluster algebra approach to representation theory of quantum affine algebras. Their most recent work [arXiv:1303.0744] yields an algorithm, based on cluster algebra techniques, for computing q-characters of Kirillov-Reshetikhin modules for any untwisted quantum affine algebra.

Positivity and bases in rank 2 cluster algebras. In the paper [arXiv:1303.5806] completed and reported at MSRI, K. Lee, L. Li, and A. Zelevinsky settled in the negative an old question posed by V. Fock and A. Goncharov: Do the extremal rays of the positive cone of a cluster algebra $\mathcal{A}$ (i.e., the cone of elements represented as positive Laurent polynomials in terms of any cluster) yield a basis in $\mathcal{A}$? The authors show that in rank 2, the answer is *no* whenever $\mathcal{A}$ is not tame.

Mutations for species with potentials. The aforementioned joint work with K. Lee and L. Li was one of A. Zelevinsky's last research projects completed before his untimely death in April 2013. Another such project, joint with D. Labardini-Fragoso [arXiv:1306.3495], is an attempt to extend the celebrated work of H. Derksen, J. Weyman, and A. Zelevinsky on mutations of quivers with potentials to the realm of valued quivers corresponding to exchange matrices that are skew-symmetrizable but not necessarily skew-symmetric.

Positive bases in cluster algebras associated with surfaces. In a paper being prepared for the special issue of PNAS dedicated to cluster algebras, D. Thurston proves the long-suspected property of the "bracelet" elements of the skein algebra of a surface with marked points: these elements give rise to a linear basis with nonnegative structure constants. Since the latter basis contains the cluster monomials, this result is closely related to the corresponding instance of the strong positivity conjecture for cluster algebras.

Clusters and webs. In joint work completed at MSRI, S. Fomin and P. Pylyavskyy [arXiv:1210.1888] initiated the study of cluster structures in classical rings of SL_k-invariants of collections of vectors and covectors in a k-dimensional vector space. In the special case $k = 3$, their theory is intimately related to G. Kuperberg's calculus of webs, and to classical planar projective geometry. While these cluster algebras are generally of infinite mutation type, the authors suggest a conjectural combinatorial description of all of their cluster variables.

Deodhar decomposition of the Grassmannian. The main result of the paper [arXiv:1210.5433] by K. Talaska and L. Williams is an explicit parameterization of each Deodhar component in a Grassmann manifold. This parametrization is based on a combinatorial machinery, developed by the authors, of certain networks associated to individual Deodhar components. The approach leads to explicit descriptions of those components in terms of vanishing and non-vanishing of Plücker coordinates.

3. Organizational structure

In addition to the three workshops, a number of ongoing activities were run during the Fall semester in order to help MSRI members efficiently spend their time in residence. They included: a weekly research seminar; a postdoc seminar; a working group on Fock–Goncharov conjectures; a Chancellor's Professor course at UC Berkeley; four MSRI-Evans lectures; and a questions and answers lunch session. Besides, many members took part in the weekly combinatorics seminar at UC Berkeley co-organized by Lauren Williams.

Weekly research seminar. A weekly research seminar on cluster algebras was organized by Michael Gekhtman and Robert Marsh. It ran the entire semester. This gave an opportunity for the more senior members to present their current research.

Postdoc seminar. Every Friday at noon a seminar was held featuring two 45-minute talks by postdocs from each of the programs. A pizza lunch was served during the break between the talks. The seminar was run and organized by two postdocs, one from each program: Dylan Rupel (cluster algebras) and Christine Berkesch (commutative algebra).

Working group on Fock–Goncharov conjectures. This was a semester long activity that ran weekly. The participants gave talks on a broad variety of subjects centered around the Fock–Goncharov conjectures. The working group was organized by Florian Block.

Chancellor's Professor course. A semester-long graduate course "Curves on Surfaces" affiliated with the cluster algebras program was taught by Dylan Thurston at UC Berkeley. Several members noted that participation in this course was extremely beneficial to them.

MSRI-Evans lectures. Seven expository MSRI-Evans lectures were given during the semester, four of them by the members of the cluster algebras program:

- Introduction to cluster algebras, by Andrei Zelevinsky
- Categorification of quiver mutation, by Idun Reiten
- Recurrence relations and cluster algebras, by Pierre-Guy Plamondon
- Quiver mutation and quantum dilogarithm identities, by Bernhard Keller.

Questions and answers lunch session. A lunchtime Q&A session ran during the second half of the semester. Several members, notably Gregg Musiker and Gregory Muller, were especially active, presenting many interesting topics in a relaxed and informal setting.

4. Workshops and conferences

The Cluster Algebras program included three workshops. The *Connections for Women* workshop (August 22–24) was run jointly with the Commutative Algebra program. The organizers were Idun Reiten and Lauren Williams from our program, and Claudia Polini and Karen Smith from the companion program. This workshop was immediately followed by the *Introductory Workshop* (August 27 – September 7), also jointly run by the two parallel programs. The organizers were Bernhard Keller and Alek Vainshtein (Cluster algebras) and David Eisenbud and Karen Smith (Commutative algebra). Towards the middle of the semester (October 29–November 02), a *Cluster Algebras in Combinatorics, Algebra and Geometry* workshop was held. It focused on recent advances in the field, and was organized by Claire Amiot, Sergey Fomin, Bernard Leclerc, and Andrei Zelevinsky.

Connections for Women. The goal of this joint workshop was to give an introduction to topics in commutative algebra and cluster algebras via talks and mini-courses; all of them were given by women. Our program contributed four lectures and a mini-course followed by a problem session. The activities related to the cluster algebras program were:

- Cluster algebras, mini-course by Lauren Williams
- Problem session on cluster algebras, led by Kelli Talaska
- Cluster algebras, quiver mutation, and triangulations, talk by Karin Baur
- Relations between cluster algebras and cluster categories, talk by Gordana Todorov
- Mirror symmetry for Grassmannians, talk by Konstanze Rietsch
- Networks and the Deodhar decomposition of real Grassmannians, talk by Kelli Talaska.

In addition, a poster session, in which junior researchers presented their results, and a panel discussion, in which several tenure-track and tenured female professors discussed issues related to being a female mathematician, were held.

Introductory workshop. Part of the impetus for the choice of the two programs at MSRI that semester was the opportunity to bring these two fields closer together. Thus it seemed appropriate to organize a joint introductory workshop, with lectures that would in particular introduce each side to the other. Each "side" fielded six minicourses starting from quite an elementary point and developing to the frontiers of the field. The six minicourses related to the cluster algebras program were

- Introduction to cluster algebras, by Sergey Fomin
- Quiver representations and cluster algebras, by Bernhard Keller
- Preprojective algebras and Lie theory, by Bernard Leclerc
- Cluster categories, by Idun Reiten
- Cluster algebras and Poisson geometry, by Alek Vainshtein
- Cluster algebras and triangulated surfaces, by Dylan Thurston

Each lecturer gave a series of three one-hour talks aimed at exposing a young researcher to a collection of key results and technical tools. In addition to the mini-courses, five one-hour tutorials were given by Gregg Musiker (for Fomin's course), Fan Qin (for Keller's course), Pierre-Guy Plamondon (for Leclerc's course), Sarah Scherotzke (for Reiten's course), and Michael Gekhtman (for Vainshtein's course). A potluck barbeque was organized on September 3 at Codornices Park.

Cluster Algebras in Combinatorics, Algebra, and Geometry. The aim of the main topical workshop was to present a broad view of the role of cluster algebras in various active areas of research, and their interactions with each other. The organizers did not attempt to cover the entire spectrum of applications, as this would require a much longer conference. The speakers and their topics were, in alphabetical order:

- Philippe di Francesco: Periodicity, positivity and integrability of T-systems
- Anna Felikson: Cluster algebras from orbifolds
- Christof Geiss: On generic bases for cluster algebras
- Michael Gekhtman: Cremmer–Gervais cluster algebras
- David Hernandez: Non-simply laced quantum affine algebras and cluster algebras
- Osamu Iyama: τ-tilting theory, 2
- Bernhard Keller: Quiver varieties and erived categories
- Richard Kenyon: The hexahedron recurrence and the Ising model
- Robert Marsh: Reflection group presentations arising from cluster algebras
- Tomoki Nakanishi: Diagrammatic description of c-vectors and d-vectors of cluster algebras of finite type
- Pierre-Guy Plamondon: Independence for exchange graphs and cluster complexes
- Pavlo Pylyavskyy: Total positivity, loop groups and electrical networks
- Nathan Reading: Mutation-linear algebra: the notion of a basis for B
- Idun Reiten: τ-tilting theory, 1
- Michael Shapiro: Generalized cluster algebras and Teichmüller spaces of Riemann surfaces with orbifold points of an arbitrary order
- Hugh Thomas: Higher-dimensional analogues of cluster structures
- Lauren Williams: Combinatorics of KP solitons from the real Grassmannian

5. Postdoctoral fellows

We were especially pleased by the strong group of young mathematicians who participated in our program as postdoctoral fellows. This group consisted of: Bruce Fontaine, Max Glick, Pierre-Guy Plamondon, Fan Qin, Dylan Rupel, Sarah Scherotzke, Kaisa Taipale and Kelli Talaska. They took a very active part in the program and greatly contributed to a lively athmosphere.

Each postdoctoral fellow was assigned one of the more senior members as a mentor. Below, we list each postdoc, their mentor, their professional placement beyond the program at MSRI, and their research themes. The mentors met regularly with their assigned postdoctoral fellows to discuss mathematics and offer career advice. The weekly postdoctoral research seminar was a joint activity of the two programs. It gave these fellows the opportunity to give a focused 45-minute research talk on their work, with the aim of familiarizing the senior members and their fellow postdocs with their research. The talks were meant to be targeting a non specialized audience. Through anonymous feedback forms, the speakers got information on various aspects of their talks (speed, clarity, level of detail, ...).

(1) **Bruce Fontaine** was mentored by Alek Vainshtein. After the program, he went to Cornell to work with Allen Knutson for 2.5 years. While at the MSRI, he submitted a paper (joint with Joel Kamnitzer): Cyclic sieving, rotation and representation theory. Bruce "found the availability of people associated with cluster algebras and geometry (Dylan Thurston, Sergey Fomin and Andrei Zelevinsky) was very useful".

(2) **Max Glick** was mentored by Misha Shapiro. After the program, he went to visit Berkeley for 1 semester to work with Lauren Williams. While at MSRI, he worked on trying to better understand how geometrically defined discrete dynamical systems can be understood in terms of cluster algebras. Towards the end of the semester, he started a related project, consulting with Pavlo Pylyavskyy, which will likely lead to a publication. According to Max, "my time at MSRI was quite beneficial. I plan to continue working in the field of cluster algebras, and I am sure the people I met and the new ideas I encountered will help to this end".

(3) **Pierre-Guy Plamondon** was mentored by Idun Reiten. After the program, Pierre–Guy started working as an assistant professor at the University Paris South. With Reiten, he worked on the question whether rigid modules over cluster-tilted algebras are determined by their dimension vector (this question is still open). With Dylan Thurston and Andrei Zelevinsky, he discussed the problem of counting friezes in different Dynkin types. A still ongoing project with Bernhard Keller and Fan Qin is devoted to showing that the "generic candidate basis" is actually a basis in cluster algebras admitting suitable categorifications. According to Pierre–Guy, "My experience was enormously beneficial. The proximity of many experts in the field is a unique chance to work and to stay up to date with the recent developments".

(4) **Fan Qin** was mentored by Christof Geiss. After the program, he started a postdoc at Tsinghua University (Beijing). In September 2013, he will start working as an assistant professor at the University of Strasbourg. At MSRI, Fan Qin worked

on a paper devoted to triangular and tropical properties of dual canonical bases of quantum cluster algebras. Fan Qin considered his experience at MSRI as very beneficial.

(5) **Dylan Rupel** was mentored by Andrei Zelevinsky. After the program he worked as a postdoc at Northeastern University (Boston). At MSRI, he began a collaboration with Andrei Zelevinsky, Kyungyong Lee and Li Li working on defining a quantum lift of their greedy basis. They made good headway on this problem. He also continued work on a project with Arkady Berenstein presenting Feigin's homomorphism as a tool for establishing quantum cluster structures on quantized coordinate rings of unipotent Kac-Moody groups. This work has progressed to its final stages and should appear on the arXiv within a short time. In addition, he discovered a polynomial generalization of rank two cluster recursions in the noncommutative setting along with a combinatorial construction of the resulting "cluster variables" which establishes Laurentness and positivity. He hopes to finalize the proofs of these results in the coming months. According to Dylan, his experience at MSRI "was extremely beneficial and productive".

(6) **Sarah Scherotzke** was mentored by Bernhard Keller. After the program, she is working as a postdoctoral fellow at the Hausdorff center in Bonn (2 years). With Keller, she worked on two papers which are now available on the arXiv: the first one devoted to a link between graded Nakajima quiver varieties and derived categories (with a view towards applications in the link between canonical bases and cluster algebras); the second one on the use of graded quiver varieties in the problem of desingularizing quiver Grassmannians. Sarah considers her stay at MSRI as "highly beneficial and productive".

(7) **Kaisa Taipale** was mentored by Philippe Di Francesco. After the program, she went to Cornell to work with Tara Holm for 1 semester. At MSRI, she worked on exploring the connection between quantum cohomology of homogeneous spaces, in particular Grassmannians, and cluster algebras, particularly cluster algebras from the coordinate rings of homogeneous spaces. According to Kaisa, her "experience at MSRI was beneficial in two ways: it allowed me to learn much more about cluster algebras in order to work on this connection between quantum cohomology and cluster algebras (and I learned about the Fock-Goncharov conjectures, which support the idea of a connection!) and it allowed me to get up to speed in high-level research after spending two years at an undergraduate institution that emphasizes teaching".

(8) During the program, **Kelli Talaska** was an NSF postdoc at Berkeley mentored by Lauren Williams. She continued this postdoc position for another term after the program. With Lauren Williams, she worked on (and completed) a paper 'Network parametrizations of the Grassmannian', which she presented in a talk at FPSAC 2013 in June 2013. She also thought about followup projects related to the Grassmannian and its non negative part. Kelli thought the program was quite beneficial to her although, because of her teaching duties (she did not receive support from the MSRI), she was not able to take full advantage of it.

6. Graduate students

Five graduate students participated in the program: **Alfredo Chavez** (a student of Bernhard Keller), **Idan Eisner** (a student of Alexander Vainshtein), **Xiao Feng** (a student of Michael Shapiro), **Mikhail Gorsky** (a student of Bernhard Keller), and **Salvatore Stella** (a student of Andrei Zelevinsky). The students participated in the weekly postdoc seminar and interacted regularly with the members of the program.

- Alfredo Chavez has submitted two papers: "On the c-vectors of an acyclic cluster algebra" and "c-vectors and dimension vectors for cluster-finite quivers".
- Idan Eisner is working on the manuscript "Exotic cluster structures on SL_5".
- Xiao Feng is studying the twist map for Grassmannians via Postnikov's networks.
- Mikhail Gorsky is completing the manuscript "Semi-derived Hall algebras".
- Salvatore Stella collaborated with Tomoki Nakanishi and wrote two papers with him: "Diagrammatic description of c-vectors and d-vectors of cluster algebras of classical type" and "Wonders of sine-Gordon Y-systems".

7. Diversity

Our MSRI program included a Connections for Women workshop specifically targeted at women and minorities. See Section 4 for a detailed description of this workshop, which was joint with the Commutative Algebra program. Participants were overwhelmingly enthusiastic about the Connections workshop. Besides it, there were several lunches throughout the semester that brought together women from MSRI and women from UC Berkeley, particularly graduate students. Each lunch had a focused topic of discussion, e.g. navigating the postdoc and tenure-track years. The lunches were very well attended (with on average 20 participants).

Altogether, the program included eleven female members (not counting workshop participants): Karin Baur, Anna Felikson, Rei Inoue Yamazaki, Rinat Kedem, Sophie Morier-Genoud, Idun Reiten, Sarah Scherotzke, Kaisa Taipale, Kelli Talaska, Gordana Todorov, and Lauren Williams. Of these three (Scherotzke, Taipale, and Talaska) were postdoctoral fellows, which makes 37.5% of the total number of postdocs.

8. Synergistic activities

Cluster algebras are commutative algebras—subalgebras of a field of rational functions—endowed with a special structure that includes a set of generators of a very particular form. The original motivation to study this structure came from Lie theory. Unsurprisingly, cluster algebras have been extensively studied from a Lie-theoretic viewpoint. Following their appearances in other contexts, cluster algebras have been thoroughly studied from other points of view as well: as discrete dynamical systems, as combinatorial gadgets (cluster complexes), as coordinate rings of generalized Teichmüller spaces, and so on.

Curiously, one way in which cluster algebras have *not* been studied very much is... as algebras (i.e., as commutative rings). The theory is hardly known in the commutative algebra community, and those studying cluster algebras have not made much use of the great storehouse of information about commutative algebra. Part of the impetus for the

choice of the two programs at MSRI this semester was an opportunity to bring these two fields closer together. We felt this arrangement was quite successful. As an example of successful interaction between the two communities, let us mention that commutative algebraist Karen Smith was able to answer a question raised in the lecture of Sergey Fomin regarding whether suitable cluster algebras are free over the subalgebra generated by their frozen variables. This led to a series of interesting conversations between Smith and Greg Muller, with input from Fomin, Tucker, and Miller, regarding whether or not certain cluster algebras might be F-regular. There is much potential for further collaboration between commutative algebraists and cluster algebraists which could lead to a better understanding of some of the commutative algebraic properties of cluster algebras.

9. Nuggets and breakthroughs

Laurent phenomenon algebras. These generalizations of cluster algebras, discovered by Pavlo Pylyavskyy and Thomas Lam, were presented by Pavlo at the first seminars of the program. The starting point is the *Laurent phenomenon*: each cluster variable is expressed as a Laurent polynomial in the variables of any cluster. Fomin and Zelevinsky [2002] showed that the Laurent phenomenon holds in a much wider setting than that of cluster algebras; they did not however propose any general rule for producing global exchange patterns satisfying the Laurent phenomenon. It is just such a rule that Lam–Pylyavskyy have devised [`arXiv:1206.2611`]. Their construction is an ingenious modification of the naive guess for such a rule (the guess does not work, as several mathematicians discovered before them). The Lam–Pylyavskyy rule is very general as it allows one to propagate arbitrary (irreducible) exchange polynomials in all directions. It includes essentially all classes of examples treated by Fomin–Zelevinsky as well as recurrences studied by Chekhov–Shapiro, Hone, and Henriques–Speyer. It is tempting to try to extend the rich theory of cluster algebras to the Lam–Pylyavskyy setting. Possible directions include: classificationof cluster-finite LP algebras; combinatorics of associated polytopal complexes; the problem of linear independence of cluster monomials; questions about (total) positivity, etc.

Mirror symmetry and cluster algebras. At the end of the first month of the program, Mark Gross (UCSD) visited MSRI to report on his ongoing work with Sean Keel and Maxim Kontsevich concerning the links between mirror symmetry and cluster algebras. In an exciting informal discussion with several members of the program (B. Keller, G. Musiker, H. Thomas, A. Zelevinsky,. . .), the properties of several different types of bases for (rank 2) cluster algebras were discussed and compared with the properties of the θ–function basis, which Gross *et al.* obtain via a general conjectural construction of a basis in the space of global polynomial functions on an affine Calabi-Yau manifold with maximal boundary. The discussion was followed by a talk by Gross at the cluster algebra seminar, where he notably presented the key ingredient of the construction: the scattering diagram (due in rank two to Kontsevich–Soibelman and in higher rank to Gross–Siebert). Further discussions between Gross and the members of the program followed. It seems certain that the work of Gross and collaborators will deeply influence the theory of cluster algebras and thus, indirectly, the many subjects they are related to.

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

Cluster Algebras

Fontaine, Bruce

Name: Bruce Fontaine
Year of Ph.D: 2012
Institution of Ph.D.: University of Toronto
Dissertation title: Bases for invariant spaces and geometric representation theory
Ph.D. advisor: Joel Kamnitzer

Institution prior to obtaining the MSRI PD fellowship: University of Toronto
Position at that institution: PhD Student
Mentor (if applicable): Joel Kamnitzer

Institution (or company) where you are going after the MSRI PD fellowship: Cornell University
Position: Assistant Professor
Anticipated length: (if it is a tenure track position just write tenure-track) 2.5 years
Mentor (if applicable): Allen Knutson

Fellow's comments:

While at MSRI I attempted to understand the links between geometric models associated to representation theory, for instance via the geometric Satake correspondence and cluster algebras. I have had some success with the program of research and hope to continue it with Allen Knutson at Cornell. I found the available of people associated with cluster algebras and geometry (Dylan Thurston, Sergy Fomin and Andrei Zelevinsky) was very useful. While there, I submitted the following work with Joel Kamnitzer to Selecta Mathematica: Cyclic sieving, rotation, rotation and representation theory.

Glick, Max

Name: Max Glick
Year of Ph.D: 2012
Institution of Ph.D. : University of Michigan
Dissertation title: The pentagram map: combinatorial and geometric perspectives
Ph.D. advisor: Sergey Fomin

Institution prior to obtaining the MSRI PD fellowship: University of Michigan
Position at that institution: Graduate student
Mentor (if applicable): Sergey Fomin

Institution (or company) where you are going after the MSRI PD fellowship: Berkeley
Position: Visiting postdoc
Anticipated length: (if it is a tenure track position just write tenure-track) 1 semester
Mentor (if applicable): Lauren Williams

Fellow's comments:

I worked on trying to better understand how geometrically defined discrete dynamical systems can be understood in terms of cluster algebras. Towards the end of the semester, I started a related project, consulting with Pavlo Pylyavskyy, which I am hopeful will lead to a publication eventually. My time at MSRI was quite beneficial. I plan to continue working in the field of cluster algebras, and I am sure the people I met and the new ideas I encountered will help to this end.

Plamondon, Pierre-Guy

Name: Pierre-Guy Plamondon
Year of Ph.D: 2011
Institution of Ph.D.: Université Paris Diderot - Paris 7
Dissertation title: Catégories amassées aux espaces de morphismes de dimension infinie, applications.
Ph.D. advisor: Bernhard Keller

Institution prior to obtaining the MSRI PD fellowship: Université de Caen
Position at that institution: Postdoc
Mentor (if applicable): Bernard Leclerc

Institution (or company) where you are going after the MSRI PD fellowship: Université Paris Sud
Position: Maître de conférences
Anticipated length: (if it is a tenure track position just write tenure-track) permanent.
Mentor (if applicable): ---

Fellow's comments:

The semester on cluster algebras at MSRI has provided me with a unique opportunity to discuss with the many experts in the field that were gathered there. The institute was constantly busy with seminars, and I had the opportunity to give several talks, including one at the MSRI-Evans lectures.

During my stay at MSRI, I have worked on several subjects related to cluster algebras. Firstly, I had the chance to work with Idun Reiten, as she was my mentor during my stay. One of the main questions we discussed is whether rigid modules over a cluster-tilted algebras are determined by their dimension vector - this question is still open. Secondly, I had the chance to study the concept of friezes (after Coxeter-Conway), and worked on the question of counting their total number in different types. Discussions with Dylan Thurston led to a (still conjectural) method to count friezes. Finally, work with Bernhard Keller and Fan Qin on cluster characters led to a result concerning "generic bases" for cluster algebras. None of these results is published (yet) in any form.

My experience was enormously beneficial. The proximity of many experts in the field is a unique chance to work and to stay up to date with the recent developments.

Qin, Fan

Name: Fan Qin
Year of Ph.D: 2012
Institution of Ph.D.: University Paris 7
Dissertation title: Algebres amassees quantiques acycliques
Ph.D. advisor: Bernhard Keller

Institution prior to obtaining the MSRI PD fellowship: University Paris 7
Position at that institution: Ph.D. student
Mentor (if applicable): Bernhard Keller

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

Fellow's comments:

The main result of the following preprint is obtained while I was in MSRI.
Paper in preparation:
"Triangular and tropical properties of dual canonical bases of quantum cluster algebras"
Abstract:
Assume that a quantum cluster algebra admits a monoidal categorification by quantum affine algebras or quantum unipotent subgroups of simply-laced type. We show that, for any chosen cluster, the dual canonical basis is a triangular basis with respect to certain linearly independent set, and the basis elements are naturally parametrized by the extended g-vectors.

Was your experience at MSRI beneficial? Yes.

Rupel, Dylan

Name: Dylan Rupel
PhD: University of Oregon, 2012
Dissertation: Quantum Cluster Characters
PhD Advisor: Arkady Berenstein

Prior Institution (Graduate school): University of Oregon
Position: Graduate Teaching Fellow

Current Institution: Northeastern University
Position: Postdoctoral Teaching Associate
Mentor: Andrei Zelevinsky

Fellow's comments:

My experience at MSRI was extremely beneficial and productive. During this time I began a collaboration with Andrei Zelevinsky, Kyungyong Lee, and Li Li working on defining a quantum lift of their greedy basis. We have not produced a publication yet but we do seem to be making headway on this problem. I continued work on a project with Arkady Berenstein presenting Feigin's homomorphism as a tool for establishing quantum cluster structures on quantized coordinate rings of unipotent Kac-Moody groups. This work has progressed to its final stages and should appear on the arXiv within a short time. In addition I discovered a polynomial generalization of rank two cluster recursions in the noncommutative setting along with a combinatorial construction of the resulting "cluster variables" which establishes Laurentness and positivity. I hope to finalize the proofs of these results in the coming months. Finally I completed a review of the ClusterQuiver package for the Sage math software and a refereeing request from the "Publications of the Research Institute for Mathematical Sciences" at Kyoto University.

Scherotzke, Sarah

Name: Sarah Scherotzke
Year of Ph.D: 2009
Institution of Ph.D.: University of Oxford
Dissertation title: On Auslander-Reiten Theory for Algebras and Derived Categories
Mathematics Subject Classification: 16—Associative rings and algebras
Ph.D. advisor: Karin Erdmann

Institution prior to obtaining the MSRI PD fellowship: Bonn U.
Position at that institution: Postdoc

Institutions after the MSRI PD fellowship: Bonn U.
Position: Postdoc

No comments

Taipale, Kaisa

Name: Kaisa Taipale
Year of Ph.D: 2010
Institution of Ph.D.: University of Minnesota
Dissertation title: Quantum cohomologies and the abelian-nonabelian correspondence
Ph.D. advisor: Ionut Ciocan-Fontanine

Institution prior to obtaining the MSRI PD fellowship: St. Olaf College
Position at that institution: visiting assistant professor
Mentor (if applicable):

Institution (or company) where you are going after the MSRI PD fellowship: Cornell University
Position: visiting assistant professor
Anticipated length: (if it is a tenure track position just write tenure-track) 1 semester
Mentor (if applicable): Tara Holm

Fellow's comments:

At MSRI I worked on exploring the connection between quantum cohomology of homogeneous spaces, in particular Grassmannians, and cluster algebras, particularly cluster algebras from the coordinate rings of homogeneous spaces. I have a number of problems that I am pursuing, but none have resulted in publications yet.

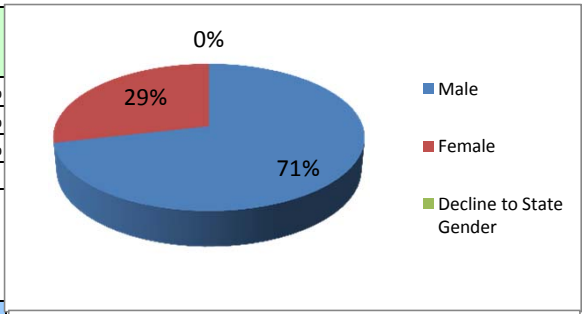
My experience at MSRI was beneficial in two ways: it allowed me to learn much more about cluster algebras in order to work on this connection between quantum cohomology and cluster algebras (and I learned about the Fock-Goncharov conjectures, which support the idea of a connection!) and it allowed me to get up to speed in high-level research after spending two years at an undergraduate institution that emphasizes teaching.

Postdoc Pre/Post-MSRI Institution Group

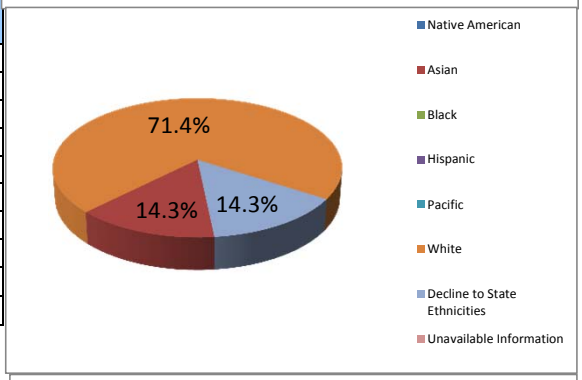
Family Name	First Name	Pre-MSRI Institution Group	Post-MSRI Institution Group	Home Institution Name	Placement Institution Name
Fontaine	Bruce	Foreign	Group I Private	University of Toronto	Cornell University
Glick	Max	Group I Public	Group I Public	University of Michigan	UC Berkeley
Plamondon	Pierre-Guy	Foreign	Foreign	Universite de Caen	Universite de Paris XI (Paris-Sud)
QIN	Fan	Foreign	Foreign	Universite de Paris VII (Denis Diderot)	Tsinghua University
Rupel	Dylan	Group I Public	Non-group	University of Oregon	Northeastern University
Scherotzke	Sarah	Foreign	Foreign	University of Bonn	University of Bonn
Taipale	Kaisa	Non-group	Group I Private	Olaf College	Cornell University

Cluster Algebras Postdoctoral Fellows Demographic Summary

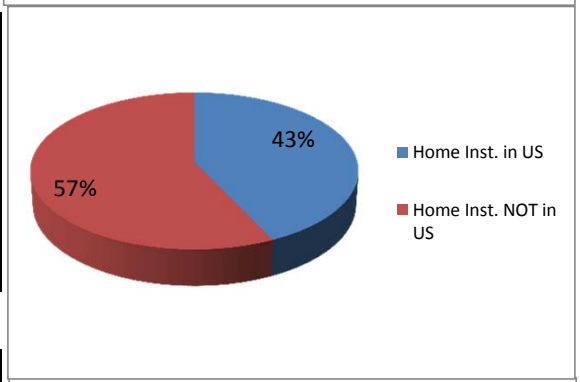
Gender	#	% (No Decl.)*	%
# of Distinct Members	7		100.0%
Male	5	71.43%	71.4%
Female	2	28.57%	28.6%
Decline to State Gender	0		



Ethnicities	#	% (No Decl.)*	%
Native American	0		
Asian	1	16.67%	14.3%
Black	0		
Hispanic	0		
Pacific	0		
White	5	83.33%	71.4%
Decline to State Ethnicities	1		14.3%
Unavailable Information	0		
Minorities	0		

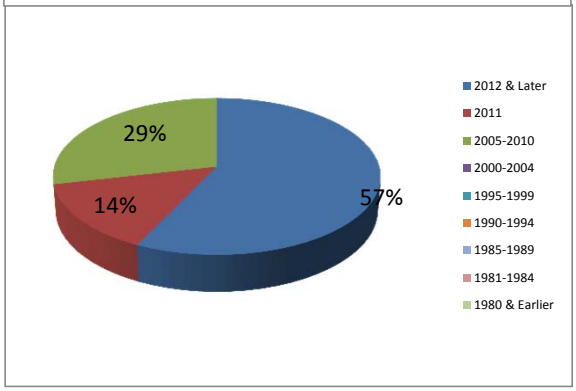


Citizenships	#		%
US Citizen & Perm. Residents	3		42.9%
Foreign	4		57.1%
Unavailable information	0		
# of Distinct Members	7		100.0%
US Citizen	3		42.9%
Perm Residents	0		0.0%
Home Inst. in US	3		42.86%



Year of Ph.D	#		%
2012 & Later	4		57.1%
2011	1		14.3%
2005-2010	2		28.6%
2000-2004	0		0.0%
1995-1999	0		0.0%
1990-1994	0		0.0%
1985-1989	0		0.0%
1981-1984	0		0.0%
1980 & Earlier	0		0.0%
Unavailable Info.	0		0.0%
Total # of Distinct Members	7		100.0%

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



Cluster Algebras

Program Summary

Role	# of Distinct Members	%	# of Citizens & Perm. Res.	%	US Citizens	# of Female	%	# of Minorities[1]	%
Organizers	5	10.9%	3	60.0%	2	1	20.0%	0	0.0%
Research Professors	7	15.2%	4	57.1%	4	1	14.3%	0	0.0%
Postdoctoral Fellows	7	15.2%	3	42.9%	3	2	28.6%	0	0.0%
NSF Postdoctoral Fellows	0	0.0%	0	0.0%	0	0	0.0%	0	0.0%
PD/RM	0	0.0%	0	0.0%	0	0	0.0%	0	0.0%
Research Members	22	47.8%	10	45.5%	9	7	31.8%	0	0.0%
Program Associates	5	10.9%	0	0.0%	0	0	0.0%	0	0.0%
Guests	0	0.0%	0	0.0%	0	0	0.0%	0	0.0%
Total # of Distinct Members	**46**		**20**	***43.5%***	**18**	**11**	***23.9%***	**-**	***0.0%***

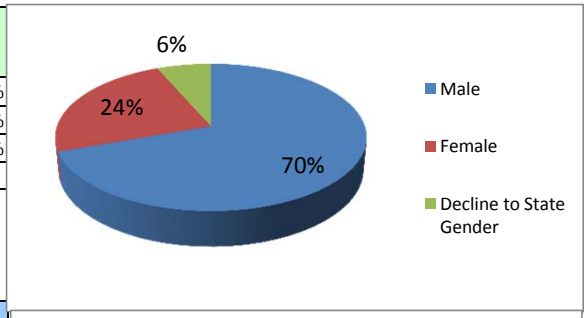
[1] *Minorities are US citizen who declare themselves American Indian, Black, Hispanic, or Pacific Islander. Minority percentage is calculated by dividing the number of Minorities by the total number of US citizens.*

Home Institute Grouping

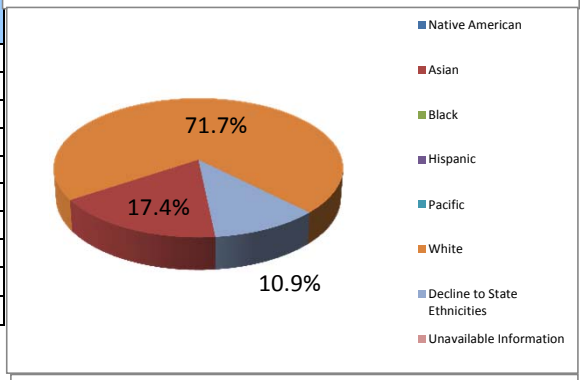
	US								
Role	**Group I Private**	**Group I Public**	**Group II**	**Group III**	**Group M**	**Group B**	**Non-Group**	**Foreign**	**Total**
Organizers	0	2	0	0	0	0	0	3	5
Research Professors	1	2	1	0	0	0	0	3	7
Postdoctoral Fellows	0	2	0	0	0	0	1	4	7
NSF Postdoctoral Fellows	0	0	0	0	0	0	0	0	0
PD/RM	0	0	0	0	0	0	0	0	0
Research Members	1	5	4	0	0	0	0	12	22
Program Associates	0	1	1	0	0	0	0	3	5
Total	**2**	**12**	**6**	**-**	**-**	**-**	**1**	**25**	**46**
%	***4.3%***	***26.1%***	***13.0%***	***0.0%***	***0.0%***	***0.0%***	***2.2%***	***54.3%***	***100.0%***

Cluster Algebras Demographic Summary

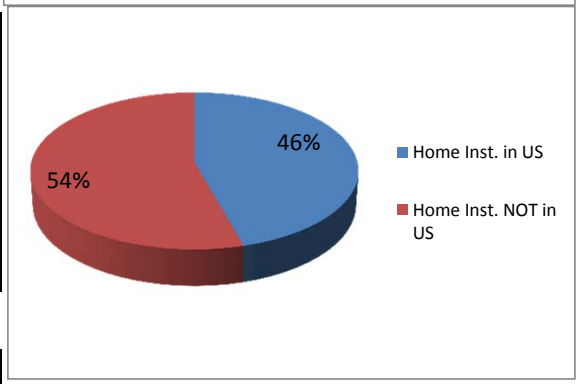
Gender	#	% (No Decl.)*	%
# of Distinct Members	46		93.5%
Male	32	74.42%	69.6%
Female	11	25.58%	23.9%
Decline to State Gender	3		



Ethnicities	#	% (No Decl.)*	%
Native American	0		
Asian	8	19.05%	17.4%
Black	0		
Hispanic	1		
Pacific	0		
White	33	78.57%	71.7%
Decline to State Ethnicities	5		10.9%
Unavailable Information	0		
Minorities	0		

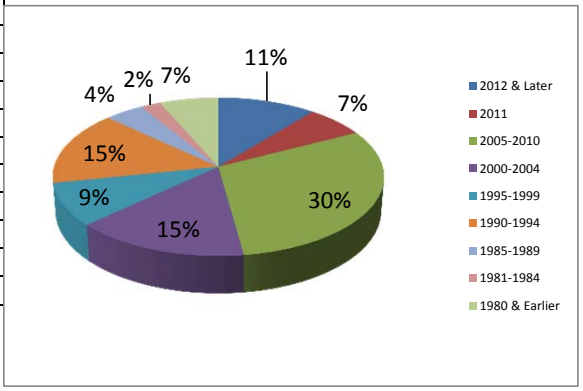


Citizenships	#		%
US Citizen & Perm. Residents	20		43.5%
Foreign	26		56.5%
Unavailable information	0		
# of Distinct Members	46		100.0%
US Citizen	18		39.1%
Perm Residents	2		4.3%
Home Inst. in US	21		45.65%



Year of Ph.D	#		%
2012 & Later	5		
2011	3		6.5%
2005-2010	14		30.4%
2000-2004	7		15.2%
1995-1999	4		8.7%
1990-1994	7		15.2%
1985-1989	2		4.3%
1981-1984	1		2.2%
1980 & Earlier	3		6.5%
Unavailable Info.	0		
Total # of Distinct Members	46		89.1%

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



MSRI
Mathematical Sciences Research Institute

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Noncommutative Algebraic Geometry and Representation Theory

January 14 to May 24, 2013
MSRI, Berkeley, CA
USA

Organizers:

Mike Artin (Massachusetts Institute of Technology)
Viktor Ginzburg (University of Chicago)
Catharina Stroppel (Universität Bonn , Germany)
Toby Stafford* (University of Manchester, United Kingdom)
Michel Van den Bergh (Universiteit Hasselt, Belgium)
Efim Zelmanov (University of California, San Diego)

NONCOMMUTATIVE ALGEBRAIC GEOMETRY AND REPRESENTATION THEORY WINTER 2013

MIKE ARTIN, VICTOR GINZBURG, CATHARINA STROPPEL, TOBY STAFFORD,
MICHEL VAN DEN BERGH, EFIM ZELMANOV

Contents

1. Introduction

The semester-long program in Noncommutative Algebraic Geometry and Representation Theory was held at MSRI in the Winter (January 24–May 31) of 2013, organised by the above six people. Broadly speaking the program covered those aspects of noncommutative algebra with significant geometric influence; for example there was considerable interest in topics like the following:

- *Noncommutative projective algebraic geometry.*
- *Calabi-Yau algebras/varieties and categories.*
- *Noncommutative resolutions.*
- *Symplectic reflection algebras*
- *Deformation theory.*
- *Growth functions of infinite dimensional algebras.*

In the sections below we will report on the various activities of the program in more detail.

2. Organisational Structure

We ran one thematic workshop, and an introductory workshop, as well as a two-day Connections for Women (CfW) workshop and a summer program for graduate students. Reports on these individual workshops are attached.

The CfW workshop incorporated a poster session and a panel discussion, along with a full slate of lectures. It received many positive comments, of which we will just repeat one: "In my opinion, that workshop was one of the most helpful things I've ever participated in during my graduate career, and I just want to say thank you for organizing it and for providing encouragement to bewildered young mathematicians like myself."

The Introductory Workshop ran immediately after the CfW workshop and ran a number of short lecture series to introduce postdocs, graduate students and non-experts to some of the major themes of the program. As many participants to this workshop also attended the "Connection for Women" workshop we made sure that the programs of the two workshops were well integrated.

Finally, the topical workshop provided high-level talks on the various topics mentioned in introduction and the interactions between them.

Outside of those workshops we ran two seminars a week, together with a postdoc seminar. The seminar were typically given by the more senior members of the program and by short-term visitors. The postdoc seminar was given on Fridays, as was the corresponding seminar from the sister program in Commutative Algebra. These were typically attended by most of the postdocs from the two programs as well as by a significant number of Research Members of the programs. MSRI also arranged for "Pizza lunch" for the postdocs in between these to seminars, which was greatly appreciated.

As may be expected by closeness of the two areas, there was also considerable interaction with the Commutative Algebra program. In particular there was a month-long intensive study of Matrix Factorisation and Noncommutative Resolutions (which are closely related topics), involving special lectures, visitors and general discussions.

3. Mathematical Nuggets

1) Sue Sierra and Chelsea Walton solved a 20-year old question in: "The universal enveloping algebra of the Witt algebra is not noetherian (arxiv:1304.0114).

2) Sasha Polishchuk and Junwu Tu developed a Fedosov-type construction of noncommutative-smooth thickenings of smooth algebraic varieties. In particular, this classified line bundles over the

standard noncommutative smooth thickening of an abelian variety and allowed them to construct the noncommutative version of the Fourier-Mukai transform. (arXiv:1308.4244).

3) Dan Rogalski, Sue Sierra and Toby Stafford classified the noetherian graded orders in the three dimensional Sklyanin algebra. This answers a significant case of the Artin program of classifying noncommutative surfaces; a central question in noncommutative algebraic geometry (arXiv:1308.2213).

4) Kevin McGerty and Tom Nevins established an effective criterion, in the context of an algebraic group acting on a ring of differential operators, that guarantees when certain D-modules (those with "unstable micro-support") have no invariant elements. Roughly speaking, this says that the corresponding system of differential equations has no invariant solutions. As a corollary, this partially validates the expectation of Ginzburg-Kaledin, Kashiwara-Rouquier, and Gordon-Stafford that there should be a "localization theory," analogous to the famous Beilinson-Bernstein theory, for many noncommutative algebras. (This is still being written up).

5) In "Moduli operad over $\mathbb{F}_1$" (arxiv:1302.6526) Matilde Marcolli and Yuri Manin answered a question of Manin's by showing that the genus zero moduli operad $M_{0,n+1}$ can be endowed with natural descent data that allow it to be considered as the lift to $Spec\,\mathbb{Z}$ of an operad over $\mathbb{F}_1$.

6) Ragnar Buchweitz, Graham Leuschke and Michel Van den Bergh continued their work on Non-commutative desingularization of determinantal varieties.

7) Sasha Premet wrote "Multiplicity-free primitive ideals associated with rigid nilpotent orbits" (arxiv:1310.3346). This proves among other things that for any nilpotent orbit $\mathbb{O}$ in a semisimple complex Lie algebra $\mathfrak{g}$ there exists a multiplicity-free (and hence completely prime) primitive ideal of $U(\mathfrak{g})$ whose associated variety equals the Zariski closure of $\mathbb{O}$ in $\mathfrak{g}$. (We remark that identifying completely prime ideals in each such class is a major part of Joseph's program for understanding semisimple Lie algebras.) In upcoming work this result will be used by Premet to resolve questions of Humphreys.

8) In "Rouquier's conjecture and diagrammatic algebra" (arxiv:1306.0074), Ben Webster proved a conjecture of Rouquier relating the decomposition numbers in category O for a cyclotomic rational Cherednik algebra to Uglov's canonical basis of a higher level Fock space.

4. Postdoctoral Fellows

We were lucky to have a very strong cohort of ten Postdocs attending the program, in part because three of the original applicants were awarded and came to MSRI on NSF Postdoctoral Fellowships. These were treated in the same way as those funded through MSRI; in particular they

joined in the same seminars and also were given mentors. Each of the postdocs was mentored by one of the Research Professors, with members of the organising committee acting as mentors when the given Research Professors were not in residence. The feedback from the postdocs indicated that this worked well.

The postdocs in our program ran a seminar series, which ran adjacent to the corresponding seminars for the sister program on Commutative Algebra. The postdocs from the two programs usually attended the talks from both series, and other members of the program were encouraged to attend the talks. This lead to very lively seminars.

The postdocs were as follows:

Kenneth Chan

Mentored by Birge Huisgen-Zimmermann (UC Santa Barbara). His PhD was from the University of New South Wales and he obtained an Assistant Professorship at the University of Washington before coming to MSRI, to which he returned after his postdoc at MSRI. While at MSRI he finished the paper "Quantum binary polyhedral groups and their actions on quantum planes (arXiv:1303.7203)" (joint with Ellen Kirkman, Chelsea Walton and James Zhang who were also visitors at MSRI). He started several other projects, especially with Colin Ingalls, a Research Member at the program.

Maria Chlouveraki

Mentored by James Zhang (University of Washington). Prior to MSRI, Maria obtained her PhD with Michel Broué in Paris 7 and held a postdoc at the University of Edinburgh, and after leaving MSRI she took up a Maître de Conférences at the Université de Versailles.

She mostly worked with Guillaume Pouchin, who was visiting MSRI for 3 months. They are at the process of writing up our article on the representation theory and bases for the Yokonuma-Temperley-Lieb algebra. She also wrote up a survey article on Cherednik algebras, that has been submitted for publication in a book of such articles arising from the program.

Michael Ehrig

Mentored by Bill Crawley-Boevey (Leeds University). Prior to coming to MSRI, he held a postdoc at the University of Bonn, to which he returned after his stay at MSRI. While at MSRI he proved results appearing in the papers "Nazarov-Wenzl algebras, coideal subalgebras and categorified skew Howe duality (arXiv:1310.1972)" "Diagrams for perverse sheaves on isotropic Grassmannians and the supergroup SOSP(m—2n) (arxiv:1306.4043)" (both with Catharina Stroppel).

Andrew Morrison

Mentored by Matilde Marcoli (Caltech). Andrew obtained a 3-year position at ETH Zurich before coming to MSRI and returned to ETH after holding his postdoc at MSRI.

While at MSRI he completed a paper on "A Gaussian distribution for refined Donaldson-Thomas invariants and 3D partitions (arXiv:1303.3882)"

Jeremy Pecharich

Mentored by Bill Crawley-Boevey (Leeds University). He held a fellowship at Mount Holyoke College prior to coming to MSRI. While at MSRI he obtained a Visiting Assistant Professorship at Pomona College.

While at MSRI he finished and submitted for publication a paper on the moment map in symplectic geometry. He worked on "Deformation quantization of modules on symplectic varieties" (with Vladimir Baranovsky) and with Alexei Oblomkov on "Representation stacks for Calabi-Yau algebras." Both these projects are currently being written up.

Alice Rizzardo

Mentored by Sasha Polishchuk (University of Oregon). Prior to coming to MSRI, she held a fellowship at SISSA, to which she returned after her stay at MSRI.

While at MSRI she wrote the final draft of her paper "Representability of cohomological functors over extension fields" and worked on a project on "Homological Projective Duality for Lagrangian Grassmannians"

Ian Shipman

Mentored by Ragnar Buchweitz (Toronto). Prior to coming to MSRI he held a Moore Instructorship at MIT. He also obtained an NSF Postdoc which he used at both MSRI and subsequently at the University of Michigan.

While at MSRI he worked on a project on Ulrich bundles and started a project with Birge Huisgen-Zimmermann (a Research Professor at MSRI) and Eric Babson. Neither project is written up as yet.

Theodore Stadnik

Mentored by Tom Nevins (University of Illinois). Prior to coming to MSRI he had a Postdoc at UC Berkeley, although unfortunately he was not able to obtain an academic position after leaving MSRI.

At MSRI he was able to prove derived localization theorems in arbitrary characteristics for large families of spaces. This will appear in a paper with working title "Methods for derived localization in arbitrary characteristics."

Adam-Christiaan van Roosmalen

Mentored by Sarah Witherspoon (University of Texas A& M). He held a position at the University of Regina (Canada) before coming to MSRI. While at MSRI he obtained a position at the University of Bielefeld.

While at MSRI he completed a paper "Numerically finite hereditary categories with Serre duality (arxiv:1304.0257)." He also started a project on Hall algebras of directed categories with Guillaume Pouchin, (who was also at MSRI), the preprint for which is in preparation.

Chelsea Walton

Mentored by Sarah Witherspoon (University of Texas A& M). Before coming to MSRI she held an NSF postdoc and a Moore Instructorship at MIT, to which she returned after her stay in MSRI.

While at MSRI she conducted research that resulted in the papers on "The universal enveloping algebra of the Witt algebra is not noetherian (arxiv:1304.0114)" (with Sue Sierra), and "Poincare-Birkoff-Witt deformations of smash product algebras from Hopf actions on Koszul algebras (arxiv:1308.6011)" (with Sarah Witherspoon). She finished the paper "Quantum binary polyhedral groups and their actions on quantum (arXiv:1303.7203)" (joint with Ellen Kirkman, Ken Chan and James Zhang). All these coauthors were visitors (Research Members or Research Professors) at MSRI during her visit.

Alex Young

Mentored by Ken Goodearl (UC Santa Barbara). Before coming to MSRI he held an NSF Postdoc at the University of Washington, to which he returned after his visit to MSRI.

While at MSRI he worked on a project establishing connections between groups and infinity-groupoids, with the end goal of a better method of estimating group growth. This is in the process of being written up.

5. Graduate Students

During the summer of 2012, Gwyn Bellamy (Glasgow University), Dan Rogalski (UC San Diego), Travis Schedler (University of Texas) and Michael Wemyss (University of Edinburgh) ran a very successful summer program for graduate students on the various topics covered by the program.

Preliminary versions of the notes for these lecture series are available—see

G. Bellamy "Symplectic reflection algebras" arXiv:1210.1239;

D. Rogalski "Noncommutative projective geometry (available from the author);

T. Schedler "Deformations of algebras in noncommutative geometry" arXiv:1212.0914;

M. Wemyss "Lectures on noncommutative resolutions" arXiv:1210.2564.

It is hoped to turn these notes into a graduate text book to be published in the MSRI series.

Many graduate students also attended both the Introductory Workshop and the Connections for Women workshop, with financial support from both the NSF and NSA. Reports on these workshops are attached. A smaller number graduate students attended the program for longer periods while accompanying their advisors.

6. Diversity

Three of the research Professors as well as three of the Postdocs were female. We worked hard to encourage applicants from minorities and under-represented groups, and solicited the advice of knowledgeable people and organisations to identify candidates and encourage applications from these communities. This had mixed success, although one of the postdocs (Chelsea Walton) is African-American.

7. Synergistic Activities

One key reason for the success of the program was the mathematical connections with the concurrently running program on Commutative Algebra. In particular there was a month-long special series of seminars and special events on "noncommutative resolutions and matrix factorizations," as these (closely related) topics are important to both subjects. A number of people also gave "Evan's Lectures" on the UC Berkeley campus and this lead to interactions with mathematicians from UCB.

NONCOMMUTATIVE ALGEBRAIC GEOMETRY AND REPRESENTATION THEORY

Chan, Kenneth

Your Name: Kenneth Chan
Year of Ph.D: 2010
Institution of Ph.D.: University of New South Wales (Australia)
Dissertation title: Resolving Singularities of Orders on Surfaces
Ph.D. advisor: Daniel Chan

Institution prior to obtaining the MSRI PD fellowship: University of Washington
Position at that institution: Acting Assistant Professor
Mentor (if applicable): James Zhang

Institution (or company) where you are going after the MSRI PD fellowship: University of Washington
Position: Acting Assistant Professor
Anticipated length: 2 years
Mentor (if applicable): James Zhang

Postdoctoral fellow's comments:

My coauthors (James Zhang and Chelsea Walton) and I finished a paper titled "Quantum binary polyhedral groups and their actions on quantum planes". I began a project with Colin Ingalls and Greg Stevenson on generalising the well known Bondal-Orlov reconstruction theorem to the setting of noncommutative algebraic geometry. I also began a project with Colin Ingalls on studying the relationship between the derived categories of a terminal order and its associated Brauer-Severi variety. Our aim is to generalise Kuznetsov's results on the relationship between the derived categories of a standard conic bundle and the associated sheaf of Clifford algebras.

Was your experience at MSRI beneficial?

Yes.

Chlouveraki, Maria

Your Name: Maria Chlouveraki
Year of Ph.D: 2007
Institution of Ph.D.: Université Paris 7 - Denis Diderot
Dissertation title: On the cyclotomic Hecke algebras of complex reflection groups
Ph.D. advisor: Prof. Michel Broué

Institution prior to obtaining the MSRI PD fellowship: University of Edinburgh
Position at that institution: Postdoctoral fellow
Mentor (if applicable): Prof. Iain Gordon

Institution (or company) where you are going after the MSRI PD fellowship: Université de Versailles
Position: Maître de conférences
Anticipated length: Permanent

Postdoctoral fellow's comments:

My participation to the MSRI program "Noncommutative Algebraic Geometry and Representation Theory" was very beneficial to me. I had the opportunity to discuss on an every-day-basis with experts in the topics that I am interested in, such as, for example, Dr. Gwyn Bellamy or Prof. Toby Stafford. I attended all workshops of the program, and also of the "Commutative Algebra" program, thus expanding my horizons. There was a lot of interaction with the other postdoctoral fellows, none of whom I had met before, and this could lead to fruitful future collaborations. I also had the opportunity to present my results to a broader audience at the Introductory Workshop and at the Postdoc Seminar. Finally, MSRI gave me the opportunity to visit UCLA, where I also gave a talk and discussed with Prof. Raphaël Rouquier, who gave me many ideas about the research topics that I am working on.

During my stay at the MSRI, I mostly collaborated with Dr. Guillaume Pouchin, who was visiting MSRI for 3 months. We are at the process of writing up our article on the representation theory and the determination of a basis for the Yokonuma-Temperley-Lieb algebra, which is a generalisation of the classical Temperley-Lieb algebra. MSRI's wonderful work environment also allowed me to finish up an article that I was already working on, together with Dr. Loïc Poulain d'Andecy, on the representation theory of the Yokonuma-Hecke algebra. Finally, I worked on the preparation of an article for the proceedings of the Introductory Workshop at the MSRI on the connections between Kazhdan-Lusztig theory and the theory of rational Cherednik algebras.

Morrison, Andrew

Your Name: Andrew Morrison
Year of Ph.D: 2012
Institution of Ph.D.: UBC
Dissertation title: Computing Motivic DT invariants
Ph.D. advisor: Jim Bryan

Institution prior to obtaining the MSRI PD fellowship: ETH Zurich
Position at that institution:
Mentor (if applicable): Rahul Pndharipande

Institution (or company) where you are going after the MSRI PD fellowship:
Position: ETH Zurich
Anticipated length: 2.5-3 years
Mentor (if applicable): Rahul Pndharipande

Postdoctoral fellow's comments:

I wrote one paper, and started at least one more. Very helpful to me was the mentor system as a younger postdoc. This was friendly and encouraging as well as mathematically sportive. Being at MSRI was great professionally,

In retrospect, it was a little hard to get to know people in the short + busy space of time. All in all the tie was grat and I would love to be back again some day in the future.

Pecharich, Jeremy

Your Name: Jeremy Pecharich
Year of Ph.D: 2011
Institution of Ph.D.: University of California, Irvine
Dissertation title: Deformations of vector bundles on coisotropic subvarieties
Ph.D. advisor: Vladimir Baranovsky

Institution prior to obtaining the MSRI PD fellowship: Mount Holyoke College
Position at that institution: Visiting Assistant Professor
Mentor (if applicable): N/A

Institution (or company) where you are going after the MSRI PD fellowship: Pomona College
Position: Visiting Assistant Professor
Anticipated length: 1 year
Mentor (if applicable): N/A

Postdoctoral fellow's comments:

While at MSRI I was working on two independent projects. The first project was to study the virtual fundamental class and the moment map in symplectic geometry; this work was submitted for publication while at MSRI. I also continued work on deformation quantization of modules on symplectic varieties with Vladimir Baranovsky, part of this work is currently being written up and will appear by the end of the summer. This work also branched out into a joint project with Kai Behrend and Barbara Fantechi while I was at MSRI; part of the travel for this research was supported by the Postdoc travel grant provided by MSRI. The time I spent at MSRI was extremely beneficial to my research program from the numerous seminars to talking with other faculty in residence to time spent in the office. I would love to come back at some point in the future.

Rizzardo, Alice

Your Name: Alice Rizzardo
Year of Ph.D: 2012
Institution of Ph.D.: Columbia University
Dissertation title: On Fourier-Mukai type functors
Ph.D. advisor: Aise Johan de Jong

Institution prior to obtaining the MSRI PD fellowship: SISSA
Position at that institution: Postdoctoral fellow
Mentor (if applicable): Ugo Bruzzo

Institution (or company) where you are going after the MSRI PD fellowship: back to SISSA
Position: Postdoctoral fellow
Anticipated length: (if it is a tenure track position just write tenure-track) 2 years (one of them being 2012-2013), renewable for another two
Mentor (if applicable): Ugo Bruzzo

Postdoctoral fellow's comments:

Final draft of a paper: Representability of cohomological functors over extension fields
Worked on a project concerning Homological Projective Duality for Lagrangian Grassmannian 3,6.

Was your experience at MSRI beneficial? Very much so!

Stadnik, Theodore

Your Name: Theodore Stadnik, Jr.
Year of Ph.D: 2012
Institution of Ph.D.:Northwestern University
Dissertation title: Constructions using differential operators in positive characteristic.
Ph.D. advisor: David Nadler

Institution prior to obtaining the MSRI PD fellowship: University of California, Berkeley
Position at that institution: Postdoc (on NSF RTG)
Mentor (if applicable):

Institution (or company) where you are going after the MSRI PD fellowship: I was unable to secure an academic position for next year.

Postdoctoral fellow's comments:

I spent the majority of my time researching methods for proving derived localization theorems in arbitrary characteristics. I was successful in using these methods to prove there are entire families of spaces where localization holds. This result generalizes results about (underived) localization in characteristic zero and results about specific spaces in characteristic $p > 0$. A working title for the publication resulting from this research is "Methods for Derived Localization in Arbitrary Characteristics".

Was your experience at MSRI beneficial?
Yes, it was extremely beneficial.

Van Roosmalen, Adam-Christiaan

Your Name: Adam-Christiaan van Roosmalen
Year of Ph.D: 2008
Institution of Ph.D.: Hasselt University
Dissertation title: On the Classification of Hereditary Categories
Ph.D. advisor: Michel Van den Bergh

Institution prior to obtaining the MSRI PD fellowship: U. of Regina
Position at that institution: Postdoctoral researcher

Institution (or company) where you are going after the MSRI PD fellowship: Bielefeld University
Position: Postdoctoral Researcher
Anticipated length: Three months

Postdoctoral fellow's comments:

During my postdoctoral position at the MSRI, I continued work on the classification of hereditary categories. This led to a paper classifying hereditary categories with Serre duality which are numerically finite (the last condition means that the numerical Grothendieck group has finite rank) up to derived equivalence. The conditions on these categories are all geometrical: the bounded derived category of coherent sheaves on a smooth projective varieties satisfy Serre duality, and Hirzebruch-Riemann-Roch implies that these categories are numerically finite. The classification can thus be seen as a classification of noncommutative curves. (A preprint is available at http://arxiv.org/abs/1304.0257).

While Guillaume Pouchin (University of Edinburgh) was visiting, we worked on Hall algebras of directed categories. We proved that some hereditary categories which are not derived equivalent might have isomorphic (as algebras) derived Hall algebras. A preprint, joint with Guillaume Pouchin and Qunhua Liu, is in preparation.

In joint work with Donald Stanley, we investigate the role of the Serre functor in the theory of t-structures. We ask the following question:
Let A be an abelian category over a field, and let S: Db A --> Db A be a Serre functor. Let (U,V) be a t-structure on Db A with heart H. Is it true that the heart H is derived equivalent with A if and only if
a) (U,V) is bounded, and
b) S U \subseteq U ?

While I was a postdoctoral researcher at the MSRI, we answered this question positively when A is the category of finite dimensional modules over a finite dimensional hereditary algebra. We hope to upload the preprint shortly.

As part of still ongoing research, Greg Stevenson and I considered the stable module category of a small triangulated category C. We show that such a category can be interpreted as the homotopy category of triangles in C; this category is an algebraic triangulated category. We wish to investigate this further. One possible way is to generalise this construction and try to construct similar categories corresponding to (homotopy categories) of higher triangles (in the sense of Heller).

Was your experience at MSRI beneficial?

I believe my time at the MSRI was beneficial. I was able to benefit from talking to experts in my (and related) fields. I was also able to present some recent results, and received valuable feedback and many ideas on interesting directions to continue. I appreciate the many opportunities at the MSRI for such interactions (such as the postdoc talks, the five-minute introductions, and a joint coffee/tea-time), and the general atmosphere and openness among the members.

I also wish to express my gratitude to my mentor Sarah Witherspoon, who gave valuable feedback on my application material, and many suggestions when I presented (early) preprints. I value her help in suggesting interesting references and, when possible, introducing me to the authors.

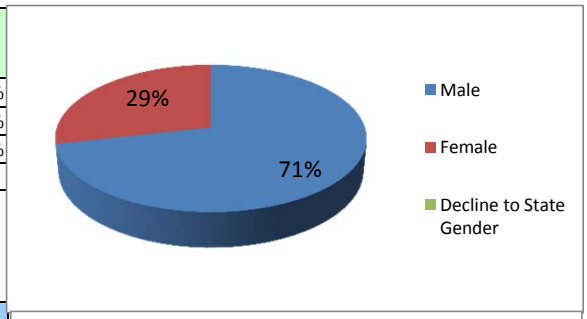
I also want to mention the high quality of the workshops and conferences. I found the given introductory talks very informative and useful, and the topics to be relevant to having a bigger picture of the ongoing research.

Postdoc Pre/Post-MSRI Institution Group

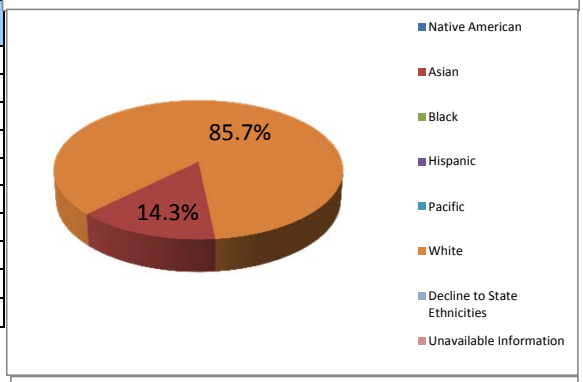
Family Name	First Name	Pre-MSRI Institution Group	Post-MSRI Institution Group	Home Institution Name	Placement Institution Name
Chan	Kenneth	Group I Public	Group I Public	University of Washington	University of Washington
Chlouveraki	Maria	Foreign	Foreign	University of Edinburgh	Universite Versailles/Saint Quentin-en-Yvelines
Morrison	Andrew	Foreign	Foreign	ETH Zurich	ETH Zurich
Pecharich	Jeremy	Non-group	Non-group	Mt. Holyoke College	Pomona College
Rizzardo	Alice	Foreign	Foreign	International School for Advanced St	International School for Advanced Studies (SISSA/ISAS)
Stadnik	Theodore	Group I Public	none	UC Berkeley	none
van Roosmale	Adam-Christia	Foreign	Foreign	University of Regina	Bielefeld University

Noncommutative Algebraic Geometry and Representation Theory Postdocs Demographic Summary

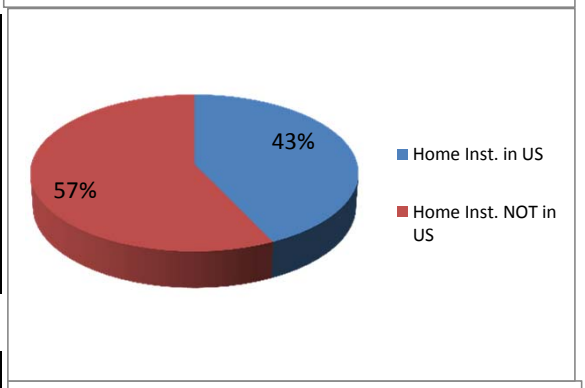
Gender	#	% (No Decl.)*	%
# of Distinct Members	7		100.0%
Male	5	71.43%	71.4%
Female	2	28.57%	28.6%
Decline to State Gender	0		



Ethnicities	#	% (No Decl.)*	%
Native American	0		
Asian	1	14.29%	14.3%
Black	0		0.0%
Hispanic	0		0.0%
Pacific	0		
White	6	85.71%	85.7%
Decline to State Ethnicities	0		0.0%
Unavailable Information	0		0.0%
Minorities	0		

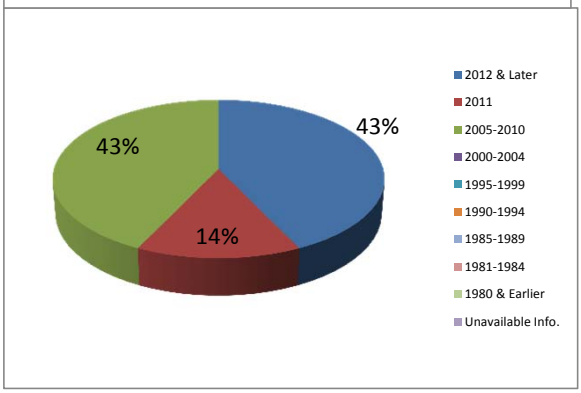


Citizenships	#		%
US Citizen & Perm. Residents	2		28.6%
Foreign	5		71.4%
Unavailable information	0		
# of Distinct Members	7		100.0%
US Citizen	2		28.6%
Perm Residents	0		0.0%
Home Inst. in US	3		42.86%



Year of Ph.D	#		%
2012 & Later	3		42.9%
2011	1		14.3%
2005-2010	3		42.9%
2000-2004	0		0.0%
1995-1999	0		0.0%
1990-1994	0		0.0%
1985-1989	0		0.0%
1981-1984	0		0.0%
1980 & Earlier	0		0.0%
Unavailable Info.	0		0.0%
Total # of Distinct Members	7		100.0%

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



Noncommutative Algebraic Geometry and Representation Theory

Program Summary

Role	# of Distinct Members	%	# of Citizens & Perm. Res.	%	US Citizens	# of Female	%	# of Minorities[1]	%
Organizers	4	6.1%	1	25.0%	1	1	25.0%	0	0.0%
Research Professors	9	13.6%	6	66.7%	4	3	33.3%	0	0.0%
Postdoctoral Fellows	7	10.6%	2	28.6%	2	2	28.6%	0	0.0%
NSF Postdoctoral Fellows	3	4.5%	3	100.0%	3	1	33.3%	1	33.3%
PD/RM	1	1.5%	0	0.0%	0	0	0.0%	0	0.0%
Research Members	35	53.0%	14	40.0%	11	7	20.0%	1	9.1%
Program Associates	7	10.6%	3	42.9%	3	1	14.3%	1	33.3%
Guests	0	0.0%	0	0.0%	0	0	0.0%	0	0.0%
Total # of Distinct Members	**66**		**29**	***43.9%***	**24**	**15**	***22.7%***	**3**	***12.5%***

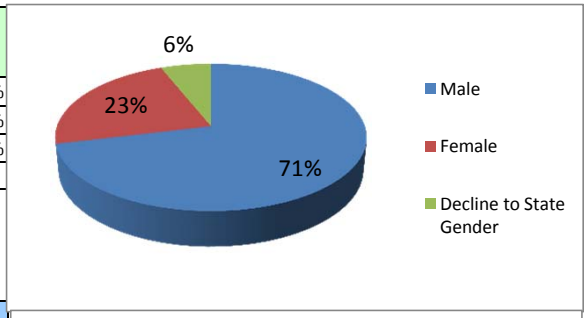
[1] *Minorities are US citizen who declare themselves American Indian, Black, Hispanic, or Pacific Islander. Minority percentage is calculated by dividing the number of Minorities by the total number of US citizens.*

Home Institute Grouping

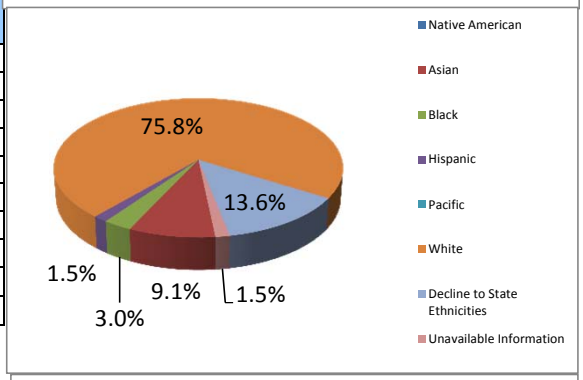
	US								
Role	**Group I Private**	**Group I Public**	**Group II**	**Group III**	**Group M**	**Group B**	**Non-Group**	**Foreign**	**Total**
Organizers	1	0	0	0	0	0	0	3	4
Research Professors	1	5	1	0	0	0	0	2	9
Postdoctoral Fellows	0	2	0	0	0	0	1	4	7
NSF Postdoctoral Fellows	1	2	0	0	0	0	0	0	3
PD/RM	0	0	0	0	0	0	0	1	1
Research Members	4	6	4	0	1	0	1	19	35
Program Associates	0	2	1	0	0	0	0	4	7
Total	**7**	**17**	**6**	**-**	**1**	**-**	**2**	**33**	**66**
%	***10.6%***	***25.8%***	***9.1%***	***0.0%***	***1.5%***	***0.0%***	***3.0%***	***50.0%***	***100.0%***

Noncommutative Algebraic Geometry and Representation Theory Demographic Summary

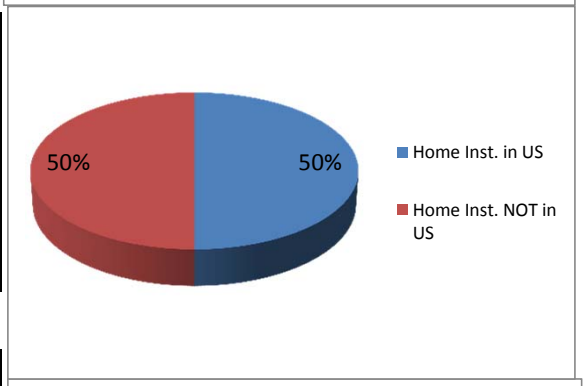
Gender	#	% (No Decl.)*	%
# of Distinct Members	66		93.9%
Male	47	75.81%	71.2%
Female	15	24.19%	22.7%
Decline to State Gender	4		



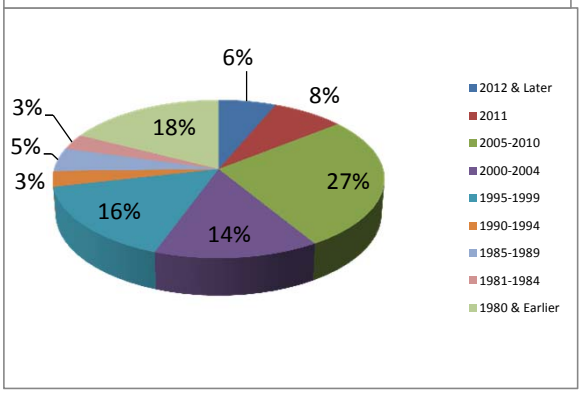
Ethnicities	#	% (No Decl.)*	%
Native American	0		
Asian	6	10.17%	9.1%
Black	2		3.0%
Hispanic	1		1.5%
Pacific	0		
White	50	84.75%	75.8%
Decline to State Ethnicities	9		13.6%
Unavailable Information	1		1.5%
Minorities	3		



Citizenships	#		%
US Citizen & Perm. Residents	29		43.9%
Foreign	37		56.1%
Unavailable information	0		
# of Distinct Members	66		100.0%
US Citizen	24		36.4%
Perm Residents	5		7.6%
Home Inst. in US	33		50.00%



Year of Ph.D	#		%
2012 & Later	4		6.1%
2011	5		7.6%
2005-2010	17		25.8%
2000-2004	9		13.6%
1995-1999	10		15.2%
1990-1994	2		3.0%
1985-1989	3		4.5%
1981-1984	2		3.0%
1980 & Earlier	11		16.7%
Unavailable Info.	3		4.5%
Total # of Distinct Members	66		100.0%



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

Complementary Program 2012–13

August 20, 2012 to May 24, 2013

MSRI, Berkeley, CA, USA

Dean Carolyn
University of Manchester
Mathematics
Oxford Road
Manchester, M13 9PL
United Kingdom

Research Member of Complementary Program 2012-13

Member's comments:

I attended a number of lectures in both the COMMA and NGART programs. Very good. The informal interactions, especially the chance to talk with so many different people at lunch.

Selinger Peter
Dalhousie University
Mathematics and Statistics

Research Member of Complementary Program 2012-13

Member's comments:

The time here was extremely valuable for me. As the member of the complementary program, I did not attend the workshops of the other programs, but I had lots of time to do new mathematics, meet my collaborators, and wrote at least 4 new papers. I also made good use of the library and other facilities. My collaborators were not members of MSRI, but some of them visited me while I was here:

Brett Giles, University of Calgary
Benoit Valiron, University of Pennsylvania
Neil J. Ross, Dalhousie University
Alexander Green, Dalhousie University
Peter LeFanu Lumsdaine, Institute for Advanced Studies

Quantum circuits of T-depth one, Quipper: A Scalable Quantum Programming Language, Exact synthesis of multi-qubit Clifford T circuits., Efficient Clifford T approximation of single-qubit operators

No, I didn't attend the workshops in other fields. Sometimes it is nice to look for inspiration and new ideas in other fields, but at this time, I was in a creative phase doing lots of new mathematics, so I was actually most happy to sequester myself, work non-stop, and write new papers. I loved the MSRI facilities. As a member of the complementary program, I was very happy to have office space, library access, and computing resources. I was able to meet with my collaborators almost every day, in the office, library, or other spaces. In the beginning, I thought a dedicated video conferencing facility would be useful, but it turns out we got by just fine with Skype and Google+.

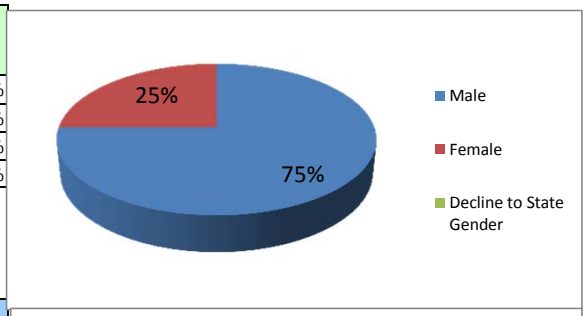
Capraro Valerio
University of Southampton
Department of Mathematics
33 8 Palmerston Road
Southampton, SO141LP
United Kingdom

Research Member of Complementary Program 2012-13

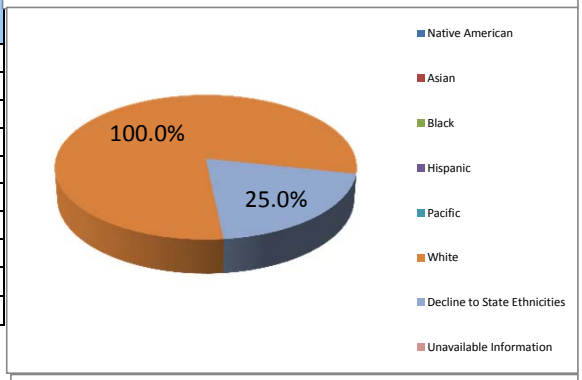
Capraro collaborated with MSRI Deputy Director, Helene Barcelo. Together they worked on a publication titled Discrete Homology Theory, A solution concept for games with altruism and cooperation.

2012–13 Program Members Demographic Summary

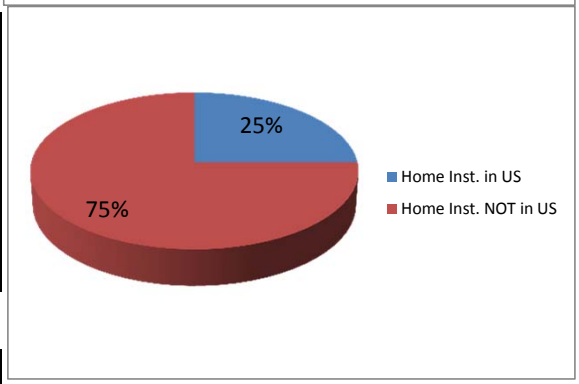
Gender	#	% (No Decl.)*	%
# of Distinct Members	4		100.0%
Male	3	75.00%	75.0%
Female	1	25.00%	25.0%
Decline to State Gender	0		0.0%



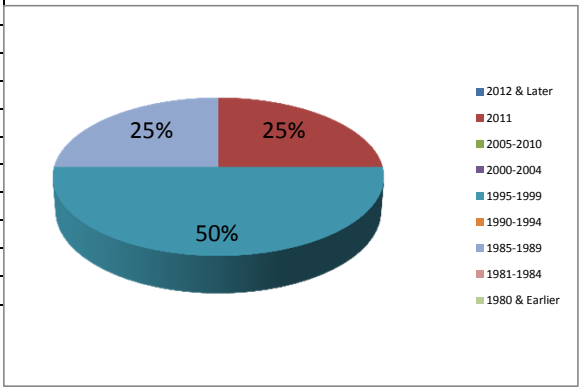
Ethnicities	#	% (No Decl.)*	%
Native American	0	0.00%	0.0%
Asian	0	0.00%	0.0%
Black	0	0.00%	0.0%
Hispanic	0	0.00%	0.0%
Pacific	0	0.00%	0.0%
White	4	100.00%	100.0%
Decline to State Ethnicities	1		25.0%
Unavailable Information	0		0.0%
Minorities	0		0.0%



Citizenships	#		%
US Citizen & Perm. Residents	1		25.0%
Foreign	3		75.0%
Unavailable information	0		0.0%
# of Distinct Members	4		100.0%
US Citizen	1		25.0%
Perm Residents	0		0.0%
Home Inst. in US	1		25.00%



Year of Ph.D	#		%
2012 & Later	0		0.0%
2011	1		25.0%
2005-2010	0		0.0%
2000-2004	0		0.0%
1995-1999	2		50.0%
1990-1994	0		0.0%
1985-1989	1		25.0%
1981-1984	0		0.0%
1980 & Earlier	0		0.0%
Unavailable Info.	0		0.0%
Total # of Distinct Members	4		100.0%



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

Programs

Complementary Program 2012–13

MSRI Mathematical Sciences Research Institute

Connections for Women: Joint Workshop on Commutative Algebra and Cluster Algebras

August 22, 2012 to August 24, 2012

MSRI, Berkeley, CA, USA

Organizers:

Claudia Polini (University of Notre Dame)

Idun Reiten (Norwegian University of Science and Technology)

Karen Smith (University of Michigan)

Lauren Williams* (University of California, Berkeley)

Final Report for the MSRI Connections for Women Workshop: Commutative algebra and cluster algebras

Organizers: Claudia Polini, Idun Reiten, Karen Smith, and Lauren Williams

The goal of this workshop was to give an introduction to topics in commutative algebra and cluster algebras, via talks and a mini-course, all of which were given by women. (However, the audience was a mix of men and women.) A secondary goal was to encourage and facilitate the exchange of ideas between researchers in commutative algebra and researchers in cluster algebras. The workshop consisted of:

1. **A mini-course** on the topic of cluster algebras, together with a problem session.
2. **Nine lectures**, some of which were expository, and some of which were research talks.
3. **A poster session**, in which junior researchers presented their results.
4. **A panel discussion**, in which several tenure-track and tenured female professors discussed issues related to being a female mathematician.

In addition to these activities, there were multiple tea breaks, and a wine and cheese social, in which participants could get to know each other and discuss mathematics.

Details on the minicourse and lectures

Minicourse on cluster algebras

Lauren Williams gave two lectures which introduced the notion of cluster algebra, and gave several examples, including the coordinate ring of the Grassmannian. She gave several problems for participants to think about, and Kelli Talaska led a problem session to help participants with these problems.

Lectures on commutative algebra

Claudia Miller (Professor of Mathematics at Syracuse University) spoke on 'Duality for Koszul Homology over Gorenstein Rings'. She first explained the classical results, due to Herzog, and then reported on recent developments obtained in collaboration with Hamid Rahmati and Janet Striuli. The aim of their work is to show that the duality forces the Cohen-Macaulayness of the Koszul homology modules whenever a certain amount of local depth is present. Irena Swanson (Professor of Mathematics at Reed College) talked about 'Minimal components over certain binomial ideals'. The work done in collaboration with Amelia Taylor, Julia Porcino, and Alessio Sammartano, spanned three different papers. Their original goal was to understand Alex Fink's paper on minimal components arising in algebraic statistics. In several instances they express the minimal components in terms of some combinatorial structures. Vijaylaxmi Trivedi (Professor at Tata Institute of Fundamental Research, Mumbai, India) delivered a lecture on her recent work on Hilbert-Kunz multiplicities. The Hilbert-Kunz multiplicity is a fundamental invariant that like the ordinary multiplicity carries meaningful information about the singularities of a local Noetherian

ring in characteristic p. The Hilbert Kunz multiplicity has been instrumental to prove, for instance, that tight closure does not localize. Unlike the ordinary multiplicity, the Hilbert-Kunz multiplicity is very difficult to compute and any result that sheds light on this mysterious invariant is a great progress towards the understanding of the structure of rings in positive characteristic. Maria Evelina Rossi (Professor of Mathematics at the University of Genova, Italy) presented recent results concerning isomorphism classes of Artin K-algebras through Macaulay's inverse system. The goal was to prove that the study of certain classes of Artin local rings can be reduced to the study of standard graded K-algebras. Interesting application to the rationality of the Poincar series were given. Finally, Alicia Dickenstein (Professor of Mathematics at the University of Buenos Aires, Argentina) described the use of linear syzygies for the implicitization of rational surfaces. These algebraic techniques, based on the theory of approximation complexes due to Jrgen Herzog, Aron Simis and Wolmer Vasconcelos, were introduced in this setting by Laurent Bus, Marc Chardin and Jean Pierre Jouanolou, whose work was inspired by the "practical" method of moving curves, proposed by Thomas Sederberg and Falai Chen.

Lectures on cluster algebras

There were four lectures on topics related to cluster algebras. Karin Baur gave a talk on *Cluster algebras, quiver mutation, and triangulations*, which was an expository talk on cluster algebras associated to surfaces. The combinatorics of such cluster algebras is encoded by triangulations of the surface. Gordana Todorov gave an expository talk on *Relations between cluster algebras and cluster categories,* in which she explained how the *cluster category* provides a categorification of a cluster algebra. In this construction, cluster variables are replaced by quiver representations, and one may use the representation theory of quivers to understand the corresponding cluster algebra. Konstanze Rietsch gave a talk on *Mirror symmetry for Grassmannians,* in which she explained how to construct the superpotential by using the cluster algebra structure on Grassmannians. Kelli Talaska gave a talk on *Networks and the Deodhar decomposition of real Grassmannians,* which explained how to parameterize Deodhar components in the Grassmannian. (This construction generalizes Postnikov's parameterization of cells in the totally non-negative part of the Grassmannian.)

Conclusion

We were extremely pleased with the outcome of the MSRI Connections workshop on commutative algebra and cluster algebras, and think that it was a very rewarding experience for the participants.

Participants seemed to enjoy the minicourse and lectures very much, and there were a number of questions after each talk. The atmosphere during the conference was very friendly and down-to-earth. One person wrote "I am very happy to say I never expected such an incredible experience getting to meet so many wonderful people from staff to students to mathematician." Other participants commented that they enjoyed being at a conference with so many women. The panel discussion was a lively discussion that involved both men and women in the audience. The men seemed to find the discussion very interesting, and one senior male mathematician asked what male mathematicians can do to help female mathematicians.

Organizers		
First Name	**Last Name**	**Institution**
Claudia	Polini	University of Notre Dame
Idun	Reiten	Norwegian University of Science and Technology
Karen	Smith	University of Michigan
Lauren	Williams	University of California (Lead Organizer)

Speakers		
First Name	**Last Name**	**Institution**
Karin	Baur	Karl-Franzens-Universität Graz
Alicia	Dickenstein	University of Buenos Aires
Claudia	Miller	Syracuse University
Konstanze	Rietsch	King's College London
Maria Evelina	Rossi	Università di Genova
Irena	Swanson	Reed College
Kelli	Talaska	University of California
Gordana	Todorov	Northeastern University
Vijaylaxmi	Trivedi	Tata Institute of Fundamental Research
Lauren	Williams	University of California

Connections for Women:
Joint Workshop on Commutative Algebra and Cluster Algebras

August 22 - 24, 2012

Schedule

Wednesday, August 22, 2012			
9:00 AM - 9:15 AM	Simons Auditorium		Welcome
9:15 AM - 10:15 AM	Simons Auditorium	Lauren William	Mini Course: Basics of Cluster Algebras
10:15 AM - 10:45 AM	Atrium		Coffee Break
10:45 AM - 11:35 AM	Simons Auditorium	Claudia Miller	Duality for Koszul Homology over Gorenstein Rings
11:35 AM - 12:30 PM	Atrium		Poster Session I
12:30 PM - 2:00 PM	Atrium		Lunch
2:00 PM - 2:50 PM	Simons Auditorium	Karin Baur	Cluster algebras, quiver mutation and triangulations.
2:50 PM - 3:30 PM	Atrium		Poster Session II
3:30 PM - 5:00 PM	Atrium		Wine and cheese social

Thursday, August 23, 2012			
9:00 AM - 10:00 AM	Simons Auditorium	Lauren Williams	Mini Course: Basics of Cluster Algebras
10:00 AM - 10:30 AM	Atrium		Coffee Break
10:30 AM - 12:00 PM	Simons Auditorium	Kelli Talaska	Discussion session for the Mini Course
12:00 PM - 1:30 PM	Atrium		Lunch
1:30 PM - 2:20 PM	Simons Auditorium	Irena Swanson	Minimal components over certain binomial ideals
2:30 PM - 3:20 PM	Simons Auditorium	Vijaylaxmi Trivedi	Hilbert-Kunz multiplicity and Hilbert-Kunz slope
3:30 PM - 4:00 PM	Atrium		Tea break
4:00 PM - 4:50 PM	Simons Auditorium	Gordana Todorov	Relations between Cluster Algebras and Cluster Categories.

Friday, August 24, 2012			
9:00 AM - 10:00 AM	Simons Auditorium	Konstanze Rietsch	On mirror symmetry for Grassmannians
10:00 AM - 10:30 AM	Atrium		Coffee Break
10:30 AM - 11:20 AM	Simons Auditorium	Maria Evelina Rossi	Analytic Isomorphisms of Artin local K-algebras
11:30 AM - 12:20 PM	Simons Auditorium	Kelli Talaska	Networks and the Deodhar decomposition of real Grassmannians
12:30 PM - 2:00 PM	Atrium		Lunch
2:00 PM - 2:50 PM	Simons Auditorium	Alicia Dickenstein	Implicitization techniques: easy algorithms, deep proofs.
3:00 PM - 3:30 PM	Atrium		Tea break
3:30PM - 5:00PM	Simons Auditorium		Panel Discussion

Participants

First Name	Last Name	Institution
Kathleen	Ansaldi	University of Notre Dame
Federico	Ardila	San Francisco State University
Spencer	Backman	Georgia Institute of Technology
Helene	Barcelo	MSRI - Mathematical Sciences Research Institute
Emily	Barnard	North Carolina State University
Karin	Baur	Karl-Franzens-Universität Graz
Arkady	Berenstein	University of Oregon
Christine	Berkesch Zamaere	Duke University
Florian	Block	UC Berkeley Math Faculty
Mats	Boij	Royal Institute of Technology (KTH)
Sarah	Brodsky	University of California
Man-Wai	Cheung	University of California, San Diego
Steven	Collazos	San Francisco State University
Aldo	Conca	Università di Genova
Alicia	Dickenstein	University of Buenos Aires
Idan	Eisner	University of Haifa
Sabine	El Khoury	American University of Beirut
Laura	Escobar	Cornell University
Sara	Faridi	Dalhousie University
Anna	Felikson	Jacobs University Bremen
Xiao	Feng	Michigan State University
Alex	Fink	North Carolina State University
Bruce	Fontaine	MSRI - Mathematical Sciences Research Institute
Claudio	Fontanari	Università degli Studi di Trento
Louiza	Fouli	New Mexico State University
Alexander	Garver	University of Minnesota Twin Cities
Michael	Gekhtman	University of Notre Dame
Sira	Gratz	Universität Hannover
Elizabeth	Gross	University of Illinois
Emily	Gunawan	University of Minnesota Twin Cities
Ines	Henriques	University of California
Daniel	Hernandez	University of Minnesota Twin Cities
Olga	Holtz	University of California
Aline	Hosry	Notre Dame University, Lebanon
Alina	Iacob	Georgia Southern University
Srikanth	Iyengar	University of Nebraska
Jack	Jeffries	University of Utah
haridas	kalbhor	University of Pune, Maharashtra (India)
Adam	Kalman	University of California
Steven	Karp	UC Berkeley Math Faculty
Leila	Khatami	Union College--Union University
Robert	Korsan	retired
Kaie	Kubjas	Freie Universität Berlin
Manoj	Kummini	Chennai Mathematical Institute
Volha	Kushel	TU Berlin
Lisa	Lamberti	Eidgenössische TH Zürich-Zentrum
Phillpp	Lampe	Universität Bielefeld
Kuei-Nuan	Lin	University of California
Jichun	Liu	Zhejiang University
Antonio	Macchia	Università di Bari
Diane	Maclagan	University of Warwick

Jeff	Madsen	University of Notre Dame
Paolo	Mantero	Purdue University
Robert	Marsh	University of Leeds
Sarah	Mayes	University of Michigan
Jason	McCullough	MSRI - Mathematical Sciences Research Institute
Claudia	Miller	Syracuse University
Jonathan	Montano	Purdue University
Sophie	Morier-Genoud	Université de Paris VI (Pierre et Marie Curie)
Gregg	Musiker	University of Minnesota Twin Cities
Leatitia	Mutombo	University Of Kinshasa
Alfredo	Nájera Chávez	Université de Paris VII (Denis Diderot)
Tomoki	Nakanishi	Nagoya University
BHARATH	NARAYANAN	Pennsylvania State University
Alyssa	Palfreyman	San Francisco State University
Rebecca	Patrias	University of Minnesota Twin Cities
Servando	Pineda Carranza	San Francisco State University
Pierre-Guy	Plamondon	Université de Caen
Claudia	Polini	University of Notre Dame
Fan	QIN	Université de Paris VII (Denis Diderot)
Jenna	Rajchgot	MSRI - Mathematical Sciences Research Institute
Denise	Rangel	University of Texas
idun	reiten	Norwegian University of Science and Technology
Vladimir	Retakh	Rutgers University
Konstanze	Rietsch	King's College London
Elina	Robeva	University of California
Maria Evelina	Rossi	Università di Genova
dylan	rupel	MSRI - Mathematical Sciences Research Institute
Steven	Sam	University of California
Jennifer	Schaefer	Dickinson College
Gus	Schrader	UC Berkeley Math Faculty
Alexandra	Seceleanu	University of Nebraska
Anurag	Singh	University of Utah
Karen	Smith	University of Michigan
Suresh	Srinivasamurthy	Kansas State University
Janet	Striuli	Fairfield University
Irena	Swanson	Reed College
Kaisa	Taipale	MSRI - Mathematical Sciences Research Institute
Kelli	Talaska	University of California
Geetha	Thangavelu	Institute of Mathematical Sciences
Howard	Thompson	University of Michigan
Gordana	Todorov	Northeastern University
vijaylaxmi	trivedi	Tata Institute of Fundamental Research
Bernd	Ulrich	Purdue University
Alexander	Vainshtein	University of Haifa
Yadira	Valdivieso Diaz	Universidad Nacional de Mar del Plata
Emanuele	Ventura	Università di Catania
Roger	Wiegand	University of Nebraska
Sylvia	Wiegand	University of Nebraska
Lauren	Williams	University of California
Emily	Witt	University of Minnesota Twin Cities
Nora	Youngs	University of Nebraska
Josephine	Yu	Georgia Institute of Technology
Andrei	Zelevinsky	Northeastern University

Officially Registered Participant Information

Participants		104

Gender		104
Male	46.15%	48
Female	53.85%	56
Declined to state	0.00%	0

Ethnicity*		104
White	65.38%	68
Asian	14.42%	15
Hispanic	8.65%	9
Pacific Islander	0.00%	0
Black	1.92%	2
Native American	0.00%	0
Mixed	0.96%	1
Declined to state	8.65%	9

* ethnicity specifications are not exclusive

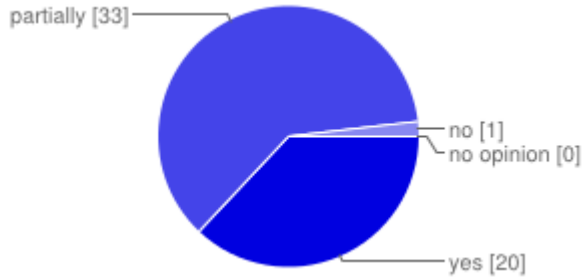
Connections for Women: Joint Workshop on Commutative Algrebra and Cluster Algebras, August 22 to 24, 2012 at MSRI, Berkeley, CA USA

54 responses

Summary See complete responses

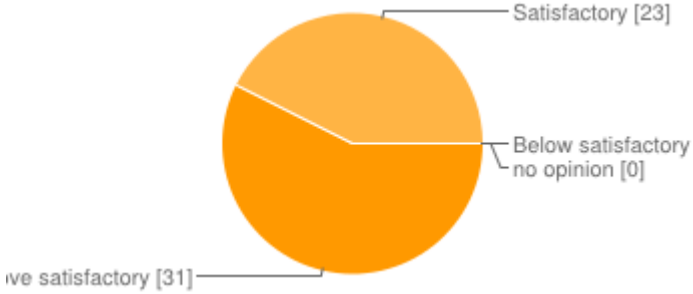
Topic presentation and organization

Did the various topics within the workshop integrate into a coherent picture?



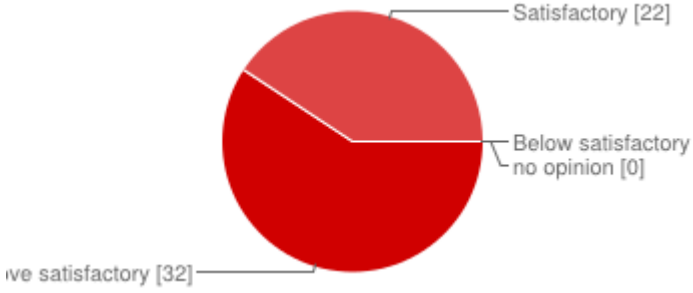
yes	**20**	37%
partially	**33**	61%
no	**1**	2%
no opinion	**0**	0%

Were the speakers generally clear and well organized in their presentation?



Above satisfactory	**31**	57%
Satisfactory	**23**	43%
Below satisfactory	**0**	0%
no opinion	**0**	0%

Was there adequate time between lectures for discussion?



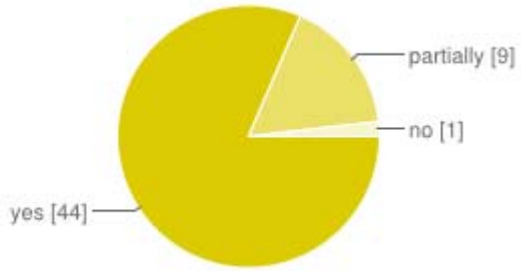
Above satisfactory	**32**	59%
Satisfactory	**22**	41%
Below satisfactory	**0**	0%
no opinion	**0**	0%

Additional comments on the topic presentation and organization

It is wonderful the second talk on the first day was more of a research talk than an introductory talk With the exception of the minicourse the talks were extremely specialized. Perhaps speakers shou ...

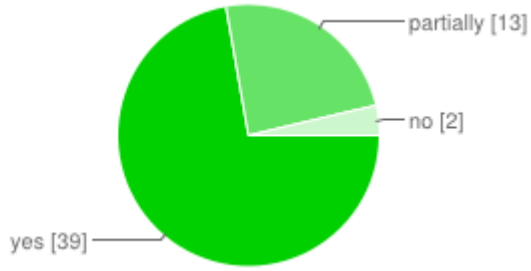
Personal assessment

Was your background adequate to access a reasonable portion of the material?



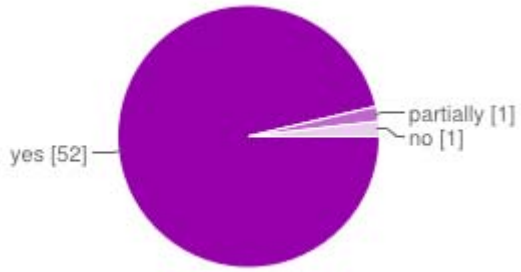
yes	**44**	81%
partially	**9**	17%
no	**1**	2%

Did the workshop increase your interest in the subject?



yes	**39**	72%
partially	**13**	24%
no	**2**	4%

Was the workshop worth your time and effort?



yes	**52**	96%
partially	**1**	2%
no	**1**	2%

Additional comments on your personal assessment

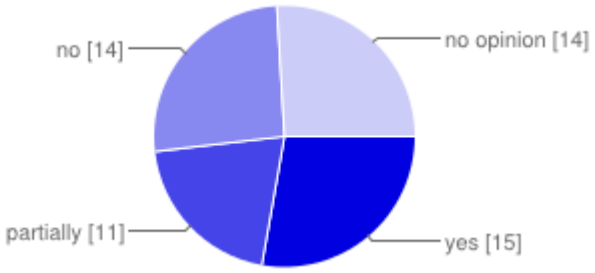
The lectures on Cluster Algebras were more accessible than the ones in Commutative Algebra.

The latter were directed mainly to specialists, it seems; a pity.

The talks really help me to understand m ...

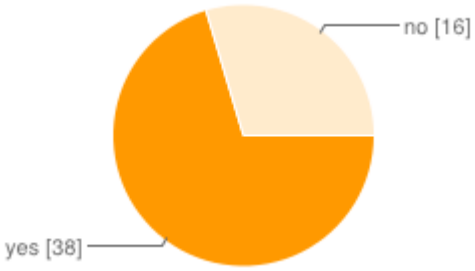
Additional Activities

Did you find the poster sessions beneficial?



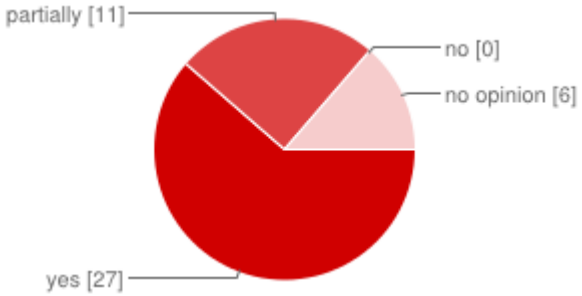
yes	**15**	28%
partially	**11**	20%
no	**14**	26%
no opinion	**14**	26%

Did you attend the panel discussion?



yes	**38**	70%
no	**16**	30%

If you did attend the panel discussion, did you find it beneficial?



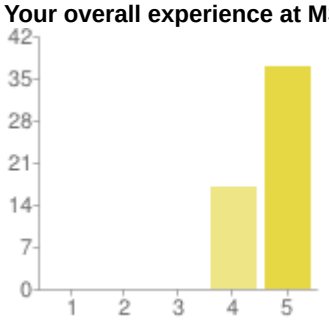
yes	**27**	50%
partially	**11**	20%
no	**0**	0%
no opinion	**6**	11%

What other subjects should be addressed in future panel discussions?

Hold the panel discussion earlier - it stimulates discussion. Probably it's best just to let things flow freely. This worked here and it should work in the future. If it is important for faculty to k ...

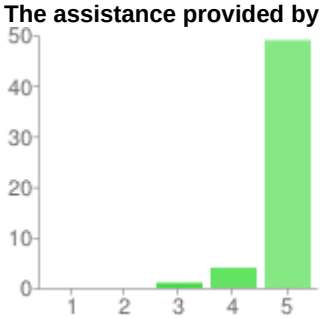
Venue

Your overall experience at MSRI



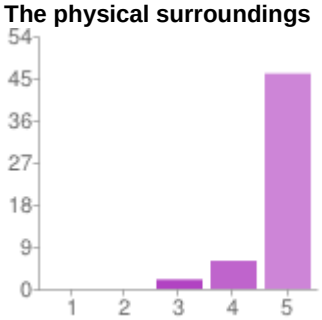
1 -Not satisfactory	**0**	0%
2	**0**	0%
3	**0**	0%
4	**17**	31%
5 -Above satisfactory	**37**	69%

The assistance provided by MSRI staff



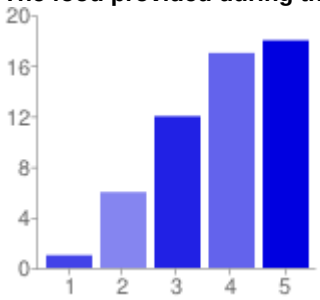
1 -Not satisfactory	**0**	0%
2	**0**	0%
3	**1**	2%
4	**4**	7%
5 -Above satisfactory	**49**	91%

The physical surroundings



1 -Not satisfactory	**0**	0%
2	**0**	0%
3	**2**	4%
4	**6**	11%
5 -Above satisfactory	**46**	85%

The food provided during the workshop



Not satisfactoryAbove satisfactory

1 -Not satisfactory	**1**	2%
2	**6**	11%
3	**12**	22%
4	**17**	31%
5 -Above satisfactory	**18**	33%

Additional comments on the venue

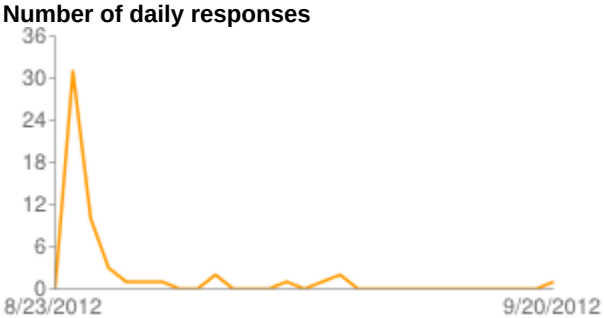
I hope workshops in future will provide more kinds of food. wow! what a view in every direction! I believe the food offerings should be more considerate of participants dietary restrictions and pref ...

Thank you for completing this survey

We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.

It was great experience and I did enjoy this workshop a lot. Thank you for everything. The only reason I felt the poster session was not beneficial was that there were so few posters and too many people. It would have been better if more people were presenting posters. It would have spread the attendees out and given us a chance to visit with the presenters. Overall, I've had a very positive experience at MSRI. This is my first time here, and I would definitely like to attend an MSRI workshop again.

Number of daily responses



Connections for Women: Joint Workshop on Commutative Algebra and Cluster Algebras
August 22 to August 24, 2012

Additional Survey Responses

Additional comments on the topic presentation and organization

- It is wonderful
- the second talk on the first day was more of a research talk than an introductory talk
- With the exception of the minicourse the talks were extremely specialized. Perhaps speakers should be asked to give more of a colloquium-style talk in the future, especially when a diverse audience is expected.
- I am very happy to say I never expected such an incredible experience getting to meet so many wonderful people from staff to students to mathematicians. Thank you.
- Cluster talks were much more appropriate for a broad audience (I'm a commutative algebraist, and got more from the cluster talks).
- A few of the speakers assumed a bit too much on the part of the audience, particularly in view of the fact that people were coming from two rather different backgrounds. Several other speakers (from both camps) did spectacularly well in selling the subject and making it accessible to the "other camp".
- The mini course together with the exercise session were excellent.
- There was a good attempt to introduce cluster algebras, but the introductory lectures did not lead naturally to the lectures on Friday (although those lectures were very helpful for me personally).
- great to have a lot of time between lectures, to discuss
- Some of the research talks were too difficult
-

Additional comments on your personal assessment

- The lectures on Cluster Algebras were more accessible than the ones in Commutative Algebra. The latter were directed mainly to specialists, it seems; a pity.
- The talks really help me to understand more!
- As a commutative algebraist, I was ignorant of cluster algebras and cluster categories, but now I have some insight into how they relate to several aspects of my own work.
- The talks on Cluster Algebras were generally very accessible and enjoyable (especially Lauren Williams's minicourse). I had a really hard time with the commutative algebra research talks. Why so elementary with cluster algebras and so advanced with commutative algebra?
- the panel discussion was great!!! I (a guy) got several insights in what it's like to be a female mathematician.

Additional comments on the venue

- I hope workshops in future will provide more kinds of food.
- wow! what a view in every direction!
- I believe the food offerings should be more considerate of participants dietary restrictions and preferences.
- Have some sugar-free food.
- New (ish) caterer is much much better than several years ago. The location is wonderful as always.

- Hard to beat!
- very beautiful!
- MSRI is a wonderful place. Food a bit pricy.
- The snacks provided by MSRI are great but the catering needs more variety.

What other subjects should be addressed in future panel discussions?

- Hold the panel discussion earlier - it stimulates discussion.
- Probably it's best just to let things flow freely. This worked here and it should work in the future.
- If it is important for faculty to know about non-academic jobs and those which are academic but not necessarily as a professor. By know about I mean being able to guide theirs students towards those directions.
- the panel discussion was great!!! I (a guy) got several insights in what it's like to be a female mathematician.
-

We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.

- It was great experience and I did enjoy this workshop a lot. Thank you for everything.
- "The only reason I felt the poster session was not beneficial was that there were so few posters and too many people. It would have been better if more people were presenting posters. It would have spread the attendees out and given us a chance to visit with the presenters.

  Overall, I've had a very positive experience at MSRI. This is my first time here, and I would definitely like to attend an MSRI workshop again."

MSRI Mathematical Sciences Research Institute

Joint Introductory Workshop: Cluster Algebras and Commutative Algebra

August 27 to September 7, 2012

MSRI, Berkeley, CA, USA

Organizers:

David Eisenbud* (University of California, Berkeley)

Bernhard Keller (Universit´e Paris VII, France)

Karen Smith (University of Michigan)

Alexander Vainshtein* (University of Haifa, Israel)

CLUSTER ALGEBRAS AND COMMUTATIVE ALGEBRAS: JOINT INTRODUCTORY WORKSHOP REPORT

ORGANIZERS:
DAVID EISENBUD (BERKELEY), BERNHARD KELLER (PARIS),
KAREN SMITH (MICHIGAN), ALEK VAINSHTEIN(HAIFA)

1. Structure of the Workshop

Cluster algebras are commutative algebras—subalgebras of a field of rational functions—with a special structure, a set of generators of a very special-looking form. Ignited by work of Fomin and Zelevinsky, there has been an explosion of activity around them. The impetus to study this structure came originally from Lie theory, but it has turned out to be present in an amazing variety of applications, from Teichmüller theory and triangulations of surfaces to representation theory and Poisson geomety, to name just those subjects that were touched upon in the workshop.

Curiously, one way in which Cluster algebras have *not* been studied very much is... as algebras. The theory is hardly known in the commutative algebra community, and those studying cluster algebras have not made much use of the great storehouse of information about commutative algebra. Part of the impetus for the choice of the two programs at MSRI this semester was the opportunity to bring these two fields closer together, and thus it seemed to us particularly appropriate to make a joint introductory workshop, with sequences of lectures that would introduce each side to the other (and also be particularly appropriate for the mathematicians who attend the introductory workshops as relative outsiders to the fields of the programs.

We felt this arrangement was quite successful. Each "side" fielded 6 minicourses starting from quite an elementary point and developing to the frontiers of the field. As an example of successful interaction between the two communities, let us mention that commutative algebraist Karen Smith was able to answer a question raised in the lecture of Sergey Fomin regarding whether suitable cluster algebras are free over the subalgebra generated by their frozen variables. This led to a series of interesting conversations between Smith and Greg Muller, with input from Fomin, Tucker, and Miller, regarding whether or not certain cluster algebras might be F-regular. There is much potential for further collaboration between commutative algebraists and cluster algebraists which could lead to a better understanding of some of the commutative algebraic properties of cluster algebras.

As a mechanism for mentoring and connecting some of the postdocs, commutative algebraists assigned a postdoc "assistant" to each lecturer giving a minicourse. Assistants ran some "tutorial" sessions or assisted in preparation of notes. This gave the assistants a direct collaborative contact with the senior lecturers, and helped them focus on the area of

one of the courses (the organizers were quite careful that the pairings made mathematical sense, but also worked to avoid pairing postdocs with senior mathematicians they already knew well.) Both the postdocs and the senior appreciated these arrangements.

2. Mini-Courses

2.1. **Commutative Algebra.**

Craig Huneke (University of Kansas): Introduction to Uniformity in Commutative Algebra. Two of the most important theorems in commutative algebra were proved by Hilbert: the Hilbert Basis Theorem (Frank Schreyer will be giving a proof of this theorem) and the Hilbert Syzygy theorem. Huneke began with the novel point of view on these theorems as avatars of the theme of uniformity in commutative algebra. His first lecture discussed resolutions and some of conjectured uniformity results on regularity and projective dimension.

In his second lecture Huneke shows how uniformity plays an important role in the technique of reduction to characteristic p, and illustrated with a proof of a theorem of Zariski and Nagata concerning multiplicities

Huneke's third lecture was devoted to uniform questions concerning symbolic powers which build on the work of Zariski and Nagata. He discussed problems motivated by combinatorics, geometry and algebra

Karen Smith (University of Michigan): Introduction to Frobenius splitting. Smith began by reviewing the famous Hochster-Roberts theorem, which states that when a linearly reductive group acts linearly on a polynomial ring, the resulting ring of invariants is a Cohen Macaulay ring. The key idea in proof is the idea of splitting. She defined what it means for a homomorphism of rings to split and give many examples of the power of this idea. In characteristic p, the splitting of the Frobenius map has especially nice consequences. The closely related notion of F-regularity is the power behind the proof of the Hochster Roberts theorem.

In the second lecture Smith took a global point of view, exploring what it means for a projective variety to be Frobenius split. Frobenius split varieties include Grassmannians, flag varieties, Schubert varieties, Hilbert schemes of points on the projective plane, and many others that arise naturally in representation theory. She demonstrated some of the very strong and yet remarkably easy to prove consequences of Frobenius splitting, including the fact that the higher cohomology groups of any ample line bundle always vanish.

In her last lecture Smith discussed an obstruction to F-regularity called the test ideal. This is a "characteristic p analog" of the multiplier ideal, an important tool in algebraic geometry that was the subject of introductory talks by Rob Lazarsfeld at the special year in commutative algebra 10 years ago at MSRI. As an application, she proved: If P is a radical ideal in a regular ring of characteristic p and dimension d, then the symbolic powers $P^{(nd)}$ are contained in P^n for all n.

Irena Peeva (Cornell University): Infinite free resolutions. There has been a lot of progress on the structure and properties of finite free resolutions. Much less is known about the properties of infinite free resolutions.

Peeva discussed three classes of rings over which infinite free resolutions have nice structures: Complete Intersections, Koszul Rings, and Golod Rings.

Holger Brenner (Universität Osnabrück): Vector bundles and ideal closure operations. Brenner discussed ideal closure operations from the point of view of the interplay between forcing algebras, vector bundles, their torsors. This interplay works best when the closure operation depends only on a cohomology class, which is true for tight closure, plus closure, and Frobenius closure under mild conditions.

The lectures emphasized the case of graded normal rings of dimension two, which correspond to smooth projective curves. He showed how the theory of curves and their vector bundles was used to obtain results about these closure operations.

Frank-Olaf Schreyer (Universität des Saarlandes): Syzygies, finite length modules, and random curves. In his first lecture, Schreyer reviewed the Gröbner basis proof of Hilbert syzygy theorem, and applied it to prove Petri's Theorem on the structure of the canonical ring of a Riemann surface.

The second lecture explained the theory of Liaison of space curves and the Hartshorne-Rao module. He illustrated how, from this point of view, one can construct space curves explicitly by constructing finite length modules with prescribed syzygies.

In the final lecture Schreyer explained some classical unirationality proofs of moduli spaces that are now greatly simplified by using computer algebra, and showed how experimental methods lead to theorems of theoretical interest.

Michel van den Bergh (Universiteit Hasselt): Noncommutative resolutions. If R is a local Gorenstein ring then a non-commutative crepant resolution for R is a reflexive R-module M such that the endomorphism ring of M is Cohen-Macaulay as an R-module and has finite global dimension. This turns out to be a sensible generalization of the algebraic geometry concept of a crepant resolution of singularities. Van den Bergh gave background on non-commutative resolutions, and surveyed some of the existence/non-existence results.

2.2. **Cluster Algebras.**

Sergey Fomin (Michigan): Introduction to cluster algebras. The first lecture reviewed the basic notions of cluster algebra theory: its original motivations (total positivity and canonical bases), quiver and seed mutations, cluster algebras of geometric type, and the key example of an affine base space of type A.

The second lecture surveyed the fundamental structural results of cluster theory: the Laurent phenomenon; cluster monomials and additive bases; the cluster complex and the exchange graph; finite type classification; and generalized associahedra.

The third lecture was devoted to two main topics: first, Zamolodchikov periodicity and its proof for the type (A,A) case using cluster structures in Grassmannians; second, the

general setting of cluster algebras over an arbitrary semifield, including general Y-patterns and separation of additions.

Bernhard Keller (Paris 7): Quiver representations and cluster algebras This course began with an introduction to the representation theory of quivers. Keller then introduced the Caldero-Chapoton map, which yields a strong link between cluster variables and the geometry of quiver representations. The further study of this map in more and more general settings naturally led to the introduction of the cluster category and to quivers with potentials following important work by Derksen–Weyman–Zelevinsky.

Bernard Leclerc (Caen): Preprojective algebras and Lie theory. Many interesting and motivating examples of cluster algebras appear in Lie theory as coordinate rings of classical varieties attached to Lie groups and Kac-Moody groups (e.g. Grassmannians, flag varieties, double Bruhat cells, etc.). Some of these examples can be understood by relating them to certain categories of modules over a preprojective algebra. Leclerc explained this mechanism of 'additive categorification' and illustrated it on concrete examples.

Idun Reiten (Trondheim): Cluster categories. by Idun Reiten: After a brief introduction to tilting theory and its links to cluster algebras, Reiten introduced cluster categories, which belong to the class of Hom-finite triangulated 2-Calabi-Yau categories that admit a cluster-tilting object. This class also contains stable categories of Cohen–Macaulay modules over certain singularities. Reiten sketched the main results of the theory developed for this class in work by herself, Amiot, Buan, Iyama and many others.

Alek Vainshtein (Haifa): Cluster algebras and Poisson geometry. In the first lecture, Vainshtein introduced Poisson structures compatible with a cluster structure of geometric type and provided a complete characterization of compatible Poisson structures in the case of full rank. As a corollary, he deduced several results on the structure of the exchange graph. He also explained that when the rank is not full, one should consider compatible pre-symplectic structures instead of Poisson ones.

In the second lecture, he described in detail how one recovers a cluster structure on a Grassmannians starting from the standard R-matrix Poisson bracket. A different way to recover this cluster structure is based on Postnikov's perfect planar netwroks in a disk.

In the last lecture, Vainshtein extended previous results to perfect planar netwroks in an annulus. As a corollary, he obtained the full integrability of the generalized pentagram map.

Dylan Thurston (Columbia): Cluster algebras and triangulated surfaces. In the first lecture, Thurston introduced the cluster algebras associated to surfaces, starting from the motivation from hyperbolic geometry.

In the second lecture, he explained how to extend the combinatorics slightly to get a mutationally finite cluster algebra. In fact, such an extension gives all but finitely many mutationally finite cluster algebras of rank > 2.

In the third lecture, Thurston showed how to get a canonical basis for surface cluster algebras. This basis is conjecturally strongly positive, in the sense that the structure constants for multiplication are all positive.

Organizers

First Name	Last Name	Institution
David	Eisenbud	University of California, Berkeley
Bernhard	Keller	Université de Paris VII (Denis Diderot)
Karen	Smith	University of Michigan
Alek	Vainshtein	University of Haifa

Speakers

First Name	Last Name	Institution
Holger	Brenner	Universitaet Osnabrueck
Bernhard	Keller	Université de Paris VII (Denis Diderot)
Bernard	Leclerc	Université de Caen
Irena	Peeva	Cornell University
Frank	Schreyer	Universität des Saarlandes
Karen	Smith	University of Michigan

Joint Introductory Workshop: Cluster Algebras and Commutative Algebra

August 27 - September 7, 2012

Week One Schedule

Monday, August 27, 2012			
8:45AM - 9:00AM	Simons Auditorium		Welcome
9:00AM - 10:00AM	Simons Auditorium	Sergey Fomin	Introduction to cluster algebras #1
10:00AM - 10:30AM	Atrium		Tea
10:30AM - 11:30AM	Simons Auditorium	Craig Huneke	Introduction to Uniformity in Commutative Algebra #1
11:30AM - 12:30PM	Simons Auditorium	Sergey Fomin	Introduction to cluster algebras #2
12:30PM - 2:00PM	Atrium		Lunch
2:00PM - 3:00PM	Simons Auditorium	Karen Smith	Introduction to Frobenius splitting #1
3:00PM - 3:30PM	Atrium		Tea
3:30PM - 5:00PM	Simons Auditorium		Cluster Algebras Tutorial Session

Tuesday, August 28, 2012			
9:00AM - 10:00AM	Simons Auditorium	Irena Peeva	Infinite free resolutions #1
10:00AM - 10:30AM	Atrium		Tea
10:30AM - 11:30AM	Simons Auditorium	Bernhard Keller	Quiver representations and cluster algebras #1
11:30AM - 12:30PM	Simons Auditorium	Craig Huneke	Introduction to Uniformity in Commutative Algebra #2
12:30PM - 2:00PM	Atrium		Lunch
2:00PM - 3:00PM	Simons Auditorium	Sergey Fomin	Introduction to cluster algebras #3
3:00PM - 3:30PM	Atrium		Tea
3:30PM - 5:00PM	Simons Auditorium		Commutative Algebra Tutorial Session
5:00PM - 7:00PM	Atrium		Reception

Wednesday, August 29, 2012			
9:00AM - 10:00AM	Simons Auditorium	Irena Peeva	Infinite free resolutions #2
10:00AM - 10:30AM	Atrium		Tea
10:30AM - 11:30AM	Simons Auditorium	Bernhard Keller	Quiver representations and cluster algebras #2
11:30AM - 12:30PM	Simons Auditorium	Karen Smith	Introduction to Frobenius splitting #2

Thursday, August 30, 2012			
9:00AM - 10:00AM	Simons Auditorium	Bernhard Keller	Quiver representations and cluster algebras #3
10:00AM - 10:30AM	Atrium		Tea
10:30AM - 11:30AM	Simons Auditorium	Irena Peeva	Infinite free resolutions #3
11:30AM - 12:30PM	Simons Auditorium	Bernard Leclerc	Preprojective algebras and Lie theory #1
12:30PM - 2:00PM	Atrium		Lunch
2:00PM - 3:00PM	Simons Auditorium	Karen Smith	Introduction to Frobenius splitting #3
3:00PM - 3:30PM	Atrium		Tea
3:30PM - 5:00PM	Baker Board Room		Tutorial Session
3:30PM - 5:00PM	Simons Auditorium		Tutorial Session

Friday, August 31, 2012			
9:00AM - 10:00AM	Simons Auditorium	Bernard Leclerc	Preprojective algebras and Lie theory #2
10:00AM - 10:30AM	Atrium		Tea
10:30AM - 11:30AM	Simons Auditorium	Holger Brenner	Vector bundles and ideal closure operations #1
11:30AM - 12:30PM	Simons Auditorium	Bernard Leclerc	Preprojective algebras and Lie theory #3
12:30PM - 2:00PM	Atrium		Lunch
2:00PM - 3:00PM	Simons Auditorium	Frank-Olaf Schreyer	Syzygies, finite length modules, and random curves #1
3:00PM - 3:30PM	Atrium		Tea
3:30PM - 5:00PM	Baker Board Room		Tutorial Session
3:30PM - 5:00PM	Simons Auditorium		Tutorial Session

Joint Introductory Workshop:
Cluster Algebras and Commutative Algebra

August 27 - September 7, 2012

Week Two Schedule

Monday, September 03, 2012			**LABOR DAY**
12:00PM - 4:00PM	Barbeque at Codornices Park		

Tuesday, September 04, 2012			
9:00AM - 10:00AM	Simons Auditorium	Idun Reiten	Cluster categories #1
10:00AM - 10:30AM	Atrium		Tea
10:30AM - 11:30AM	Simons Auditorium	Holger Brenner	Vector bundles and ideal closure operations #2
11:30AM - 12:30PM	Simons Auditorium	Alek Vainshtein	Cluster algebras and Poisson geometry #1
12:30PM - 2:00PM	Atrium		Lunch
2:00PM - 3:00PM	Simons Auditorium	Craig Huneke	Introduction to Uniformity in Commutative Algebra #3
3:00PM - 3:30PM	Atrium		Tea
3:30PM - 4:30PM	Simons Auditorium	Alek Vainshtein	Cluster algebras and Poisson geometry #2

Wednesday, September 05, 2012			
9:00AM - 10:00AM	Simons Auditorium	Holger Brenner	Vector bundles and ideal closure operations #3
10:00AM - 10:30AM	Atrium		Tea
10:30AM - 11:30AM	Simons Auditorium	Idun Reiten	Cluster categories #2
11:30AM - 12:30PM	Simons Auditorium	Frank-Olaf Schreyer	Syzygies, finite length modules, and random curves #2
12:30PM - 2:00PM	Atrium		Lunch
2:00PM - 3:00PM	Simons Auditorium	Alek Vainshtein	Cluster algebras and Poisson geometry #3
3:00PM - 3:30PM	Atrium		Tea
3:30PM - 5:00PM	Baker Board Room		Tutorial Session
3:30PM - 5:00PM	Simons Auditorium		Tutorial Session

Thursday, September 06, 2012			
9:00AM - 10:00AM	Simons Auditorium	Frank-Olaf Schreyer	Syzygies, finite length modules, and random curves #3
10:00AM - 10:30AM	Atrium		Tea
10:30AM - 11:30AM	Simons Auditorium	Idun Reiten	Cluster categories #3
11:30AM - 12:30PM	Simons Auditorium	Michel van den Bergh	Non-commutative resolutions #1
12:30PM - 2:00PM	Atrium		Lunch
2:00PM - 3:00PM	Simons Auditorium	Dylan Thurston	Cluster Algebras and Triangulated Surfaces #1
3:00PM - 3:30PM	Atrium		Tea
3:30PM - 5:00PM	Baker Board Room		Tutorial Session
3:30PM - 5:00PM	Simons Auditorium		Tutorial Session

Friday, September 07, 2012			
9:00AM - 10:00AM	Simons Auditorium	Dylan Thurston	Cluster Algebras and Triangulated Surfaces #2
10:00AM - 10:30AM	Atrium		Tea
10:30AM - 11:30AM	Simons Auditorium	Michel van den Bergh	Non-commutative resolutions #2
11:30AM - 12:30PM	Simons Auditorium	Dylan Thurston	Cluster Algebras and Triangulated Surfaces #3
12:30PM - 2:00PM	Atrium		Lunch
2:00PM - 3:00PM	Simons Auditorium	Michel van den Bergh	Non-commutative resolutions #3
3:00PM - 3:30PM	Atrium		Tea

Participants		
First Name	**Last Name**	**Institution**
Ali	Alilooee Dolatabad	Dalhousie University
Kathleen	Ansaldi	University of Notre Dame
Federico	Ardila	San Francisco State University
Spencer	Backman	Georgia Institute of Technology
Karin	Baur	Karl-Franzens-Universität Graz
Arkady	Berenstein	University of Oregon
Christine	Berkesch Zamaere	Duke University
Florian	Block	University of California
Mats	Boij	Royal Institute of Technology (KTH)
Holger	Brenner	Universitaet Osnabrueck
Giulio	Caviglia	Purdue University
Yi-Chang	Chen	University of California
Man-Wai	Cheung	University of California, San Diego
sangmin	chun	Seoul National University
Aldo	Conca	Università di Genova
Amanda	Croll	University of Nebraska
Emanuele	Delucchi	Universität Bremen
Philippe	Di Francesco	Centre d'Etudes Nucleaires de Saclay
David	Eisenbud	University of California
Idan	Eisner	University of Haifa
Juan	Elias	University of Barcelona
Laura	Escobar	Cornell University
Sergio	Estrada	University of Murcia
Sara	Faridi	Dalhousie University
Jiarui	Fei	University of California
Anna	Felikson	Jascobs University Bremen
Xiao	Feng	Michigan State University
Alex	Fink	North Carolina State University
Sergey	Fomin	University of Michigan
Bruce	Fontaine	MSRI - Mathematical Sciences Research Institute
Louiza	Fouli	New Mexico State University
Alexander	Garver	University of Minnesota Twin Cities
Michael	Gekhtman	University of Notre Dame
Courtney	Gibbons	University of Nebraska
Sira	Gratz	Universität Hannover
Stephen	Griffeth	Universidad de Talca
Emily	Gunawan	University of Minnesota Twin Cities
Kangjin	Han	Korea Institute for Advanced Study (KIAS)
Raymond	Heitmann	University of Texas
Aloysius	Helminck	North Carolina State University
Daniel	Hernandez	University of Minnesota Twin Cities
Olga	Holtz	University of California
Ko	Honda	University of Southern California
Jen-Chieh	Hsiao	Purdue University
Craig	Huneke	University of Virginia
Brian	Hwang	California Institute of Technology
Nathan	Ilten	University of California
Rei	Inoue	Chiba University
Srikanth	Iyengar	University of Nebraska-Lincoln
Jack	Jeffries	University of Utah

Tadeusz	Jozefiak	Mathematical Reviews
Arye	Juhasz	Technion
Arye	Juhasz	Technion---Israel Institute of Technology
Thomas	Kahle	ETH Zürich
Rinat	Kedem	University of Illinois at Urbana-Champaign
Bernhard	Keller	Université de Paris VII (Denis Diderot)
Leila	Khatami	Union College--Union University
Youngsu	Kim	Purdue University
Ryan	Kinser	Northeastern University
Robert	Korsan	retired
Olga	Kravchenko	Université Claude-Bernard (Lyon I)
Darla	Kremer	National Science Foundation
Kaie	Kubjas	Freie Universität Berlin
Manoj	Kummini	Chennai Mathematical Institute
Volha	Kushel	TU Berlin
Lisa	Lamberti	Eidgenössische TH Zürich-Zentrum
Philipp	Lampe	Universität Bielefeld
Bernard	Leclerc	Université de Caen
Chul-hee	Lee	Max-Planck-Institut für Mathematik
Matthias	Lenz	TU Berlin
Kuei-Nuan	Lin	University of California
Jichun	Liu	Zhejiang University
Linquan	Ma	University of Michigan
Antonio	Macchia	Università di Bari
Diane	Maclagan	University of Warwick
Jeff	Madsen	University of Notre Dame
Toshiaki	Maeno	Meijo University
Paolo	Mantero	Purdue University
Tom	Marley	University of Nebraska
Robert	Marsh	University of Leeds
Thomas	McConville	University of Minnesota Twin Cities
Jason	McCullough	MSRI - Mathematical Sciences Research Institute
Claudia	Miller	Syracuse University
Ezra	Miller	Duke University
Damien	Mondragon	University of California
Maria	Monks	UC Berkeley Math Faculty
Jonathan	Montano	Purdue University
Sophie	Morier-Genoud	Université de Paris VI (Pierre et Marie Curie)
Gregory	Muller	Louisiana State University
Daniel	Murfet	University of California
Gregg	Musiker	University of Minnesota Twin Cities
Muhammad	Naeem	COMSATS Institute of Information Technology Sahiwal, Pakistan.
Alfredo	Nájera Chávez	Université de Paris VII (Denis Diderot)
Tomoki	Nakanishi	Nagoya University
BHARATH	NARAYANAN	Pennsylvania State University
Patrice	Ntumba	University of Pretoria
Luis	Nunez-Betancourt	University of Michigan
Luke	Oeding	University of California
Christopher	ONeill	Duke University
Rebecca	Patrias	University of Minnesota Twin Cities
Irena	Peeva	Cornell University

Pierre-Guy	Plamondon	Université de Caen
Christopher	Policastro	University of Chicago
Claudia	Polini	University of Notre Dame
David	Pospisil	Karlovy (Charles) University (UK)
claudio	procesi	Accademia Nazionale dei Lincei
You	Qi	Columbia University
Fan	QIN	Université de Paris VII (Denis Diderot)
Claudiu	Raicu	Princeton University
Jenna	Rajchgot	MSRI - Mathematical Sciences Research Institute
idun	reiten	Norwegian University of Science and Technology (NTNU)
Vladimir	Retakh	Rutgers University
Elina	Robeva	University of California
Maria Evelina	Rossi	Università di Genova
dylan	rupel	Northeastern University
Steven	Sam	University of California
Jennifer	Schaefer	Dickinson College
Frank	Schreyer	Universität des Saarlandes
Alexandra	Seceleanu	University of Nebraska
Liana	Sega	University of Missouri
Anurag	Singh	University of Utah, Department of Mathematics
Karen	Smith	University of Michigan
Suresh	Srinivasamurthy	Kansas State University
Salvatore	Stella	Northeastern University
Jan	Stovicek	Karlovy (Charles) University (UK)
Kaisa	Taipale	MSRI - Mathematical Sciences Research Institute
Kelli	Talaska	University of California
Geetha	Thangavelu	The Institute of Mathematical Sciences, Chennai, India
Hugh	Thomas	University of New Brunswick
Howard	Thompson	University of Michigan
Dylan	Thurston	University of California
Gordana	Todorov	Northeastern University
Jan	Trlifaj	Karlovy (Charles) University (UK)
Kevin	Tucker	Princeton University
Pavel	Tumarkin	University of Durham
Bernd	Ulrich	Purdue University
Alek	Vainshtein	University of Haifa
Yadira	Valdivieso Diaz	Universidad Nacional de Mar del Plata
Michel	Van den Bergh	Limburgs Universitair Centrum
Matteo	Varbaro	Università di Genova
Emanuele	Ventura	Università di Catania
Roger	Wiegand	University of Nebraska
Sylvia	Wiegand	University of Nebraska
Lauren	Williams	UC Berkeley Math Faculty
Nathan	Williams	University of Minnesota Twin Cities
Emily	Witt	University of Minnesota Twin Cities
Nora	Youngs	University of Nebraska
Josephine	Yu	Georgia Institute of Technology
Andrei	Zelevinsky	Northeastern University
Wenliang	Zhang	University of Nebraska

Officially Registered Participant Information

Participants		**150**

Gender		**150**
Male	66.67%	100
Female	30.67%	46
Declined to state	2.67%	4

Ethnicity*		**150**
White	63.33%	95
Asian	19.33%	29
Hispanic	5.33%	8
Pacific Islander	0.00%	0
Black	1.33%	2
Native American	0.67%	1
Mixed	0.67%	1
Declined to state	9.33%	14

* ethnicity specifications are not exclusive

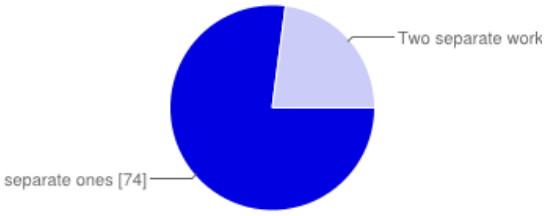
Joint Introductory Workshop: Cluster Algebras and Commutative Algebra, August 27 to September 7, 2012 at MSRI, Berkeley, CA USA

100 responses

Summary See complete responses

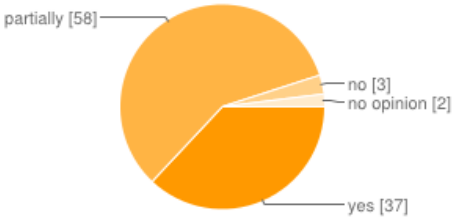
Topic presentation and organization

Did you feel that having one combined introductory workshop was successful? Or would it have been better as two separate weeks, each focusin on one topic?



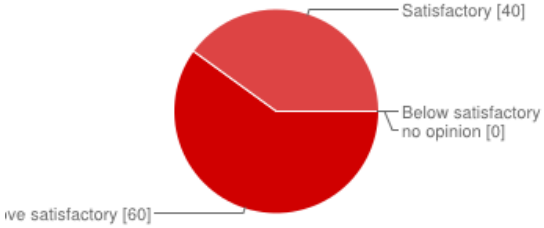
The combined workshop was successful and better than two separate ones	**74**	74
Two separate workshops would have been better	**22**	22

Did the various topics within the workshop integrate into a coherent picture?



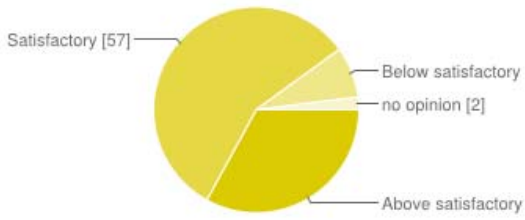
yes	**37**	37%
partially	**58**	58%
no	**3**	3%
no opinion	**2**	2%

Were the speakers generally clear and well organized in their presentation?



Above satisfactory	**60**	60%
Satisfactory	**40**	40%
Below satisfactory	**0**	0%
no opinion	**0**	0%

Was there adequate time between lectures for discussion?



Above satisfactory	**33**	33%
Satisfactory	**57**	57%
Below satisfactory	**8**	8%
no opinion	**2**	2%

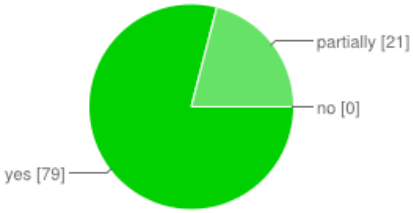
Joint Introductory Workshop: Cluster Algebras and Commutative Algebra, August 27 to September 7, 2012 at MSRI, Berkeley, CA USA

Additional comments on the topic presentation and organization

Very good speakers! Could have been more lectures on commutative algebra I liked having a joint introductory workshop, but it was too long. A one week joint introductory workshop following the three ...

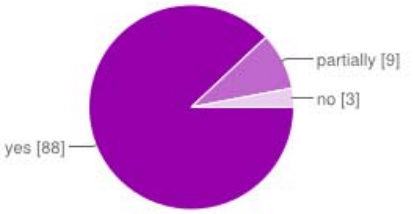
Personal assessment

Was your background adequate to access a reasonable portion of the material?



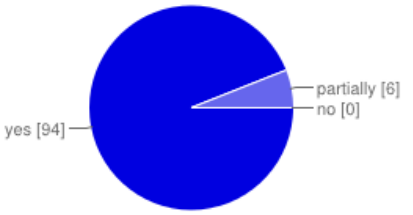
yes	**79**	79%
partially	**21**	21%
no	**0**	0%

Did the workshop increase your interest in the subject?



yes	**88**	88%
partially	**9**	9%
no	**3**	3%

Was the workshop worth your time and effort?



yes	**94**	94%
partially	**6**	6%
no	**0**	0%

Additional comments on your personal assessment

I really liked having the opportunity to learn more about cluster algebras. I learned a lot and started a potential collaboration with someone outside my field, so I consider it a big success. The wor ...

Venue

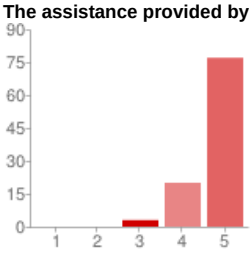
Your overall experience at MSRI

Joint Introductory Workshop: Cluster Algebras and Commutative Algebra, August 27 to September 7, 2012 at MSRI, Berkeley, CA USA

Not satisfactoryAbove satisfactory

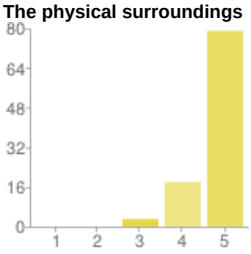
1 -	Not satisfactory	**0**	0%
2		**0**	0%
3		**1**	1%
4		**28**	28%
5 -	Above satisfactory	**71**	71%

The assistance provided by MSRI staff



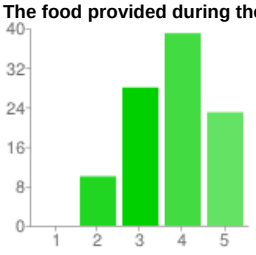
1 -	Not satisfactory	**0**	0%
2		**0**	0%
3		**3**	3%
4		**20**	20%
5 -	Above satisfactory	**77**	77%

The physical surroundings



1 -	Not satisfactory	**0**	0%
2		**0**	0%
3		**3**	3%
4		**18**	18%
5 -	Above satisfactory	**79**	79%

The food provided during the workshop



1 -	Not satisfactory	**0**	0%
2		**10**	10%
3		**28**	28%
4		**39**	39%
5 -	Above satisfactory	**23**	23%

Additional comments on the venue

Heating/Cooling problems in the auditorium Is there a tactful way to indicate which caterer will be providing lunch each day? I'm not alone in vastly preferring stuffed inn. the quality and quantity ...

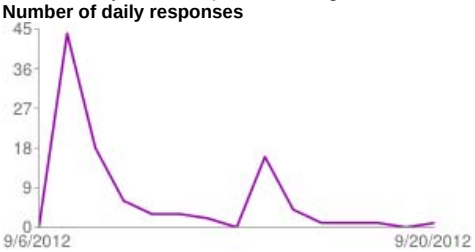
Thank you for completing this survey

We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.

I didn't realize that the "connections for women" workshop would provide even more background for the talks. Many thanks. A drinks/chocolate vending machine. A telephone room with computer to allow di ...

Joint Introductory Workshop: Cluster Algebras and Commutative Algebra, August 27 to September 7, 2012 at MSRI, Berkeley, CA USA

Number of daily responses



Joint Introductory Workshop: Cluster Algebras and Commutative Algebra
August 27 to September 7, 2012

Additional Survey Responses

Additional comments on the topic presentation and organization

- Very good speakers!
- Could have been more lectures on commutative algebra
- I liked having a joint introductory workshop, but it was too long. A one week joint introductory workshop following the three days of connections workshop would have been better. Some evidence that it was too long was that the organizers of the workshop, and more notably the programs, didn't come to all talks... As a commutative algebraist, I found the cluster talks almost all accessible, and generally of a higher quality than the commutative algebra talks. Also on logistics, it was unfortunate for the third speaker each day that the audience was starting to lose the ability to pay attention by 12:30. Having the problem sessions in that slot and two talks after lunch might have been easier to deal with. The problem of two one-hour talks back-to-back was something that the MSRI administration could have predicted would cause a problem. On the flip side, I'm only complaining about the length because the overall quality of the talks was so high that I wanted to come to everything (so am complaining about the lack of time to work!).
- it would be veru useful to have the videos of the lecture the next day because some speakers were very fast l.
- Talks going over time took away from discussion potential. There was no clear session chair to keep them on time, it would have been better if there were.
- Having three morning talks felt very rushed and made it impossible to stick to the schedule. It would have been much better to put a tutorial in place of the third morning talk and rearranged the afternoon. Also, it was difficult to do other work/collaboration due to the number of talks. It would have been better to give most lecturers only 2 talks. Not only did the third talks take up a lot of time, they also often became technical and hard to follow.
- It would have been better if the lectures were 50 minutes with time for questions built in. Too often the speakers spoke for 65-70 minutes before asking for questions.
- The areas covered were very broad - more focus might have worked better. But I got a lot out of the talks.
- I disliked the problem session format. I prefer the setting where the participants do the work, with the advice of the experts. Just watching an expert work examples seems less helpful than doing them yourself.
- The speakers were of very high level mathematically and also didactically. They were clear also for non-experts.
- (As usual) some of the tutorials were just additional lectures.
- I wish the tutorials were more interactive. Most of them ended up being yet another lecture. I think Huneke's list of problems was great. There should be more "homework" and discussion among participants.
- The Cluster Algebras portion was particularly coherent and unfailingly well presented, all the way through to each speaker's third lecture. Some of the Commutative Algebra lectures were

pitched too high (not accessible) or could have included more to motivate someone coming from outside the field.
- All three series of talks (first week) on cluster algebras were excellent
- I am not sure about the relative advantages and disadvantages. I think having the tutorials for both themes simultaneously is a bad idea. As it was, people mainly attended the tutorials from their own theme. Perhaps in part because of this, the presentation in the commutative algebra tutorials which I attended was not at the level where I felt like I could understand it in a hands-on way. (Jason did a very good job on free resolutions, and I didn't attend all of the commutative algebra tutorials, so there may have been others which were equally good.)
- It was very difficult to understand the advanced talks of the other field.
- All speakers were excellent

Additional comments on your personal assessment
- I really liked having the opportunity to learn more about cluster algebras.
- I learned a lot and started a potential collaboration with someone outside my field, so I consider it a big success.
- The workshop was long, and became a bit tiring to continue to go to talks for that long. On the other hand many of the talks were very good, so it was a mixed blessing.
- It was a fantastic opportunity for me to listen to specialists, I learned a lot and gto many ideas about what to do next
- It was wonderful. The speakers were mostly very clear and stimulating and I became very interested in looking for connections between the topics.
- It was a really amazing experience. Thank you
- See my topic presentation comments.
- I guess I am kind of an expert on cluster algebras. I wouldn't normally describe myself as such, and there are lots of people here who know more about particular topics, but I feel like I already understood most of what was said in the cluster algebra talks. This is more or less fine with me, but I hope there were people attending who found the ideas more new than I did. As regards the commutative algebra, I mostly felt that the talks were well done on their own terms, but hard to take much away from for someone without a background in current topics of interest in commutative algebra. Brenner's series was, I would say, particularly accessible; and Van den Bergh's was close to my interests, so I found those comparatively valuable.

Additional comments on the venue
- Heating/Cooling problems in the auditorium
- the quality and quantity of the food didn't math the price
- lecture hall was cold down, most people were freezing, but nothing changed during the two weeks
- Occasionally food ran out at lunch which was hard for previous speakers arriving later.
- The stuffed inn catering was much more efficient than the caterer for the second week.
- Prefer the first week's food to the second week's food. Please invite Stuffed Inn again!
- it is very convenient to have lunch venue in the institute
- The doors in women's restroom need to be fixed.
- The lecture hall was too cold because of the air conditioning
- The lunch vendor the first week was preferable to the lunch vendor the second week
- The lunch selections were limited and unvarying. The lecture hall had temperature issues; many participants covered the nearby vents. Getting down the hill on the bus was sometimes difficult or impossible, particularly when the special MSRI event shuttle didn't run.
- capacity of downhill buss is too small that somebody could not get on. This is expected and should be remedied.

- A comment on food orders not during the workhops: It would be nice if it were possible to order lunch using a credit card rather than PayPal. I do not want to use PayPal, so I have not ordered any lunches.
- Physical surroundings is great except for temperature control in the auditorium. Stuffed Inn Caterer greatly preferred.

We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.

- I didn't realize that the "connections for women" workshop would provide even more background for the talks.
- Many thanks.
- A drinks/chocolate vending machine. A telephone room with computer to allow discussion without disturbing other officemates.
- It was very frustrating not to be able to rewatch the lectures online right away, particularly as they were lecture series with future coming parts. Quite frankly, having a four week gap before the lectures become available online makes the video taping process helpful only to those people who were not at the conference in person at all.
- It's a great environment for doing math. Thank you. I guess the only minor inconvenience especially for foreigners is that the reibursement happens at the very end of the conference. One has to change money coming to the States and then change back what was reimbursed in dollars in the very last day. I understand that it is probably impossible to do in advance but it seems that there is not time constraints to do it in the middle of a two-week workshop, and not at the very end.
- vending machines might be helpful at times
- If possible a little more free time to communicate informally with other participants and keep up with one's own projects. Also possibly the time limits should be enforced for talks.
- Provide a summary of some good restaurants and places of interest in Berkeley. I personally used to live in Berkeley, so most evenings I ended up gathering visitors and taking them to a restaurant, pub or other venue for dinner and discussions; there shouldn't have to be a (former) local in the group to make this happen.

MSRI Mathematical Sciences Research Institute

Cluster Algebras in Combinatorics, Algebra, and Geometry Workshop

October 29 to November 2, 2012

MSRI, Berkeley, CA, USA

Organizers:

Claire Amiot (Université de Strasbourg)

Sergey Fomin (University of Michigan)

Bernard Leclerc (Université de Caen)

Andrei Zelevinsky* (Northeastern University)

REPORT ON THE MSRI WORKSHOP "CLUSTER ALGEBRAS IN COMBINATORICS, ALGEBRA, AND GEOMETRY" OCTOBER 29 - NOVEMBER 2, 2012

Organizers

- Claire Amiot (Université de Strasbourg)
- Sergey Fomin (University of Michigan)
- Bernard Leclerc (Université de Caen)
- Andrei Zelevinsky (Northeastern University)

1. Scientific description

The theory of cluster algebras is a young subject (they were discovered in 2000), so it is quite unusual to see a semester long MSRI program devoted to it. At the heart of the theory there are several discrete dynamical systems based on birational and piecewise-linear recurrences, and defined in a totally elementary way. Surprisingly, the resulting structure is very rich and exhibits many unexpected features - for instance, there is a natural notion of cluster algebras of finite type, and their classification turns out to be parallel to the famous Cartan-Killing classification of semisimple Lie algebras.

The importance of the theory is rooted in its unexpected appearances in numerous and diverse fields of mathematics and theoretical physics. Here is an incomplete list: Total positivity; Representation theory and geometry of semisimple Lie groups, Kac-Moody groups and quantum groups; String theory; Integrable models in statistical physics; Quiver representations; Non-commutative geometry; Teichmüller theory; Poisson geometry; Discrete integrable systems; Tropical geometry; Algebraic and polyhedral combinatorics. Cluster algebras provide a unifying algebraic/combinatorial framework for a wide variety of phenomena in these and other settings.

Since its inception, the theory of cluster algebras has attracted a lot of activity from many excellent researchers all around the world. The information about numerous conferences, summer schools, seminars, thematic programs, etc. related to cluster algebras can be found at the online `Cluster Algebras Portal` maintained by S. Fomin.

The aim of the MSRI workshop was to present a broad view of the state-of-the-art understanding of the role of cluster algebras in various active areas of research, and their interactions with each other. The organizers did not attempt to cover the entire spectrum of appearances and applications of the theory of cluster algebras, since this would require a much longer conference. In our choice of speakers we aimed instead at presenting several important areas of active current research. Alongside lectures by world-renowned mathematicians such as I. Reiten or B. Keller, there were those by talented and promising young researchers such as for example A. Felikson

and P.-G. Plamondon. We hoped that the speakers are able to present the latest developments in the subject while keeping their presentations accessible to young researchers. We believe that most of the speakers did an admirable job at succesfully fulfilling both goals.

2. The workshop program

Several lectures were devoted to different categorical constructions closely related to cluster alebras. The lectures by I. Reiten and O. Iyama discussed the *tau-tilting theory*, a far-reaching generalization of the classical tilting theory. They explained how this new theory is motivated by cluster theory, and how it generalizes earlier results on 2- Calabi-Yau triangulated categories. This development culminated in a very recent work where the main constructions and results of the tau-tilting theory were extended to *arbitrary* finite-dimensional algebras, an unexpected and unprecedented level of generality.

B. Keller discussed his ongoing joint work with a postdoc Sarah Scherotzke devoted to new relations between quiver varieties and the derived category of a Dynkin quiver. P.-G. Plamondon has explained a recent beautiful application (obtained in a joint work with G. Cerulli Irelli, B. Keller and D. Labardini-Fragoso) of cluster categories to the combinatorics of cluster algebras, namely a proof that exchange graphs and cluster complexes of cluster algebras are independent of the choice of coefficients.

The lecture by D. Hernandez presented new connections between cluster algebras and the representation theory of non-simply-laced quantum affine algebras, found in his joint work with B. Leclerc. Another connection between Kac-Moody algebras and cluster algebras has appeared in the lecture by C. Geiss who reported his most recent joint work with B. Leclerc and J. Schroër devoted to generic bases for cluster algebras (he also discussed his very recent work with D Labardini Fragoso and J. Schroër on surface cluster algebras).

A totally different Lie-theoretic connection was presented in the lecture by M. Gekhtman. He reported on his ongoing joint project with M. Shapiro and A. Vainshtein focused on the following conjecture: to every Poisson-Lie structure on a simple Lie group (such structures are given by the famous Belavin-Drinfeld classification) one can naturally asociate a cluster algebra structure in the ring of regular functions on the group.

Some of the most important sources and applications of cluster algebras come from (generalized) Teichmüller spaces of Riemann surfaces with boundary and marked points. A. Felikson and M. Shapiro devoted their lectures to various aspects of cluster structures (and their generalizations) associated to Teichmüller spaces of Riemann surfaces with orbifold points.

Surprising recently discovered connections with probems in mathematical and statistical physics were discussed by R. Kenyon (The hexahedron recurrence and the Ising model) and L. Wiliams (Combinatorics of KP solitons from the real Grassmannian). Some features of cluster algebras closely related to discrete integrable systems were discussed in the lectures by T. Nakanishi and P. di Francesco.

Upon request by the organizers, P. Pylyavskyy gave a survey of a fascinating series of joint papers with T. Lam dealing with total positivity, loop groups and electrical networks.

Some more elementary (but by no means trivial) combinatorial and algebraic features and applications of cluster algebras were discussed in the lectures by H. Thomas, R. Marsh, and in the informal presentation organized by N. Reading.

3. Concluding remarks

Judging by comments we heard from several participants, the workshop seems to have been a big success. In the choice of speakers and funded participants, the organizers took into account not only the scientific aspects of the program but also the diversity. There were three women among the speakers (Anna Felikson, Idun Reiten and Lauren Williams), and their lectures were some of the best organized and the most successful in the program. In our choice of funded participants, we took special care to select women, young people at the beginning of their careers (graduate students and postdocs), and US based researchers, keeping in mind geographical diversity.

Organizers

First Name	Last Name	Institution
Sergey	Fomin	University of Michigan
Bernard	Leclerc	Université de Caen
Andrei	Zelevinsky	Northeastern University

Speakers

First Name	Last Name	Institution
Philippe	Di Francesco	Commissariat à l'Énergie Atomique (CEA)--Centre d'Études Nucléaires de Saclay (CENS) Institut de Physique Théorique, CEA Saclay
Anna	Felikson	Jacobs University Bremen
Christof	Geiss	Universidad Nacional Autonoma de Mexico
Michael	Gekhtman	University of Notre Dame
David	Hernandez	Université de Paris VII (Denis Diderot)
Osamu	Iyama	Nagoya University
Bernhard	Keller	Université de Paris VII (Denis Diderot)
Richard	Kenyon	Brown University
Robert	Marsh	University of Leeds
Kentaro	Nagao	Nagoya University
Tomoki	Nakanishi	Nagoya University
Pierre-Guy	Plamondon	Université de Caen
Pavlo	Pylyavskyy	University of Minnesota Twin Cities
Idun	Reiten	Norwegian University of Science and Technology (NTNU)
Michael	Shapiro	Michigan State University
Hugh	Thomas	University of New Brunswick
Lauren	Williams	UC Berkeley Math Faculty

Cluster Algebras in Combinatorics, Algebra, and Geometry

October 29 - November 2, 2012

Schedule

Monday, October 29, 2012			
9:15 AM - 9:30 AM	Simons Auditorium		Welcome
9:30 AM - 10:30 AM	Simons Auditorium	I.Reiten	tau-tilting theory 1
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00	Simons Auditorium	B.Keller	Quiver varieties and derived categories
12:00 - 2:00 PM	Atrium		Lunch
2:00 - 3:00 PM	Simons Auditorium	P.-G.Plamondon	Independence for exchange graphs and cluster complexes
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:30 PM	Simons Auditorium	H.Thomas	Higher-dimensional analogues of cluster structures

Tuesday, October 30, 2012			
9:30 AM - 10:30 AM	Simons Auditorium	R.Marsh	Reflection group presentations arising from cluster algebras
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00	Simons Auditorium	R.Kenyon	The hexahedron recurrence and the Ising model
12:00 - 2:00 PM	Atrium		Lunch
2:00 - 3:00 PM	Simons Auditorium	T.Nakanishi	Diagrammatic description of c-vectors and d-vectors of cluster algebras of finite type
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:30 PM	Simons Auditorium	P. Di Francesco	Periodicity, positivity and integrability of T-systems
4:30 PM - 6:20 PM	Atrium		Reception

Wednesday, October 31, 2012			
9:30 AM - 10:30 AM	Simons Auditorium	A.Felikson	Cluster algebras from orbifolds
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00	Simons Auditorium	L.Williams	Combinatorics of KP solitons from the real Grassmannian

Thursday, November 1, 2012			
9:30 AM - 10:30 AM	Simons Auditorium	C.Geiss	On Generic Bases for Cluster Algebras
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00	Simons Auditorium	D.Hernandez	Non-simply laced quantum affine algebras and cluster algebras
12:00 - 2:00 PM	Atrium		Lunch
2:00 - 3:00 PM	Simons Auditorium	P.Pylyavskyy	Total positivity, loop groups and electrical networks
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:30 PM	Simons Auditorium	O.Iyama	tau-tilting theory 2

Friday, November 2, 2012			
9:30 AM - 10:30 AM	Simons Auditorium	M.Gekhtman	Cremmer-Gervais Cluster Algebras
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00	Simons Auditorium	M.Shapiro	Generalized cluster algebra and Teichmüller spaces of Riemann surfaces with orbifold points of arbitrary order (joint with L.Chekhov)

Participants

First Name	Last Name	Institution
Ibraheem	Alolyan	King Saud University
Federico	Ardila	San Francisco State University
Helene	Barcelo	MSRI - Mathematical Sciences Research Institute
Karin	Baur	Karl-Franzens-Universität Graz
Anna	Bertiger	Cornell University
Florian	Block	UC Berkeley Math Faculty
Joe	Buhler	Institute for Defense Analyses (CCR-LJ)
Ilke	Canakci	University of Connecticut
Giulio	Caviglia	Purdue University
Cesar	Ceballos	Freie Universität Berlin
Giovanni	Cerulli-Irelli	Universität Bonn
Alfredo Najera	Chavez	Université de Paris VII (Denis Diderot)
Xueqing	Chen	University of Wisconsin
Steven	Collazos	San Francisco State University
Philippe	Di Francesco	Commissariat à l'Énergie Atomique (CEA)--Centre d'Études Nucléaires de Saclay (CENS) Institut de Physique Théorique, CEA Saclay
Anton	Dzhamay	University of Northern Colorado
Idan	Eisner	University of Haifa
Jiarui	Fei	University of California
Anna	Felikson	Jacobs University Bremen
Xiao	Feng	Michigan State University
Alex	Fink	North Carolina State University
Sergey	Fomin	University of Michigan
Bruce	Fontaine	MSRI - Mathematical Sciences Research Institute
Alexander	Garver	University of Minnesota Twin Cities
Christof	Geiss	Universidad Nacional Autonoma de Mexico
Michael	Gekhtman	University of Notre Dame
Max	Glick	MSRI - Mathematical Sciences Research Institute
Joseph	Grant	University of Leeds
Emily	Gunawan	University of Minnesota Twin Cities
Stephen	Hermes	Brandeis University
David	Hernandez	Université de Paris VII (Denis Diderot)
Olga	Holtz	University of California
Ko	Honda	University of Southern California
Jishan	Hu	Hong Kong University of Science and Technology
Osamu	Iyama	Nagoya University
Srikanth	Iyengar	University of Nebraska
Jack	Jeffries	University of Utah
Bernhard	Keller	Université de Paris VII (Denis Diderot)
Richard	Kenyon	Brown University
Yoshiyuki	Kimura	Osaka City University
Daniel	Labardini-Fragoso	Universität Bonn
Lisa	Lamberti	Eidgenössische TH Zürich-Zentrum
Ian	Le	Northwestern University
Bernard	Leclerc	Université de Caen
Kyungyong	Lee	Wayne State University

Antonio	Macchia	Università di Bari
Christopher	Manon	George Mason University
Robert	Marsh	University of Leeds
Thomas	McConville	University of Minnesota Twin Cities
Jason	McCullough	MSRI - Mathematical Sciences Research Institute
Grigory	Mikhalkin	Université de Genève
Damien	Mondragon	University of California
Gregory	Muller	Louisiana State University
Gregg	Musiker	University of Minnesota Twin Cities
Tomoki	Nakanishi	Nagoya University
Soichi	OKADA	Nagoya University
Greta	Panova	University of California
Pierre-Guy	Plamondon	Université de Caen
Pavlo	Pylyavskyy	University of Minnesota Twin Cities
Fan	QIN	Université de Paris VII (Denis Diderot)
Ali	Rajaei	Stanford University
Nathan	Reading	North Carolina State University
Idun	Reiten	Norwegian University of Science and Technology (NTNU)
Ilan	Roth	UC Berkeley Math Faculty
Dylan	Rupel	MSRI - Mathematical Sciences Research Institute
Steven	Sam	University of California
Jennifer	Schaefer	Dickinson College
Ralf	Schiffler	University of Connecticut
Alexandra	Seceleanu	University of Nebraska
Michael	Shapiro	Michigan State University
Kristin	Shaw	University of Toronto
Fedor	Soloviev	University of Toronto
David	Speyer	University of Michigan
Suresh	Srinivasamurthy	Kansas State University
Salvatore	Stella	Northeastern University
Jessica	Striker	University of Minnesota Twin Cities
Kaisa	Taipale	MSRI - Mathematical Sciences Research Institute
Ryo	Takahashi	Nagoya University
Kelli	Talaska	University of California
Hugh	Thomas	University of New Brunswick
Howard	Thompson	University of Michigan
Gordana	Todorov	Northeastern University
Pavel	Tumarkin	University of Durham
EMANUELE	VENTURA	Università di Catania
Hannah	Vogel	Carnegie-Mellon University
Harold	Williams	University of California
Lauren	Williams	UC Berkeley Math Faculty
Shih-Wei	Yang	National Cheng Kung University
Andrei	Zelevinsky	Northeastern University
Patrick	Zwick	University of Utah

Officially Registered Participant Information

Participants		**90**

Gender		**90**
Male	77.78%	70
Female	21.11%	19
Declined to state	1.11%	1

Ethnicity*		**90**
White	61.11%	55
Asian	18.89%	17
Hispanic	5.56%	5
Pacific Islander	0.00%	0
Black	1.11%	1
Native American	1.11%	1
Mixed	1.11%	1
Declined to state	11.11%	10

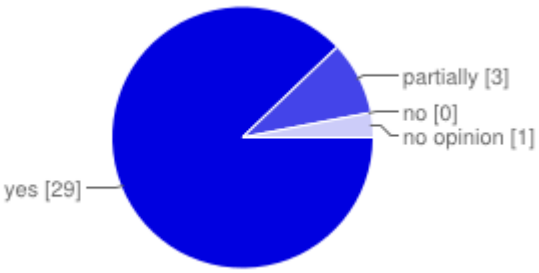
* ethnicity specifications are not exclusive

33 responses

Summary See complete responses

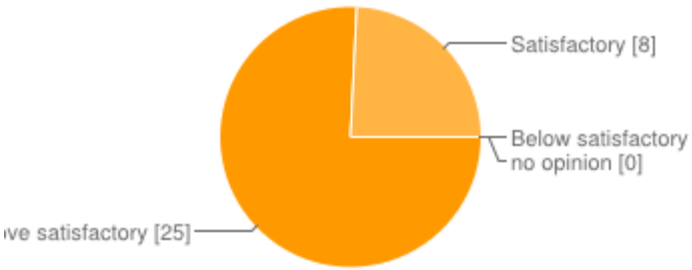
Topic presentation and organization

Did the various topics within the workshop integrate into a coherent picture?



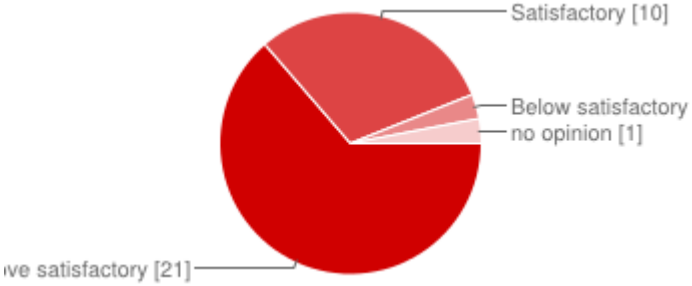
yes	**29**	88%
partially	**3**	9%
no	**0**	0%
no opinion	**1**	3%

Were the speakers generally clear and well organized in their presentation?



Above satisfactory	**25**	76%
Satisfactory	**8**	24%
Below satisfactory	**0**	0%
no opinion	**0**	0%

Was there adequate time between lectures for discussion?



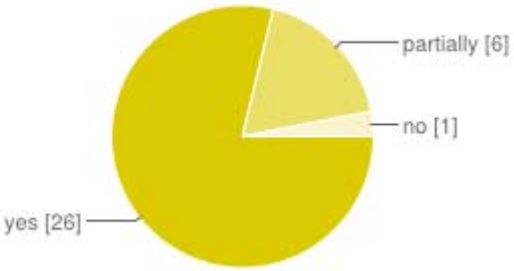
Above satisfactory	**21**	64%
Satisfactory	**10**	30%
Below satisfactory	**1**	3%
no opinion	**1**	3%

Additional comments on the topic presentation and organization

An enjoyable conference the takls on day 1 required specialized and sophisticated knowledge...it would have been more appropriate to give a little more background for these talks. Very well organized ...

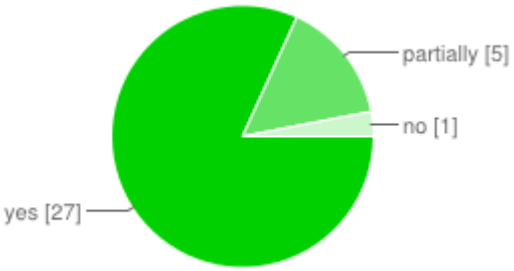
Personal assessment

Was your background adequate to access a reasonable portion of the material?



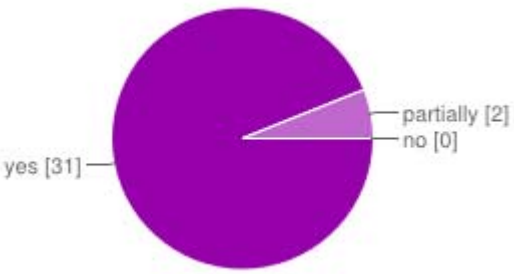
yes	**26**	79%
partially	**6**	18%
no	**1**	3%

Did the workshop increase your interest in the subject?



yes	**27**	82%
partially	**5**	15%
no	**1**	3%

Was the workshop worth your time and effort?



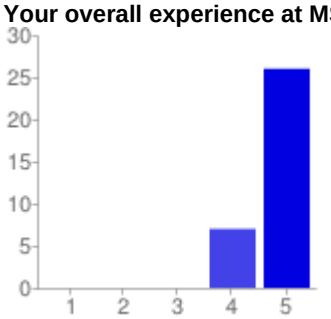
yes	**31**	94%
partially	**2**	6%
no	**0**	0%

Additional comments on your personal assessment

I knew nothing about cluster algebras when I started, and now I know a little, and want to know more. Attending the workshop was very useful to me. A very usefull workshop.

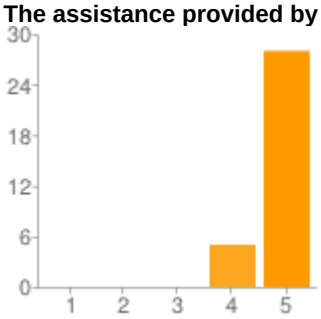
Venue

Your overall experience at MSRI



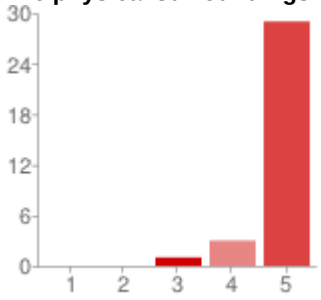
1 -Not satisfactory	**0**	0%
2	**0**	0%
3	**0**	0%
4	**7**	21%
5 -Above satisfactory	**26**	79%

The assistance provided by MSRI staff



1 -Not satisfactory	**0**	0%
2	**0**	0%
3	**0**	0%
4	**5**	15%
5 -Above satisfactory	**28**	85%

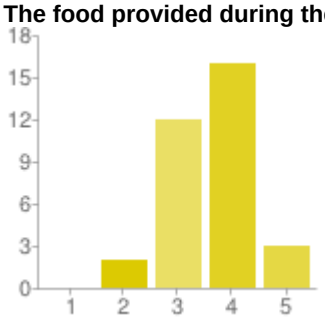
The physical surroundings



1 -Not satisfactory	**0**	0%
2	**0**	0%
3	**1**	3%
4	**3**	9%
5 -Above satisfactory	**29**	88%

Not satisfactoryAbove satisfactory

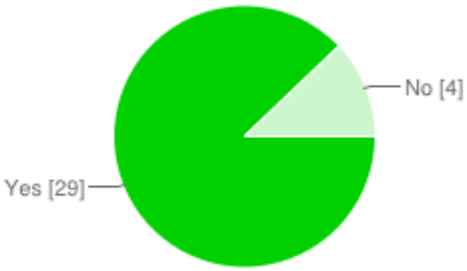
The food provided during the workshop



Not satisfactoryAbove satisfactory

1 -Not satisfactory	**0**	0%
2	**2**	6%
3	**12**	36%
4	**16**	48%
5 -Above satisfactory	**3**	9%

Did you use MSRI's wireless network?



Yes	**29**	88%
No	**4**	12%

Did you experience any difficulties with the network? If so, please explain:

no No No no Generally worked very well. Occasionally had to log off then on again on my ipad, but laptop worked fine. No

Additional comments on the venue

bad phone reception Temperature control in Simons lecture theatre is not good - often too cold and sometimes overwarm also. The locks on many of the bathroom stalls in the womens' bathroom are broken. ...

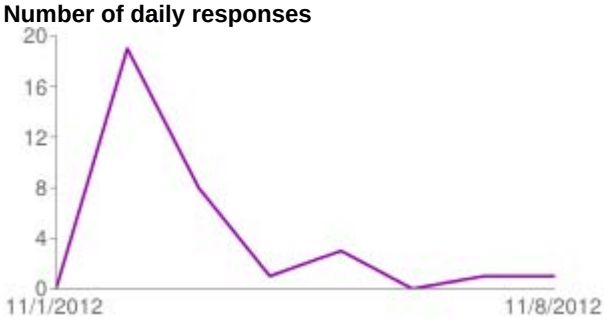
Thank you for completing this survey

We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.

MSRI is a wonderful institution. Thank you so much!

The Workshop per diem should be higher to meet the standards of hotel and restaurant prices in Berkeley.

Number of daily responses



Cluster Algebras in Combinatorics, Algebra, and Geometry Workshop October 29 to November 2, 2012

Additional Survey Responses

Additional comments on the topic presentation and organization

- An enjoyable conference
- the takls on day 1 required specialized and sophisticated knowledge...it would have been more appropriate to give a little more background for these talks.
- Very well organized and coherent. tau-tilting talks should have been consecutive.
- The open Friday afternoon turned out to be amazingly useful.
- Very well chosen topics
- Brillant Workshop.

Additional comments on your personal assessment

- I knew nothing about cluster algebras when I started, and now I know a little, and want to know more.
- Attending the workshop was very useful to me.
- A very usefull workshop.

Additional comments on the venue

- bad phone reception
- Temperature control in Simons lecture theatre is not good - often too cold and sometimes overwarm also.
- The locks on many of the bathroom stalls in the womens' bathroom are broken. Please fix them.
- Air condition is not satisfactory at all. It was very often cooling when not needed. I think it would be better to have it have turned off permanently.
- Really good environment for conference and discussion.

We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.

- MSRI is a wonderful institution. Thank you so much!
- The Workshop per diem should be higher to meet the standards of hotel and restaurant prices in Berkeley.

Combinatorial Commutative Algebra and Applications

December 3 to December 7, 2012

MSRI, Berkeley, CA, USA

Organizers:

Winfried Bruns (Universität Osnabrück)

Alicia Dickenstein (University of Buenos Aires)

Takayuki Hibi (Osaka University)

Allen Knutson* (Cornell University)

Bernd Sturmfels (University of California, Berkeley)

REPORT ON THE MSRI WORKSHOP COMBINATORIAL COMMUTATIVE ALGEBRA DECEMBER 3-7, 2012

Organizers

- Winfried Bruns (Universität Osnabrück)
- Alicia Dickenstein (Universidad de Buenos Aires)
- Takayuki Hibi (Osaka University)
- Allen Knutson (Cornell University)
- Bernd Sturmfels (University of California, Berkeley)

1. Scientific Description

Combinatorial Commutative Algebra is, as its name suggests, a field using (1) combinatorial techniques to study commutative rings and (2) commutative algebras (and their associated varieties) to study combinatorics. Our workshop focused on both pure and applied aspects. Specific topics we had in mind for this even were: toric algebras associated with polyhedra and simplicial complexes; flag varieties, Schubert varieties, and their degenerations to toric schemes; Hilbert schemes; connections to D-modules and dynamical systems; algebraic statistics, and connections to tropical algebraic geometry. Participants from all these areas attended the workshop.

In 1975, Richard P. Stanley proved affirmatively the upper bound conjecture for spheres by using the theory of Cohen–Macaulay rings. Stanley's work created a new trend of commutative algebra and it turned out that commutative algebra supplies basic methods in the algebraic study of combinatorics on convex polytopes and simplicial complexes. Stanley was the first to use concepts and techniques from commutative algebra in a systematic way to study simplicial complexes by considering the Hilbert function of **Stanley–Reisner rings**. Since then, the study of square-free monomial ideals from both the algebraic and combinatorial points of view has become a very active area of research in commutative algebra and neighboring fields.

In the late 1980s, **Gröbner bases** came into fashion in many branches of mathematics. Gröbner bases, together with initial ideals, provided new methods. They have been used not only for computational purposes but also to deduce theoretical results in commutative algebra and combinatorics. For example, based on the fundamental work by Gel'fand, Kapranov, Zelevinsky and Sturmfels, far beyond the classical techniques in combinatorics, the study of regular triangulations of a convex polytope by using suitable initial ideals turned out to be a very successful approach. A part of the workshop was devoted to current trends on monomial ideals, binomial ideals and initial ideals, in particular those arising in combinatorics, Gröbner bases and initial ideals of toric ideals, the g-conjecture, and problems on pure O-sequences.

While monomial ideals and Stanley-Reisner rings encode incidence structures, **toric algebra** captures the combinatorics of point sets in an algebraic structure:

lattice points are considered as monomials and the affine dependencies of the lattice points appear as their binomial relations. The correspondence between algebra and geometry is especially good if the point sets are defined by convex bodies. Therefore toric algebra is the bridge between commutative algebra and convex geometry. Since lattice points in convex sets come up naturally in integer programming, the same bridge links commutative algebra to this field of optimization. Algebraic invariants of toric algebras can often be measured by combinatorial data, and can therefore be computed more easily than for general commutative rings. This makes toric algebras an attractive target for deformations. Such deformations have been constructed for many classical commutative rings and used very fruitfully for their investigation.

The name "toric algebra" stems from the fact that monomials represent characters of torus actions. Toric algebras are the affine building blocks of **toric varieties**. Therefore toric algebra provides the foundation of toric geometry and cannot be separated from it. Despite of considerable recent progress, there remain intriguing open problems that relate the structure of lattice polytopes, projective toric varieties and the corresponding toric rings. Prototypical examples are two questions about smooth projective toric varieties: are these varieties (i) arithmetical normal and (ii) defined by degree two equations in every equivariant embedding into projective space?

Gel'fand, Graev, Kapranov, and Zelevinsky developed in the late '80s a highly interesting point of view, by endowing multivariate **hypergeometric functions** and differential operators with homogeneities. This approach opened the way to understand the properties of classical hypergeometric systems via tools in algebraic geometry and combinatorics. Toric ideals together with a complex homogeneity vector are used to define a left D-module. The resulting A-hypergeometric systems of PDE's have many applications; for example, they arise naturally in the moduli theory of Calabi-Yau complete intersections in toric varieties. Saito, Sturmfels and Takayama developed the theory with emphasis on computations. Berkesch, Dickenstein, Matusevich, Miller, Schulze and Walther used further tools from combinatorial and homological commutative algebra, to describe the holonomicity, the holonomic rank, the regularity and the shape of solutions of **binomial D-modules**.

Toric dynamical systems describe mass-action kinetics with complex balancing states. These systems of ODE's have been studied extensively in mathematical chemistry, starting with the work of Horn, Jackson and Feinberg in the '70s. Mass-action kinetics has a wide range of applications in the physical sciences and systems biology. Important special cases of these dynamical systems include recombination equations in population genetics and quadratic dynamical systems in computer science. Gatermann introduced the connection between mass-action kinetics and computer algebra. The basic theory of toric dynamical systems within the context of computational algebraic geometry was developed by Craciun, Dickenstein, Sturmfels and Shiu.

The basic combinatorial invariant of a Lie group is its Weyl group, and since the symmetric group S_n arises as a Weyl group it is almost always interesting to try to generalize combinatorial questions about permutations to other Weyl groups. The algebro-geometric varieties associated to individual Weyl group elements are the **Schubert varieties** inside a flag variety. While Schubert varieties have arbitrarily bad singularities (any polynomial with non-negative integer coefficients arises

as a local intersection Poincaré polynomial), their coordinate algebras are **Cohen-Macaulay rings**, suggesting that their geometry is more easily studiable from the commutative algebra point of view. For example, toric degenerations of flag varieties have been found that compatibly degenerate the Schubert varieties. This work began with Hodge (before Gröbner bases), of the Grassmannian in its Plücker embedding, continued with the "standard monomial theory" of Lakshmibai, Mehta, Seshadri, et al., and has reached some level of completion in the works of Chirivì and Caldero.

Tropical geometry is an exploding field that straddles many branches of mathematics. The objects of study are tropical varieties, which are piecewise-linear versions of algebraic varieties that reflect and simplify the geometry of their classical counterparts. Valuation theory, singularity theory, Gröbner bases and rigid analytic geometry play a role on the interface of tropical geometry and commutative algebra.

Algebraic statistics is concerned with applications of algebraic methods in performing statistical inference. What makes this possible is that many statistical models for discrete or Gaussian data correspond to algebraic varieties whose geometry is responsible for their statistical properties; for instance, dimension and singularities determine whether the model is identifiable and how difficult it is to compute maximum likelihood estimates. Commutative algebra is key here, and there have been numerous fascinating advances on coordinate rings of statistical models.

Hilbert schemes are varieties that parametrize classes of ideals in a given graded ring. Classically, one considers saturated ideals in a standard graded ring, and this leads to Grothendieck's Hilbert scheme of subschemes of a projective variety, but in recent years that classical construction has been extended to more combinatorial settings, such as toric Hilbert schemes and multigraded Hilbert schemes, and there is a lot of fascinating current research on Hilbert schemes of points in affine space.

2. Highlights and Accomplishments

The 22 invited lectures covered the full spectrum of Combinatorial Commutative Algebra described above. The talks were at a uniformly high level, in terms of both mathematical content and quality of exposition. A special effort was made to include younger scholars and members from underrepresented groups among the invited speakers. More than half of the speakers were within five years of their PhD degree, and they did an excellent job in presenting their cutting edge research.

We received enthusiastic comments from the participants about how inspiring that workshop had been. Our happy participants also included a number of students and postdocs who had attended the Fall 2013 graduate course, taught by Bernd Sturmfels at UC Berkeley, which had been designed to prepare the students for this workshop.

From the lectures, we wish to cite three that, in our view, were especially exciting.

Satoshi Murai presented his joint work with Eran Nevo, *On the generalized lower bound conjecture for polytopes and spheres.* In 1971, McMullen and Walkup posed the following conjecture, which is called the generalized lower bound conjecture: If P is a simplicial d-polytope then its h-vector $(h_0, h_1, ..., h_d)$ satisfies $h_0 \leq h_1 \leq ... \leq h_{\lfloor \frac{d}{2} \rfloor}$. Moreover, if $h_{r-1} = h_r$ for some $r \leq \frac{d}{2}$ then P can be triangulated without introducing simplices of dimension $\leq d - r$. The first part of the conjecture was solved by Stanley in 1980 using the hard Lefschetz theorem for projective toric varieties. In his

lecture, Murai presented a proof of the remaining part of the conjecture. In addition, he explained a generalization to a certain class of simplicial spheres, namely those admitting the weak Lefschetz property.

June Huh talked about some of the results from his outstanding research into which homology class on a scheme X are not just representable by a subscheme ("effective"), but by an irreducible subvariety. Already when X is a product of two projective spaces this condition is extremely restrictive, and indeed, he explained why the counterexamples to the integral Hodge conjecture make it very difficult to get nonasymptotic sufficiency results. But even his necessary conditions were enough to establish a graph theory conjecture from the 1960s (where the subvariety is the closure of the graph of a rational function, in the other sense of graph). Wresting Huh from his duties as a graduate student instructor so that he could come give this truly exceptional talk took some doing on the part of the organizers.

Greg Smith spoke about two 19th-/early 20th-century problems, each of which had been given a classification result; affine cones on whom every nonnegative real polynomial function is a sum of squares (1888), and varieties of minimal degree (1907). It has taken another century to discover that these are the same list, the proof of which Smith explained beautifully. The resulting joint paper with Greg Blekherman and Mauricio Velasco was posted on the `arXiv` in August 2013, and it is becoming an instant classic in the emerging field of convex algebraic geometry.

The workshop was the climax of the Fall 2013 research period on combinatorial aspects of commutative algebra, and it led to a number of unexpected encounters and new collaborations. Here are three examples: A collaboration on matrix completion problems was started between Winfried Bruns and Franz Kiraly, now in Statistics at University College, London. Augstine O'Keefe and Takayuki Hibi embarked on a project concerning the normality of Minkowski sums of edge polytopes Aldo Conca, Emanuela De Negri, and Elisa Gorla began to work on Universal Gröbner bases for maximal minors, and they just posted their paper on this subject.

Overall, the workshop was a big success that led to further advances in combinatorial commutative algebra, and it got lots of young people involved in new research directions.

Organizers		
First Name	**Last Name**	**Institution**
Winfried	Bruns	Universität Osnabrück
Alicia	Dickenstein	University of Buenos Aires
Takayuki	Hibi	Osaka University
Allen	Knutson	Cornell University
Bernd	Sturmfels	University of California

Speakers		
First Name	**Last Name**	**Institution**
Christine	Berkesch Zamaere	Duke University
Aldo	Conca	Università di Genova
David	Eisenbud	Mathematical Sciences Research Institute
Daniel	Erman	University of Michigan
Juergen	Herzog	Universitaet Duisburg-Essen
June	Huh	University of Michigan
Thomas	Kahle	Mathematical Sciences Research Institute
Mateusz	Michalek	Polish Academy of Sciences, Warsaw
Ezra	Miller	Duke University
Satoshi	Murai	Yamaguchi University
Uwe	Nagel	University of Kentucky
Hidefumi	Ohsugi	Rikkyo University
Sonja	Petrovic	Pennsylvania State University
Claudia	Polini	University of Notre Dame
Jenna	Rajchgot	Mathematical Sciences Research Institute
Tim	Roemer	Universität Osnabrück
Steven	Sam	University of California
Anne	Shiu	University of Chicago
Gregory	Smith	Queen's University
Adam	Van Tuyl	Lakehead University
Matteo	Varbaro	Università di Genova
Josephine	Yu	Georgia Institute of Technology

MSRI Mathematical Sciences Research Institute

Combinatorial Commutative Algebra and Applications

December 3 - 7, 2012

Schedule

Monday, December 03, 2012			
9:15 AM - 9:30 AM	Simons Auditorium		Welcome
9:30 AM - 10:30 AM	Simons Auditorium	Jürgen Herzog	On the stable set of associated prime ideals of a monomial ideal
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00	Simons Auditorium	Claudia Polini	Hilbert coefficients, generalized Hilbert functions, and associated graded rings
12:00 - 2:00 PM	Atrium		Lunch
2:00 - 3:00 PM	Simons Auditorium	June Huh	Positivity of algebraic cycles and convexity of combinatorial geometries
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:30 PM	Simons Auditorium	Anne Shiu	Extensions of Birch's Theorem, with applications to dynamical systems

Tuesday, December 04, 2012			
9:00 AM - 10:00 AM	Simons Auditorium	Sonja Petrovic	Toric algebra of hypergraphs
10:00 AM - 10:30 AM	Atrium		Tea
10:30 AM - 11:30 AM	Simons Auditorium	Satoshi Murai	On generalized lower bound conjecture for simplicial polytopes
11:30 AM -12:30 AM	Smons Auditorium	Uwe Nagel	Enumerations deciding the Weak Lefschetz Property
12:30 - 2:00 PM	Atrium		Lunch
2:00 - 3:00 PM	Simons Auditorium	Mateusz Michalek	Derived Categories of Toric Varieties
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:30 PM	Simons Auditorium	Hidefumi Ohsugi	Cut ideals and their application to regular designs in statistics
4:30 PM - 6:20 PM	Atrium		Reception

Wednesday, December 05, 2012			
9:00 AM - 10:00 AM	Simons Auditorium	Tim Römer	Absolutely Koszul algebras
10:00 AM - 10:30 AM	Atrium		Tea
10:30 AM - 11:30 AM	Simons Auditorium	Daniel Erman	Duality in Boij-Soederberg Theory
11:30 AM -12:30 AM	Smons Auditorium	Christine Berkesch	Euler--Koszul homology for hypergeometric systems

Thursday, December 06, 2012			
9:00 AM - 10:00 AM	Simons Auditorium	Thomas Kahle	The combinatorics of binomial ideals
10:00 AM - 10:30 AM	Atrium		Tea
10:30 AM - 11:30 AM	Simons Auditorium	Josephine Yu	Tropical geometry for computational algebra
11:30 AM -12:30 AM	Smons Auditorium	Aldo Conca	Regularity for powers of ideals of maximal minors
12:30 - 2:00 PM	Atrium		Lunch
2:00 - 3:00 PM	Simons Auditorium	Mateo Varbaro	Relations Between Minors (joint with Winfried Bruns and Aldo Conca)
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:30 PM	Simons Auditorium	David Eisenbud	Twenty Points in P^3

Friday, December 07, 2012			
9:00 AM - 10:00 AM	Simons Auditorium	Steven Sam	Homology of Littlewood complexes
10:00 AM - 10:30 AM	Atrium		Tea
10:30 AM - 11:30 AM	Simons Auditorium	Jenna Rachgot	Compatibly split subvarieties of the Hilbert scheme of points in the plane
11:30 AM -12:30 AM	Smons Auditorium	Adam van Tuyl	Do squarefree monomial ideals satisfy the persistence property?
12:30 - 2:00 PM	Atrium		Lunch
2:00 - 3:00 PM	Simons Auditorium	Greg Smith	Sums of squares and nonnegative polynomials in multigraded rings
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:30 PM	Simons Auditorium	Ezra Miller	Alexander duality and total positivity: a cluster/commutative algebra connection

Participants

First Name	Last Name	Institution
Ali	Alilooee Dolatabad	Dalhousie University
Katie	Ansaldi	University of Notre Dame
Arindam	Banerjee	University of Kansas
Matthias	Beck	San Francisco State University
Christine	Berkesch Zamaere	Duke University
Jennifer	Biermann	Lakehead University
Florian	Block	UC Berkeley Math Faculty
Mats	Boij	Royal Institute of Technology (KTH)
Winfried	Bruns	Universität Osnabrück
Giulio	Caviglia	Purdue University
Hara	Charalambous	Aristotle University of Thessaloniki
Alfredo	Chavez	Paris Diderot-Paris 7
Timothy	Clark	Loyola College
Gemma	Colomé-Nin	Purdue University
Aldo	Conca	Università di Genova
Emma	Connon	Dalhousie University
Alexandru	Constantinescu	Université de Neuchâtel
Susan	Cooper	Central Michigan University
Sebastian	Csar	University of Minnesota Twin Cities
Carlos	DAndrea	University of Barcelona
Emanuela	De Negri	Università di Genova
Alicia	Dickenstein	University of Buenos Aires
Michael	DiPasquale	University of Illinois at Urbana-Champaign
Anton	Dochtermann	University of Miami
John	Eagon	University of Minnesota Twin Cities
David	Eisenbud	Mathematical Sciences Research Institute
Nursel	Erey	Dalhousie University
Daniel	Erman	University of Michigan
christina	eubanks-turner	University of Louisiana--Lafayette
Sara	Faridi	Dalhousie University
Alex	Fink	North Carolina State University
Jens	Forsgård	Stockholm University
Louiza	Fouli	New Mexico State University
Elisa	Gorla	Universität Basel
Ornella	Greco	Royal Institute of Technology (KTH)
Elizabeth	Gross	University of Illinois
Tai	Ha	Tulane University
Kangjin	Han	Korea Institute for Advanced Study (KIAS)
Milena	Hering	University of Edinburgh
Juergen	Herzog	Universitaet Duisburg-Essen
Takayuki	Hibi	Osaka University
Olga	Holtz	University of California
June	Huh	University of Michigan
Craig	Huneke	University of Virginia
Anthony	Iarrobino	Northeastern University
Nathan	Ilten	University of California
Srikanth	Iyengar	University of Nebraska
Jack	Jeffries	University of Utah
Thomas	Kahle	Mathematical Sciences Research Institute
Steven	Karp	University of California, Berkeley
Bernhard	Keller	Université de Paris VII (Denis Diderot)
Yvonne	Kemper	University of California
Leila	Khatami	Union College--Union University

Kyouko	Kimura	Shizuoka University
Franz	Király	TU Berlin
Allen	Knutson	Cornell University
Manoj	Kummini	Chennai Mathematical Institute
Jeff	Madsen	University of Notre Dame
Sara	Malec	Georgia State University
Paolo	Mantero	University of California
Sonja	Mapes	University of Notre Dame
Tiago	Marques	Federal University of Pernambuco
Abraham	Martin del Campo	Institute of Science and Technology Austria
Jason	McCullough	Mathematical Sciences Research Institute
Trevor	McGuire	Louisiana State University
Mateusz	Michalek	Polish Academy of Sciences, Warsaw
Ezra	Miller	Duke University
Mitsuhiro	Miyazaki	Kyoto University of Education
Jonathan	Montano	Purdue University
HyunSuk	Moon	Korea Advanced Institute of Science and Technology
Ralph	Morrison	University of California
Satoshi	Murai	Yamaguchi University
Uwe	Nagel	University of Kentucky
Jorge	Neves	University of Coimbra
Trung	Ngo	Institute of Mathematics
Augustine	O'Keefe	University of Kentucky
Luke	Oeding	University of California
Hidefumi	Ohsugi	Rikkyo University
Christopher	ONeill	Duke University
Alyssa	Palfreyman	San Francisco State University
Markus	Perling	Universität Bielefeld
Sonja	Petrovic	Pennsylvania State University
Claudia	Polini	University of Notre Dame
Jenna	Rajchgot	Mathematical Sciences Research Institute
Elina	Robeva	Harvard University
Tim	Roemer	Universität Osnabrück
dylan	rupel	Mathematical Sciences Research Institute
Steven	Sam	University of California
Jose Alejandro	Samper Casas	University of Washington
Hal	Schenck	University of Illinois at Urbana-Champaign
Frank	Schreyer	Universität des Saarlandes
Karl	Schwede	Pennsylvania State University
Alexandra	Seceleanu	University of Nebraska
jimmy	shan	University of Illinois at Urbana-Champaign
Kazuki	Shibata	Rikkyo University
Anne	Shiu	University of Chicago
Farbod	Shokrieh	Georgia Institute of Technology
Anurag	Singh	University of Utah
Emil	Sköldberg	National University of Ireland, Galway
Gregory	Smith	Queen's University
Suresh	Srinivasamurthy	Kansas State University
Salvatore	Stella	Northeastern University
Bernd	Sturmfels	University of California
Seth	Sullivant	North Carolina State University
peter	symonds	Mathematical Sciences Research Institute
Howard	Thompson	University of Michigan
Bernd	Ulrich	Purdue University
Adam	Van Tuyl	Lakehead University
Matteo	Varbaro	Università di Genova

Maria	Vaz Pinto	Technical University of Lisbon
Thanh	Vu	University of California
David	Wehlau	Royal Military College of Canada
Roger	Wiegand	University of Nebraska
Sylvia	Wiegand	University of Nebraska
Lauren	Williams	University of California, Berkeley
Franz	Winkler	Johannes Kepler Universität Linz
Russ	Woodroofe	Mississippi State University
Yu	Xie	Georgia State University
Jihyeon	Yang	McMaster University
Arnold	Yim	Purdue University
Josephine	Yu	Georgia Institute of Technology
Andrei	Zelevinsky	Northeastern University

Officially Registered Participant Information

Participants		122

Gender		122
Male	66.39%	81
Female	30.33%	37
Declined to state	3.28%	4

Ethnicity*		122
White	64.75%	79
Asian	18.85%	23
Hispanic	2.46%	3
Pacific Islander	0.00%	0
Black	1.64%	2
Native American	0.00%	0
Mixed	1.64%	2
Declined to state	10.66%	13

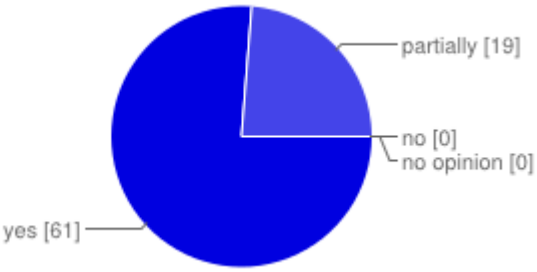
* ethnicity specifications are not exclusive

80 responses

Summary See complete responses

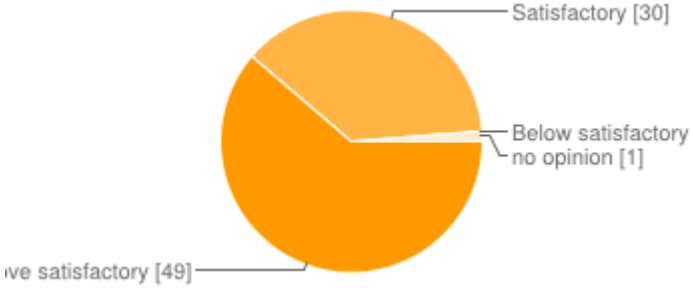
Topic presentation and organization

Did the various topics within the workshop integrate into a coherent picture?



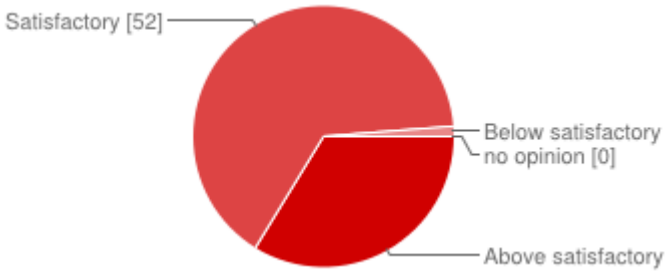
yes	**61**	76%
partially	**19**	24%
no	**0**	0%
no opinion	**0**	0%

Were the speakers generally clear and well organized in their presentation?



Above satisfactory	**49**	61%
Satisfactory	**30**	38%
Below satisfactory	**0**	0%
no opinion	**1**	1%

Was there adequate time between lectures for discussion?



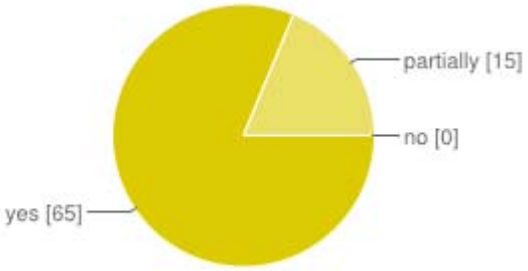
Above satisfactory	**27**	34%
Satisfactory	**52**	65%
Below satisfactory	**1**	1%
no opinion	**0**	0%

Additional comments on the topic presentation and organization

There was not adequate time for discussion between the last lecture and the special shuttle down the

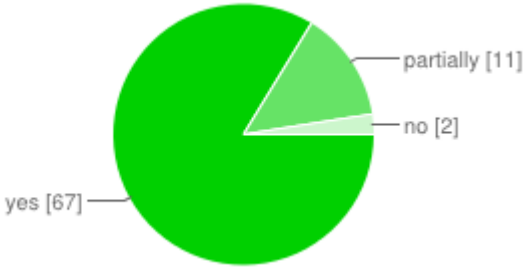
Personal assessment

Was your background adequate to access a reasonable portion of the material?



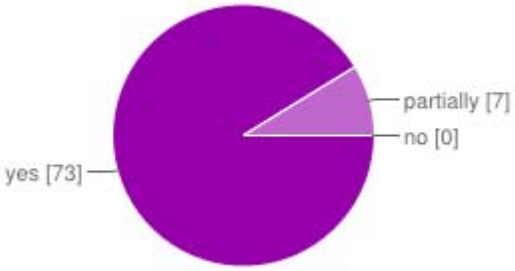
yes	**65**	81%
partially	**15**	19%
no	**0**	0%

Did the workshop increase your interest in the subject?



yes	**67**	84%
partially	**11**	14%
no	**2**	3%

Was the workshop worth your time and effort?

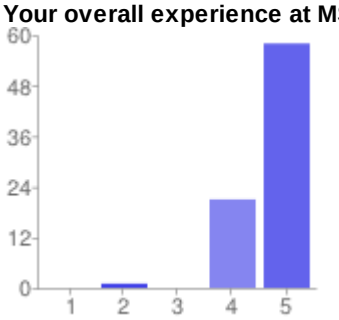


yes	**73**	91%
partially	**7**	9%
no	**0**	0%

Additional comments on your personal assessment

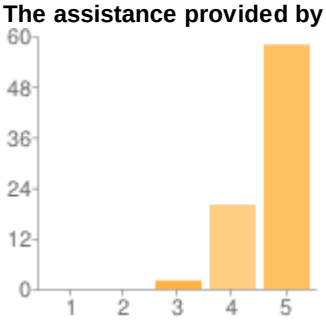
I have been a member at MSRi this semester, nevertheless this workshop gave me the occasion to interact with people that are not here for the semester and this interaction has been very valuable for ...

Your overall experience at MSRI



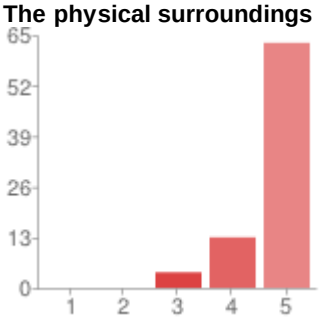
1 -	Not satisfactory	**0**	0%
2		**1**	1%
3		**0**	0%
4		**21**	26%
5 -	Above satisfactory	**58**	73%

The assistance provided by MSRI staff



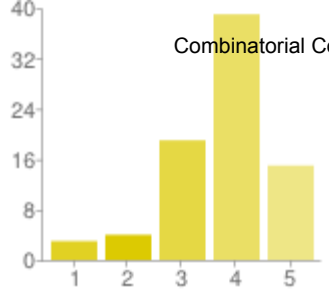
1 -	Not satisfactory	**0**	0%
2		**0**	0%
3		**2**	3%
4		**20**	25%
5 -	Above satisfactory	**58**	73%

The physical surroundings



1 -	Not satisfactory	**0**	0%
2		**0**	0%
3		**4**	5%
4		**13**	16%
5 -	Above satisfactory	**63**	79%

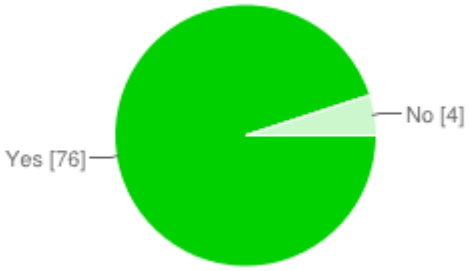
The food provided during the workshop



Not satisfactoryAbove satisfactory

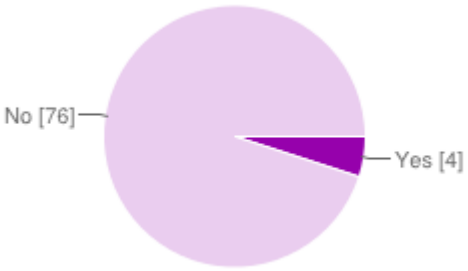
1 -	Not satisfactory	**3**	4%
2		**4**	5%
3		**19**	24%
4		**39**	49%
5 -	Above satisfactory	**15**	19%

Did you use MSRI's wireless network?



Yes	**76**	95%
No	**4**	5%

Did you experience any difficulties with the network?



Yes	**4**	5%
No	**76**	95%

If you did experience difficulties with the network, please explain:

The connection repeated hung, requiring manual kill of the ssh session.

Additional comments on the venue

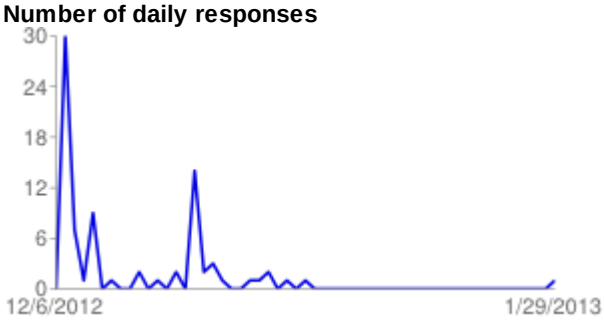
It took me until Wednesday to get the IT guys to get Mathematica to work. I started on Monday. the seast in the main conference room are very oddly distributed, in general uncomfortable. it was a lit ...

Thank you for completing this survey

We welcome any additional comments or suggestions you may have to improve the overall experience for future participants. Combinatorial Commutative Algebra and Applications, December 3 - 7, 2012 at MSRI, Berkeley, CA USA

This is a small thing. It would be nice if the name-tags were the hanging kind, rather than the pinning kind (perhaps they could be recycled?), and it would be nice if the name-tag stated you affil ...

Number of daily responses



Combinatorial Commutative Algebra and Applications Workshop December 3 to December 7, 2012

Additional Survey Responses

Additional comments on the topic presentation and organization

- There was not adequate time for discussion between the last lecture and the special shuttle down the hill.
- I would have preferred more working time on the workshop topics.
- Good survey of recent progress
- Just, I really enjoyed the survey of current developments, and friendliness o questions (I asked many)
- There was no time for discusion after the last talk, because we needed to take the shuttle within 15 mins after the talk.

Additional comments on your personal assessment

- I have been a member at MSRi this semester, nevertheless this workshop gave me the occasion to interact with people that are not here for the semester and this interaction has been very valuable for me.
- I found new ways in which to approach my subjects of interest
- Enjoyed very much informal contact, discussion
- Much of the value for me came from interpersonal interactions rather than the talks.
- Helped me a lot
- It was a really fun workshop, I am active in some areas of the workshop, and learned new events, had a chance to talk to persons I really wanted to speak with.

Additional comments on the venue

- It took me until Wednesday to get the IT guys to get Mathematica to work. I started on Monday.
- the seast in the main conference room are very oddly distributed, in general uncomfortable.
- it was a little difficult to find a working copying machine
- Heating in auditorium issue needs solving.
- The projector needs to be replaced.
- Vegetarian sandwiches from Stuffed Inn ran out quickly!
- 1. Get better control of the temperature regulation system in Simons Auditorium. 2. Add chalk/eraser racks to the side boards in Simons.
- This was my first time to MSRI. I really enjoyed it, and I look forward to coming back.
- Temperature controls need to be fixed!! Either freezing or too hot in the main lecture room. Also, the projector in the main lecture seems to need updating to show a broader range of colors and project finer details.
- Staff were very helpful with a heating problem in Simons auditorium (tendency of system to let in cool outside air so overcool participants when a certain heat level is exceeded.
- I think that the two side boards in the Simons auditorium should also have chalk holders. Because they are missing there, speakers often leave chalk under those boards, and it rolls off onto the ground, causing a small disruption.

We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.

- This is a small thing. It would be nice if the name-tags were the hanging kind, rather than the pinning kind (perhaps they could be recycled?), and it would be nice if the name-tag stated you affiliation as well. Thanks for a great conference!

- Overall, a great opportunity to hear about research in this area and meet researchers. Good mix of young researchers and senior researchers.
- As an organizer, I was absolutely delighted with how smoothly the whole process ran, and am extremely grateful to Helene, Mick, Christine, and everyone involved.
- Lunch/tea lines would go faster if placed on separate tables on both sides of the line, allowing the line to split.
- MSRI always does a fantastic job; great programs, excellent and well organized workshops (but with plenty of time in between for talking and thinking). There is some kind of mathematical fermentation that occurs at MSRI that happens nowhere else in the world (while I love MFO and BIRS, for me, MSRI tops them). Keep up the great work, and thanks!
- MSRI is working on the heating problem. I managed not to realize that the bus route (641?) going uphill only went by MSRI half the time. Really great and diverse talks, I really enjoyed this workshop and talking with pariticipants.

Representation Theory, Homological Algebra, and Free Resolutions

February 11 to February 17, 2013

MSRI, Berkeley, CA, USA

Organizers:

Luchezar Avramov (University of Nebraska)

David Eisenbud (University of California, Berkeley)

Irena Peeva* (Cornell University)

REPORT ON THE MSRI WORKSHOP

Representation Theory, Homological Algebra, and Free Resolutions

February 11-17, 2013

Organizers:

- Luchezar Avramov (University of Nebraska)
- David Eisenbud (University of California at Berkeley)
- Irena Peeva (Cornell University)

The workshop explored homological aspects of the study of commutative rings and their modules in areas where recent developments have had a particularly strong impact. The focus was on recent breakthroughs in understanding and applications of free resolutions and on interactions of commutative algebra and representation theory, where algebraic geometry often appears as a third player. A specific goal of the workshop was to stimulate further interaction between these fields.

Free resolutions were introduced by David Hilbert in his work on invariant theory, in order to study numerical functions attached to graded modules. He used resolutions to describe the solutions of inductively defined sequences of systems of linear equations with coefficients in rings. With the advent of homological algebra, part of the attention shifted from resolutions to invariants, constructed by using them, such as derived functors. Subsequent developments have led to surge in interest in the original point of view. Major advances in this classical area have been made during the last decade.

On a basic level, many problems both in commutative algebra and in the **representation theory of finite-dimensional algebras** boil down to classification results about classes of modules and their homomorphisms. In addition both subjects share a number of key contributors, such as Emmy Noether, Wolfgang Krull, and Maurice Auslander, but in the past their trajectories have intersected rarely and unpredictably. The situation is changing rapidly, partly due to newly discovered and actively explored ties between representations of algebras and algebraic geometry, adding a new facet to the traditional ties between algebraic geometry and commutative algebra.

Special Sessions

The workshop included three and a half ours of short (20 min. each) talks in three parallel special sessions, organized by Milena Herring, Liana Sega, and Hema Srinivasan. There were twenty one such talks. For example:

- Graduate student Luis Nunez gave a talk on associated primes of local cohomology of flat extensions with regular fibers, giving a positive answer in special cases to a

question raised by Hochster.

- Kristen Beck gave a talk on depth and dimension for high syzygies, giving necessary conditions for the stabilization of dimensions of high syzygy modules.
- Leila Khatami gave a talk on nilpotent commutator of a nilpotent matrix.
- Graduate student Alessandro De Stefani gave a talk on artinian level algebras of low socle degree, characterizing h-vectors which are admissible for level local algebras with $\mathbf{m}^4 = t0$.
- Oana Veliche reported on a recent paper joint with L. Christensen. They give examples of algebra structures that have been conjectured not to occur.
- Graduate student Xin Zhou gave a talk on the syzygies of Veronese embeddings, showing that their Schur decompositions have very rich structures in various asymptotic situations.
- Postdoc Kuei-Nuan Lin reported on a joint work with J. McCullough. They studied regularity of monomial ideals using hypergraphs.

The goal of these special sessions was to give opportunity to junior mathematicians to present their work and to be better integrated in the workshop. The special sessions were a success.

Highlights of presentations

The first lecture in the workshop was given by Melvin Hochster (University of Michigan), who reported on progress on Stillman's Question whether there exists an upper bound independent on the number of variables on the projective dimension of an ideal generated by forms of fixed degrees $a_1, \ldots, a_n$ in a polynomial ring. G. Caviglia has proved that the problem is equivalent to the existence of an upper bound on the regularity of such ideals.T. Ananyan and M. Hochster recently proved that a bound exists for quadratic and cubic forms.

Four of the plenary lectures were given by postdocs:

- Tobias Dyckerhoff (Yale University) outlined some aspects of the theory of higher Segal spaces which is a joint project with M. Kapranov.
- Daniel Murfet (UCLA) reported on recent joint work with N. Carqueville on the bicategory of Landau-Ginzburg models which is built out of isolated hypersurface singularities and matrix factorisations.
- Jason McCullough (MSRI) discussed constructions of examples with large projective dimension related to Stillman's Question and Hochster's talk.
- Claudiu Raicu (Princeton University) discussed a number of examples of varieties with an action of the general linear group, from the point of view of studying their defining ideals, or more generally their minimal free resolutions.

The closing lecture in the workshop was given by Jürgen Herzog. A natural question to consider for infinite minimal free resolutions is if their invariants are encoded in finite data. The main peak in this direction was the Serre-Kaplansky problem, "*Is the Poincaré series of the residue field over a finitely generated commutative local Noetherian ring rational?*", which was one of the central questions in Commutative Algebra for many years. The high enthusiasm for research on this problem was partly motivated by the expectation that the answer is positive. However, in 1982 Anick constructed an example of an irrational Poincaré series. Meanwhile, there has been continuing interest in discovering rings (local or graded) over which all modules have rational Poincaré series. J. Herzog and C. Huneke proved during the Fall semester in the special MSRI year in Commutative Algebra that if $s \geq 2$ and I is a homogeneous ideal in a polynomial ring S, then every finitely generated module over the quotient ring S/I^s has a rational Poincaré series. They established that result for the symbolic powers of I as well.

Organizers

First Name	Last Name	Institution
Luchezar	Avramov	University of Nebraska
David	Eisenbud	University of California
Irena	Peeva	Cornell University

Speakers

First Name	Last Name	Institution
Lidia	Angeleri Huegel	Università di Verona
David	Benson	University of Aberdeen
Ragnar-Olaf	Buchweitz	University of Toronto
Giulio	Caviglia	Purdue University
Marc	Chardin	Centre National de la Recherche Scientifique (CNRS)
Hailong	Dao	University of Kansas
Tobias	Dyckerhoff	Yale University
Gavril	Farkas	Humboldt-Universität
Gavril	Farkas	Humboldt-Universität
Juergen	Herzog	Universitaet Duisburg-Essen
Mel	Hochster	University of Michigan
Osamu	Iyama	Nagoya University
Srikanth	Iyengar	University of Nebraska
Henning	Krause	Universität Bielefeld
Robert	Lazarsfeld	University of Michigan
Jason	McCullough	Rider University
Claudia	Miller	Syracuse University
Rosa	Miro-Roig	University of Barcelona
Daniel	Murfet	University of California
Alexander	Polishchuk	University of Oregon
Claudiu	Raicu	Princeton University
idun	reiten	Norwegian University of Science and Technology (NTNU)
peter	symonds	MSRI - Mathematical Sciences Research Institute
Bernd	Ulrich	Purdue University

Representation Theory, Homological Algebra, and Free Resolutions

February 11 to February 17, 2013

Schedule

Monday, February 11, 2013			
9:15 AM - 9:30 AM	Simons Auditorium		Welcome
9:30 AM - 10:30 AM	Simons Auditorium	Melvin Hochster	Ideals and algebras generated by quadratic and cubic forms in polynomial rings
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00 PM	Simons Auditorium	Lidia Angeleri Huegel	t-structures and cotilting modules over commutative noetherian rings
12:00 PM - 2:00 PM	Atrium		Lunch
2:00 PM - 3:00 PM	Simons Auditorium	Idun Reiten	Maximal Cohen-Macaulay modules and generalised cluster categories
3:00 PM - 3:30 PM	Atrium		Tea
4:10 PM - 5:00 PM	UCB, 60 Evans Hall	Steven Cutkosky	MSRI/Evans Lecture: Multiplicities of graded families of ideals

Tuesday, February 12, 2013			
9:30 AM - 10:30 AM	Simons Auditorium	Srikanth Iyengar	The derived category of a complete intersection ring
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00 PM	Simons Auditorium	Alexander Polishchuk	Lefschetz theorems for dg-categories with applications to matrix factorizations
12:00 PM - 2:00 PM	Atrium		Lunch
2:00 PM - 3:00 PM	Simons Auditorium	Daniel Murfet	The bicategory of Landau-Ginzburg models
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:30 PM	Simons Auditorium	Peter Symonds	Group actions on rings and the Cech complex

Wednesday, February 13, 2013			
9:30 AM - 10:30 AM	Simons Auditorium	Ragnar-Olaf Buchweitz	Graded Maximal Cohen-Macaulay Modules over Elliptic Curves
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00 PM	Simons Auditorium	Tobias Dyckerhoff	Higher Segal Spaces
12:00 PM - 1:30 PM	Atrium		Lunch
1:30 PM - 2:30 PM	Simons Auditorium	Rosa M. Miró-Roig	The representation type of a projective variety
2:30 PM - 3:00 PM	Atrium		Tea
3:00 PM - 3:20 PM	Simons Auditorium	Alexander Dugas	Periodicity of d-cluster tilted algebras
3:00 PM - 3:20 PM	Commons	Laura Ghezzi	Variation of the first Hilbert coefficients
3:00 PM - 3:20 PM	Baker Board Room	Luis Nunez	Associated primes of local cohomology of flat extensions with regular fibers
3:30 PM - 3:50 PM	Baker Board Room	Kristen Beck	Depth and Dimension for High Syzygies
3:30 PM - 3:50 PM	Simons Auditorium	Jesse Burke	Graded matrix factorizations and complete intersections
3:30 PM - 3:50 PM	Commons	Federico Galetto	Representations with finitely many orbits and free resolutions
4:00 PM - 4:20 PM	Simons Auditorium	Gregory Stevenson	Grothendieck duality and complete intersections
4:00 PM - 4:20 PM	Commons	Louiza Fouli	Lower Bounds for the Depth of Powers of Edge Ideals
4:00 PM - 4:20 PM	Baker Board Room	Javid Validashti	Lech's Inequality
4:30 PM - 6:20 PM	Atrium		Reception

Thursday, February 14, 2013			
9:00 AM - 10:00 AM	Simons Auditorium	Dave Benson	Modules for elementary abelian p-groups and hypersurface singularities
10:00 AM - 10:30 AM	Atrium		Tea
10:30 AM - 11:30 AM	Simons Auditorium	Hailong Dao	Cohen-Macaulay cones and subcategories
11:30 AM - 12:30 PM	Simons Auditorium	Robert Lazarsfeld	Asymptotic syzygies of algebraic varieties

Friday, February 15, 2013			
9:30 AM - 10:30 AM	Simons Auditorium	Gavril Farkas	Syzygies of torsion bundles and the geometry of the level l modular variety over Mg
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00 PM	Simons Auditorium	Osamu Iyama	Tilting and cluster tilting for Cohen-Macaulay modules
12:00 PM - 1:30 PM	Atrium		Lunch
1:30 PM - 2:30 PM	Simons Auditorium	Jason McCullough	Bounds on the Projective Dimension and Regularity of Ideals
2:30 PM - 3:00 PM	Atrium		Tea
3:00 PM - 3:20 PM	Baker Board Room	Oana Veliche	Local rings of embedding codepth 3. Examples
3:00 PM - 3:20 PM	Simons Auditorium	Kuei-Nuan Lin	Hypergraphs and Regularity of Square-Free Monomial Ideals
3:00 PM - 3:20 PM	Commons	Olgur Celikbas	On a conjecture of Huneke and R. Wiegand
3:30 PM - 3:50 PM	Baker Board Room	Xin Zhou	Asymptotic Schur Decomposition of Veronese Syzygy Functors
3:30 PM - 3:50 PM	Simons Auditorium	Van Nguyen	Tate cohomology relation for finite dimensional Hopf algebras with an application to group algebras
3:30 PM - 3:50 PM	Commons	Leila Khatami	Nilpotent commutator of a nilpotent matrix
4:00 PM - 4:20 PM	Baker Board Room	Jennifer Biermann	Balanced vertex decomposable simplicial complexes and their h-vectors
4:00 PM - 4:20 PM	Simons Auditorium	Fatemeh Mohammadi	Divisors on graphs, Connected flags, and Syzygies
4:00 PM - 4:20 PM	Commons	Saeed Nasseh	Contracting endomorphisms and dualizing complexes
4:30 PM - 4:50 PM	Baker Board Room	Alessandro De Stefani	Artinian level algebras of low socle degree
4:30 PM - 4:50 PM	Simons Auditorium	Frank Moore	Revisiting Auslander's 1962 ICM Address
4:30 PM - 4:50 PM	Commons	Kavita Sutar	Resolutions of orbit closures of quiver representations

Saturday, February 16, 2013			
9:00 AM - 10:00 AM	UC Berkeley	Bernd Ulrich	Socles, quasi-socles, and integral dependence
10:00 AM - 11:00 AM	UC Berkeley		Break
11:00 AM - 12:00 PM	UC Berkeley	Claudiu Raicu	Equations and syzygies via representation theory and combinatorics
12:00 PM - 1:30 PM	UC Berkeley		Lunch
1:30 PM - 2:30 PM	UC Berkeley	Claudia Miller	Duality Phenomena for Koszul Homology
2:30 PM - 3:30 PM	UC Berkeley		Break
3:30 PM - 4:30 PM	UC Berkeley	Henning Krause	Koszul, Ringel, and Serre duality for strict polynomial functors

Sunday, February 17, 2013			
9:00 AM - 10:00 AM	UC Berkeley	Giulio Caviglia	Some results on the Lex-Plus-Power conjecture
10:00 AM - 10:15 AM	UC Berkeley		Break
10:15 AM - 11:15 AM	UC Berkeley	Marc Chardin	Powers of graded ideals
11:15 AM - 11:30 AM	UC Berkeley		Break
11:30 AM - 12:30 PM	UC Berkeley	Juergen Herzog	Ordinary and symbolic powers are Golod

Participants

First Name	Last Name	Institution
Lidia	Angeleri Huegel	Università di Verona
Katie	Ansaldi	University of Notre Dame
Luchezar	Avramov	University of Nebraska
Arindam	Banerjee	University of Kansas
Kristen	Beck	University of Arizona
Hanno	Becker	University of Bonn
Gwyn	Bellamy	University of Glasgow
David	Benson	University of Aberdeen
Petter	Bergh	Norwegian University of Science and Technology (NTNU)
Jennifer	Biermann	Lakehead University
Manuel	Blickle	Johannes Gutenberg-Universität Mainz
Mats	Boij	Royal Institute of Technology (KTH)
Holger	Brenner	Universität Osnabrück
Michael	Brown	University of Nebraska
Ragnar-Olaf	Buchweitz	University of Toronto
Jesse	Burke	University of California
Jon	Carlson	University of Georgia
Giulio	Caviglia	Purdue University
Olgur	Celikbas	University of Missouri
Kenneth	Chan	University of Washington
Marc	Chardin	Centre National de la Recherche Scientifique (CNRS)
Harrison	Chen	UC Berkeley Math Faculty
Maria	Chlouveraki	Université Versailles/Saint Quentin-en-Yvelines
Yonghwa	Cho	Korea Advanced Institute of Science and Technology (KAIST)
Lars	Christensen	Texas Tech University
Gemma	Colomé-Nin	Purdue University
William	Crawley-Boevey	University of Leeds
Steven	Cutkosky	University of Missouri
Hailong	Dao	University of Kansas
Alessandro	De Stefani	University of Kansas
Kosmas	Diveris	St. Olaf College
Emilie	Dufresne	Universität Basel
Alex	Dugas	University of the Pacific
Tobias	Dyckerhoff	Yale University
John	Eagon	University of Minnesota Twin Cities
Rebecca	Egg	University of Nebraska
Michael	Ehrig	Universität Bonn
David	Eisenbud	University of California
Juan	Elias	University of Barcelona
Eleonore	Faber	University of Toronto
Gavril	Farkas	Humboldt-Universität
Gavril	Farkas	Humboldt-Universität
Gunnar	Floystad	University of Bergen
Louiza	Fouli	New Mexico State University
Federico	Galetto	Northeastern University
Laura	Ghezzi	New York City Technical College, CUNY
Kenneth	Goodearl	University of California

Mikhail	Gudim	University of Toronto
Tai	Ha	Tulane University
Mitsuyasu	Hashimoto	Nagoya University
Ines	Henriques	University of California
Milena	Hering	University of Edinburgh
Juergen	Herzog	Universitaet Duisburg-Essen
Lutz	Hille	Westfälische Wilhelms-Universität Münster
Mel	Hochster	University of Michigan
Justin	Hoffmeier	University of Missouri
Birge	Huisgen-Zimmerm	University of California
Alina	Iacob	Georgia Southern University
Colin	Ingalls	University of New Brunswick
Osamu	Iyama	Nagoya University
Srikanth	Iyengar	University of Nebraska
Andrew	Jaramillo	University of California
Jack	Jeffries	University of Utah
David	Jorgensen	University of Texas
Moty	Katzman	University of Sheffield
Leila	Khatami	Union College--Union University
Yeong Rak	Kim	Korea Advanced Institute of Science and Technology (KAIST)
Youngsu	Kim	Purdue University
Henning	Krause	Universität Bielefeld
Sijong	Kwak	Korea Advanced Institute of Science and Technology (KAIST)
Robert	Lazarsfeld	University of Michigan
Graham	Leuschke	Syracuse University
Jinjia	Li	University of Louisville
Kuei-Nuan	Lin	University of California
Haydee	Lindo	University of Nebraska
joseph	Lipman	Purdue University
Jason	Lutz	University of Nebraska
Tom	Marley	University of Nebraska
Matey	Mateev	Universität Basel
Jason	McCullough	Rider University
Marianne	Merz	Freie Universität Berlin
Claudia	Miller	Syracuse University
Cleto	Miranda Neto	Federal University of Paraíba
Rosa	Miro-Roig	University of Barcelona
fatemeh	mohammadi	Philipps-Universität Marburg
Fatemeh	Mohammadi Aghje	Islamic Azad University
Jonathan	Montano	Purdue University
Frank	Moore	Wake Forest University
Andrew	Morrison	Eidgenössische TH Zürich-Hönggerberg
Andrew	Morrison	Eidgenössische TH Zürich-Hönggerberg
Vivek	Mukundan	Purdue University
Satoshi	Murai	Yamaguchi University
Daniel	Murfet	University of California
Saeed	Nasseh	North Dakota State University
Amnon	Neeman	Australian National University
Thomas	Nevins	University of Illinois at Urbana-Champaign
Lan	Nguyen	Purdue University

Van	Nguyen	Texas A & M University
Luis	Nunez-Betancourt	University of Michigan
KAZUHO	OZEKI	Yamaguchi University
Keith	Pardue	NSA - National Security Agency
Jung Pil	Park	Seoul National University
Bregje	Pauwels	University of California
Jeremy	Pecharich	Mount Holyoke College
Irena	Peeva	Cornell University
Julia	Pevtsova	University of Washington
Vinh	Pham	University of Missouri
Greg	Piepmeyer	University of Missouri
Claudia	Polini	University of Notre Dame
Alexander	Polishchuk	University of Oregon
David	Pospisil	Karlovy (Charles) University (UK)
Hamid	Rahmati	Miami University
Claudiu	Raicu	Princeton University
Ali	Rajaei	Tarbiat Modares
Kristian	Ranestad	University of Oslo
idun	reiten	Norwegian University of Science and Technology (NTNU)
Alice	Rizzardo	International School for Advanced Studies (SISSA/ISAS)
Steven	Sam	Massachusetts Institute of Technology
William	Sanders	University of Kansas
Antonio	Sartori	Universität Bonn
Sean	Sather-Wagstaff	North Dakota State University
Travis	Schedler	University of Texas
Liana	Sega	University of Missouri
Katharine	Shultis	University of Nebraska
Susan	Sierra	University of Edinburgh
Anurag	Singh	University of Utah
Ilya	Smirnov	University of Kansas
Gregory	Smith	Queen's University
Frank	Sottile	Texas A & M University
Suresh	Srinivasamurthy	Kansas State University
Hema	Srinivasan	University of Missouri
John	Stafford	University of Manchester
James	Stark	University of Washington
Johan	Steen	Norwegian University of Science and Technology (NTNU)
Greg	Stevenson	Universität Bielefeld
Michael	Stillman	Cornell University
Branden	Stone	Bard College
Janet	Striuli	Fairfield University
Catharina	Stroppel	Max-Planck-Institut für Mathematik
Stephen	Sturgeon	University of Kentucky
Kavita	Sutar	Chennai Mathematical Institute
peter	symonds	MSRI - Mathematical Sciences Research Institute
Ryo	Takahashi	Nagoya University
Jan	Trlifaj	Karlovy (Charles) University (UK)
Bernd	Ulrich	Purdue University
Javid	Validashti	University of Illinois at Urbana-Champaign
Adam-Christiaan	van Roosmalen	University of Regina

Matteo	Varbaro	Università di Genova
Oana	Veliche	Northeastern University
Friedrich	Wagemann	Universite de Nantes
Chelsea	Walton	Massachusetts Institute of Technology
Marcus	Webb	University of Nebraska
David	Wehlau	Royal Military College of Canada
Jerzy	Weyman	Northeastern University
Roger	Wiegand	University of Nebraska
Sylvia	Wiegand	University of Nebraska
Sarah	Witherspoon	Texas A&M University
Emily	Witt	University of Minnesota Twin Cities
Zheng	Yang	University of Nebraska
Siamak	Yassemi	University of Tehran
Amnon	Yekutieli	Ben Gurion University of the Negev
Xuan	Yu	University of Nebraska
Dan	Zacharia	Syracuse University
Santiago	Zarzuela	University of Barcelona
James	Zhang	University of Washington
Wenliang	Zhang	University of Nebraska
Yi	Zhang	MSRI - Mathematical Sciences Research Institute
Xin	Zhou	University of Michigan
Radoslav	Zlatev	Cornell University

Officially Registered Participant Information

Participants		**169**

Gender		**169**
Male	73.96%	125
Female	23.67%	40
Declined to state	2.37%	4

Ethnicity*		**169**
White	67.46%	114
Asian	21.30%	36
Hispanic	1.18%	2
Pacific Islander	0.00%	0
Black	1.18%	2
Native American	0.00%	0
Mixed	0.59%	1
Declined to state	8.28%	14

* ethnicity specifications are not exclusive

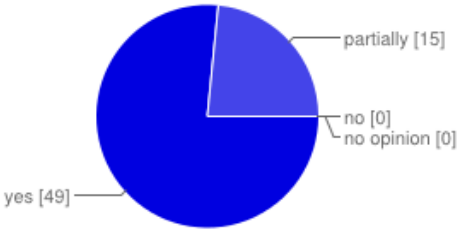
64 responses

Summary

See complete responses

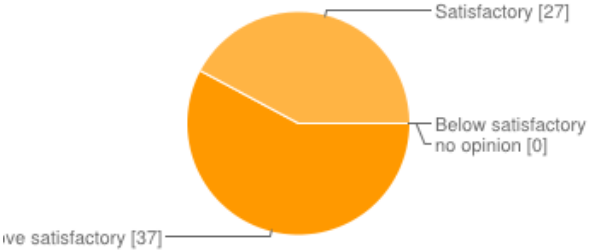
Topic presentation and organization

Did the various topics within the workshop integrate into a coherent picture?



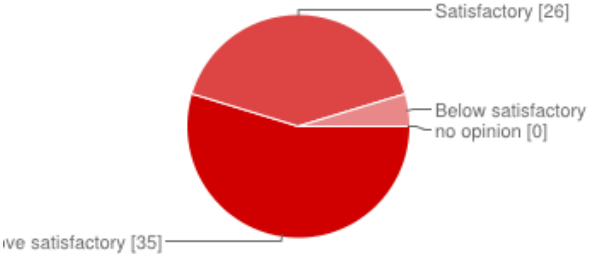
yes	**49**	77%
partially	**15**	23%
no	**0**	0%
no opinion	**0**	0%

Were the speakers generally clear and well organized in their presentation?



Above satisfactory	**37**	58%
Satisfactory	**27**	42%
Below satisfactory	**0**	0%
no opinion	**0**	0%

Was there adequate time between lectures for discussion?



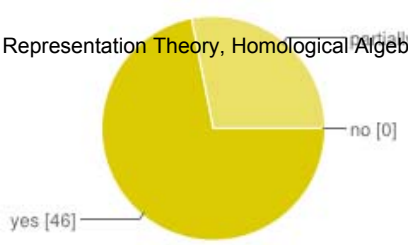
Above satisfactory	**35**	55%
Satisfactory	**26**	41%
Below satisfactory	**3**	5%
no opinion	**0**	0%

Additional comments on the topic presentation and organization

I didn't like the parallel sessions I can't see text written by white chalk on a white (dirty) blackboard :(Too many talks; parallel sessions should be avoided. Also, the workshop should not include ...

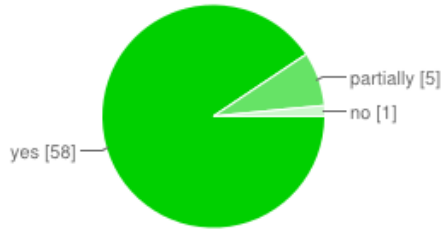
Personal assessment

Was your background adequate to access a reasonable portion of the material?



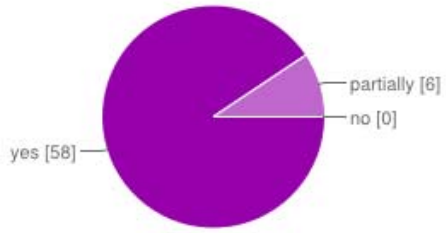
yes	**46**	72%
partially	**18**	28%
no	**0**	0%

Did the workshop increase your interest in the subject?



yes	**58**	91%
partially	**5**	8%
no	**1**	2%

Was the workshop worth your time and effort?



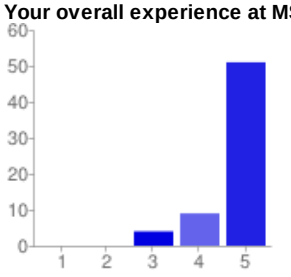
yes	**58**	91%
partially	**6**	9%
no	**0**	0%

Additional comments on your personal assessment

It was again perfect The workshop was too "heavy": Too many talks, running through the weekend The talks which were best were those where the audience asked questions during the talk. These talks wer ...

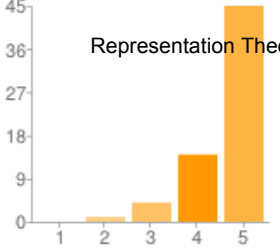
Venue

Your overall experience at MSRI



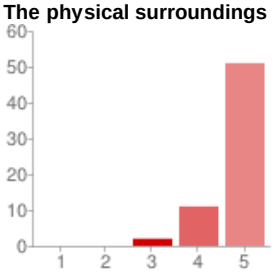
1 -	Not satisfactory	**0**	0%
2		**0**	0%
3		**4**	6%
4		**9**	14%
5 -	Above satisfactory	**51**	80%

The assistance provided by MSRI staff



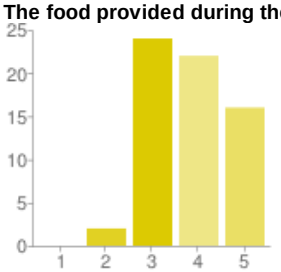
1 -	Not satisfactory	**0**	0%
2		**1**	2%
3		**4**	6%
4		**14**	22%
5 -	Above satisfactory	**45**	70%

The physical surroundings



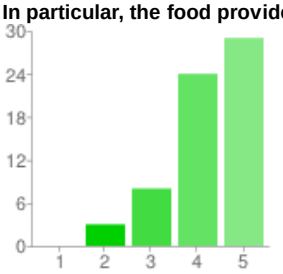
1 -	Not satisfactory	**0**	0%
2		**0**	0%
3		**2**	3%
4		**11**	17%
5 -	Above satisfactory	**51**	80%

The food provided during the workshop



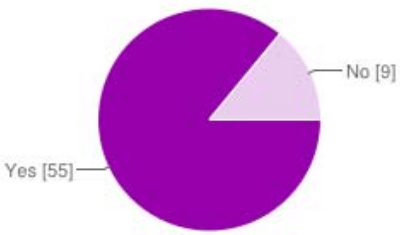
1 -	Not satisfactory	**0**	0%
2		**2**	3%
3		**24**	38%
4		**22**	34%
5 -	Above satisfactory	**16**	25%

In particular, the food provided during the reception



1 -	Not satisfactory	**0**	0%
2		**3**	5%
3		**8**	13%
4		**24**	38%
5 -	Above satisfactory	**29**	45%

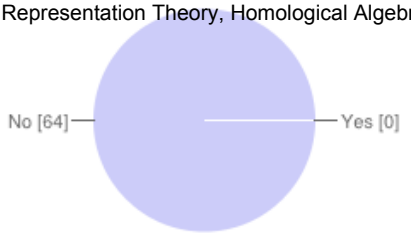
Did you use MSRI's wireless network?



Yes	**55**	86%
No	**9**	14%

Did you experience any difficulties with the network?

Yes	**0**	0%
No	**64**	100%



If you did experience difficulties with the network, please explain:

N/A

Additional comments on the venue

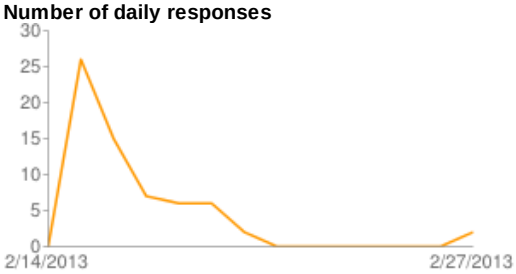
Find better erasers for the blackboards. The current ones leave the blackboards too dirty, once they have been used three/four times on a given blackboard. vegan options, please! The tea water often t ...

Thank you for completing this survey

We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.

Please use name tags without safety pins. I would like to extremely thank you for everything parallel sessions are unpleasant; name tags should have clips or lanyards instead of pins; this textbox is ...

Number of daily responses



Representation Theory, Homological Algebra, and Free Resolutions February 11 to February 17, 2013

Additional Survey Responses

Additional comments on the topic presentation and organization

- I didn't like the parallel sessions
- I can't see text written by white chalk on a white (dirty) blackboard :(
- Too many talks; parallel sessions should be avoided. Also, the workshop should not include the weekend.
- Greater suggestion that speakers discuss fewer results in greater depth could be given. In particular, more of a push towards board talks could help this.
- There were too many talks.
- For better readability, blackboards should be properly cleaned before each lecture
- I think that you could add more talks every day and do not have to come during the weekend. 7 days is too much.
- I didn't like having to choose between closely related topics during the shorter twenty minute talks.
- Excellent choice of topics
- The blackboard becomes white quickly and hard to read.
- A few of the younger speakers gave talks that were too technical and covered too much.
- This was a very long workshop. Some of the breaks could have been shortened so we wouldn't have talks over the weekend.

Additional comments on your personal assessment

- This was a very long workshop. Some of the breaks could have been shortened so we wouldn't have talks over the weekend.
- The workshop was too "heavy": Too many talks, running through the weekend
- The talks which were best were those where the audience asked questions during the talk. These talks were paced so that the audience had time to formulate questions/comments. Perhaps the 10 minute question periods at the end might be more effective if the organizers placed part of that mid-way in the talk. It would also help to let the speaker assess how his/her pace is.
- This was an outstanding conference collecting some of the leading experts in the area
- The lectures were very useful to me
- I learned a lot, both from talks and from informal collaborations that began during the workshop.

Additional comments on the venue

- Find better erasers for the blackboards. The current ones leave the blackboards too dirty, once they have been used three/four times on a given blackboard.
- vegan options, please!
- The tea water often tasted like coffee.
- Gorgeous location!
- More vegetarian options at the reception would be welcome.
- A great place (and splendid weather, too!)
- Great surroundings for discussion and work. Great library!
- The venue is exceptional
- I didn't attend the reception.
- no phone signal
- A great place to do math!

We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.

- Please use name tags without safety pins
- I would like to extremely thank you for eve
- parallel sessions are unpleasant; name tags should have clips or lanyards instead of pins; this textbox is too small

MSRI Mathematical Sciences Research Institute

The Commutative Algebra of Singularities in Birational Geometry:

Multiplier Ideals, Jets, Valuations, and Positive Characteristic Methods

May 6 - May 10, 2013

MSRI, Berkeley, CA, USA

Organizers:

Craig Huneke (University of Virginia)

Yujiro Kawamata (University of Tokyo)

Mircea Mustata (University of Michigan)

Karen Smith (University of Michigan)

Kei-Ichi Watanabe (Nihon University)

THE COMMUTATIVE ALGEBRA OF SINGULARITIES IN BIRATIONAL GEOMETRY: MULTIPLIER IDEALS, JETS, VALUATIONS, AND POSITIVE CHARACTERISTIC METHODS, MAY 6–10, 2013

1. Organizers

- Craig Huneke (University of Virginia)
- Yujiro Kawamata (University of Tokyo)
- Mircea Mustaţă (University of Michigan)
- Karen Smith (University of Michigan)
- Kei-ichi Watanabe (Nihon University)

2. Scientific Program

Connections between algebraic geometry and prime characteristic commutative algebra have long been theorized. Already in the seventies, Hochster and Roberts used Frobenius techniques to control the singularities of rings of invariants, and Kunz proved that smooth varieties can be characterized as those for which the Frobenius map is flat. A decade later, Mehta and Ramanathan formally introduced the concept of F-spilt projective varieties, while simultaneously and independently Hochster and Huneke developed the theory of tight closure for local rings. Each of these developments was remarkably powerful, but only in more recent years have they begun to be recognized as aspects of the same deep ideas.

The main focus of the workshop was on the recent developments in commutative algebra in positive characteristic (in particular, in connection with the study of singularities in this setting) and its connections with other fields, such as

- Birational geometry (especially the study of invariants of singularities that appear in this setting);
- Valuation theory;

and

- Spaces of arcs and motivic integration.

3. The Presentations

Since the audience consisted of both commutative algebraists and people working in various areas of algebraic geometry (especially birational geometry), we had several survey-style lectures, with the goal of introducing different topics to a diverse group of participants.

Two impressive commutative algebra talks were given by Bhargav Bhatt (IAS) and Karl Schwede (Penn State). Bhatt presented his joint work with de Jong, proving an improvement of Grothendieck's version of the local Lefschetz property which was conjectured by Kollár. The result fitted very well in the main theme of our workshop: while mainly a result in characteristic zero, the proof was by reduction to positive characteristic, making use of the results of Hochster and Huneke on absolute integral closures of rings. Schwede discussed his work with Patakfalvi and Zhang on the behavior in families of some classes of singularities that appear in positive characteristic. The new insight is that while invariants of singularities such as test ideals do not restrict well to the fibers of a family of varieties, the situation dramatically improves after a pull-back by Frobenius (which would not change the fibers). This result has interesting applications to the study of singularities and to the positivity of direct images of canonical sheaves.

Another talk that has attracted quite a bit of attention was by Holger Brenner (Universität Osnabrück). This concerned a famous open problem in the field, that of finding an example of an irrational Hilbert-Kunz multiplicity. Brenner discussed several general generalizations of this invariant, and building on geometric methods of Cutkosky, he showed that some of these more general invariants are indeed irrational. Another successful talk on Hilbert-Kunz multiplicities was delivered by Trivedi Vijaylaxmi (TIFR), who considered their behavior in families over the integers, as the characteristic varies. Kevin Tucker gave an exceptionally clear talk on his important result on the existence of F-signature, an invariant intimately related to the Hilbert-Kunz multiplicity; the main point was the uniform convergence of certain limits which could also have important consequences for Hilbert-Kunz multiplicities.

Some of the talks treated the subtle connections between singularities and global properties of algebraic varieties via reduction to positive characteristic. An important question concerns the relation between varieties of Fano type (or Calabi-Yau type) in characteristic zero and the so-called globally F-regular type (respectively, globally F-split type) varieties, defined by reduction to positive characteristic. A relation between these two notions has been conjectured by Schwede and Smith and a very interesting talk by Shunsuke Takagi (University of Tokyo) presented a proof of this conjecture, joint with Gonyo, of the two-dimensional case of this conjecture. Another intriguing talk on this connection was given by Nobuo Hara (Tohoku University), who connected the concept with F-blowups. In particular, Professor Kawamata was

impressed that the iteration of the Frobenius morphisms in positive characteristic can be a substitute of a resolution of singularities in characteristic zero. Vasudevan Srinivas (Tata Institute) discussed a conjecture relating some invariants of singularities in characteristic zero (the multiplier ideals) with similar invariants (the test ideals) defined using the Frobenius morphism in positive characteristic. He presented his joint work with Mustaţă, reducing a conjecture relating these invariants via reduction mod p to a conjecture predicting the ordinarity of infinitely many reductions to positive characteristic for a smooth projective variety defined over a number field.

Some of the recent talks concerning birational geometry were related to the spectacular advances in this field over the past few years. The first talk in the workshop, given by János Kollár (Princeton University), presented an application of the Minimal Model Program to invariants of isolated singularities associated via a resolution of singularities. More precisely, work of many people has shown that the homotopy type of a certain regular cell complex associated to a resolution of an isolated singularity is an invariant of the singularity. In joint work with de Fernex and Xu, Kollár has shown that for nice singularities (more precisely, for log terminal singularities) this complex is contractible, a result that has attracted a lot of interest among the experts in the field.

James M$^{\text{c}}$Kernan (MIT) gave a talk on a web of conjectures, going back to Shokurov, that would allow proving one of the remaining open problems in birational geometry, namely Termination of Flips. In a recent breakthrough, M$^{\text{c}}$Kernan with Hacon and Xu proved a conjecture of Shokurov concerning the ACC property of an invariant of singularities in characteristic zero, the log canonical threshold. M$^{\text{c}}$Kernan's talk discussed similar properties for related invariants, that would be closer related to the termination of sequences of flips.

Two related talks about singularities in characteristic zero have been given by Shihoko Ishii (University of Tokyo) and Lawrence Ein (UIC). These covered some versions of invariants of singularities that can be defined in a very general setting, by replacing the usual discrepancy in birational geometry by a version going back to the work of Mather. Masayuki Kawakita (RIMS) gave a talk on a conjecture of Shokurov on the index of canonical singularities, proving the conjecture for 3-folds.

There were two talks on connections to valuation theory, given by Charles Favre (École Polytechnique) and Bernard Teissier (Inst. Math. Jussieu). Favre discussed his work with Boucksom and Jonsson on a uniform version of a theorem of Izumi, that over the years generated a lot of work in commutative algebra. Teissier presented some recent progress on his approach towards the Local Uniformization theorem (a key step in resolution of singularities) in positive characteristic. The talk gave a general overview of this approach based on toric methods, and on how this can be applied in the case of Abhyankar valuations.

While many of the talks in the workshop had an important didactic component, there were a few of the talks whose goal was to introduce some particular topic to a wide audience. Claudia Polini (University of Notre Dame) gave a beautiful introduction to an algebraic notion, the core of an ideal, emphasizing its connections with geometric concepts, such as multiplier ideals. Gennady Lyubeznik (University of Minnesota) gave an overview of recent results related to local cohomology, with emphasis on positive characteristic. Tommaso de Fernex (University of Utah) surveyed a topic that has recently attracted a lot of attention, the Nash problem concerning the connections between families of arcs and divisors on a resolution of singularities. In particular, de Fernex discussed the recent solution of the problem in dimension 2, due to Fernández de Bobadilla and Pe Pereira, as well as the counterexamples in higher dimensions due to Ishii and Kollar (in dimension ≥ 4) and to himself (in dimension 3). Mehta (IIT, Bombay) gave a beautiful overview of the applications of Frobenius splitting to the study of moduli of vector bundles on curves, including an exposition of some of the relevant GIT theory connecting these results to, for example, the Hochster-Roberts theorem on Cohen-Macaulayness of invariant rings. Willem Veys (University of Leuven) gave a nice introduction to the Monodromy Conjecture for Igusa's p-adic zeta function, discussing the connections between classical invariants of singularities (such as the monodromy action on the Milnor fiber) and invariants associated to p-adic, topological, and motivic zeta functions.

On Wednesday afternoon, younger mathematicians were given the opportunity to present their work in two parallel sessions. These talks were well-attended, well-received and in general of high quality. In particular, a number of conversations were sparked that have led to new collaborations or improved results. The speakers were: Angelica Benito (Madrid/UMich), Wenbo Niu (Purdue University), Jenna Rajchgot (UMich), Akiyoshi Sannai (Nagoya University), Takafumi Shibuta (Kyushu University), Adela Vraciu (University of South Carolina), Emily Witt (Univ. Minnesota), and Yuchen Zhang (University of Utah).

In summary, the organizers were extremely pleased by the results of the workshop. The talks were of high quality, beautiful results were presented connecting the fields, collaborations developed, and new conjectures and opportunities wait to be explored.

MSRI Mathematical Sciences Research Institute

The Commutative Algebra of Singularities in Birational Geometry: Multiplier Ideals, Jets, Valuations, and Positive Characteristic Methods

May 6 to May 10, 2013

Schedule

Monday, May 6, 2013			
9:00 AM - 9:30 AM	Simons Auditorium		Welcome
9:30 AM - 10:20 AM	Simons Auditorium	János Kollár	Resolutions of dlt pairs
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 11:50 AM	Simons Auditorium	Gennady Lyubeznik	Recent results on the grading of local cohomology modules
12:00 PM - 2:00 PM	Atrium		Lunch
2:00 PM - 2:50 PM	Simons Auditorium	Claudia Polini	the core of an ideal
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:20 PM	Simons Auditorium	James McKernan	ACC for the log canonical threshold and termination of flips

Tuesday, May 7, 2013			
9:00 AM - 9:50 AM	Simons Auditorium	Steven Cutkosky	Multiplicities of graded families of linear series
10:00 AM - 10:30 AM	Atrium		Tea
10:30 AM - 11:20 AM	Simons Auditorium	Vasudevan Srinivas	Ordinary varieties and the comparison between multiplier ideals and test ideals
11:30 AM - 12:20 PM	Simons Auditorium	Karl Schwede	F-singularities in families
12:30 PM - 2:00 PM	Atrium		Lunch
2:00 PM - 2:50 PM	Simons Auditorium	Bernard Teissier	On the local uniformization of Abhyankar valuations using toric maps
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:20 PM	Simons Auditorium	Bhargav Bhatt	A local Lefschetz theorem
4:30 PM - 6:20 PM	Atrium		Reception

Wednesday, May 8, 2013			
9:00 AM - 9:50 AM	Simons Auditorium	Tommaso de Fernex	The Nash problem on families of arcs
10:00 AM - 10:30 AM	Atrium		Tea
10:30 AM - 11:20 AM	Simons Auditorium	Kevin Tucker	F-Signature and Relative Hilbert-Kunz Multiplicity
11:30 AM - 12:20 PM	Simons Auditorium	Vijaylaxmi Trivedi	Some computations of Hilbert-Kunz functions
12:30 PM - 2:00 PM	Atrium		Lunch
2:00 PM - 2:25 PM	SSL Addition Conference Room (Room 105)	Yuchen Zhang	Pluri-canonical maps in positive characteristic
2:00 PM - 2:25 PM	Baker Board Room	Emily Witt	F-pure thresholds of quasi-homogeneous polynomials
2:30 PM - 2:55 PM	SSL Addition Conference Room (Room 105)	Wenbo Niu	Generic linkage and regularity of algebraic varieties
2:30 PM - 2:55 PM	Baker Board Room	Adela Vraciu	Degrees of relations, the Weak Lefschetz Property, and top socle degrees in positive characteristic
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 3:55 PM	SSL Addition Conference Room (Room 105)	Angelica Benito	Asymptotic test ideals and their possible applications to resolution problems
3:30 PM - 3:55 PM	Baker Board Room	Takafumi Shibuta	Multiplier ideals and test ideals of complete intersection binomial ideals
4:00 PM - 4:25 PM	SSL Addition Conference Room (Room 105)	Jenna Rajchgot	Frobenius splitting of orbit closures associated to type A quivers
4:00 PM - 4:25 PM	Baker Board Room	Akiyoshi Sannai	Dual F-signature

Thursday, May 9, 2013			
9:00 AM - 9:50 AM	Simons Auditorium	Shunsuke Takagi	Globally F-regular and Frobenius split surfaces
10:00 AM - 10:30 AM	Atrium		Tea
10:30 AM - 11:20 AM	Simons Auditorium	Masayuki Kawakita	The index of a threefold canonical singularity
11:30 AM - 12:20 PM	Simons Auditorium	Charles Favre	Uniform Izumi's theorem
12:30 PM - 2:00 PM	Atrium		Lunch
2:00 PM - 2:50 PM	Simons Auditorium	Shihoko Ishii	Singularities with respect to Mather-Jacobian discrepancies
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:20 PM	Simons Auditorium	Willem Veys	The monodromy conjecture for motivic and related zeta functions

Friday, May 10, 2013			
9:30 AM - 10:20 AM	Simons Auditorium	Lawrence Ein	Mather multiplier ideals
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 11:50 AM	Simons Auditorium	Holger Brenner	Something is irrational in Hilbert-Kunz theory
12:00 PM - 2:00 PM	Atrium		Lunch
2:00 PM - 2:50 PM	Simons Auditorium	Vikram Mehta	The Singularities of the Moduli Spaces of Vector Bundles over Curves in characteristic p
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:20 PM	Simons Auditorium	Nobuo Hara	Stabilization of the Frobenius push-forward and the F-blowup sequence

Participants

First Name	Last Name	Institution
Paolo	Aluffi	Florida State University
Josep	Alvarez-Montaner	Universitat Politecnica de Catalunya
Yuri	Bazlov	University of Manchester
Angelica	Benito	University of Michigan
David	Benson	University of Aberdeen
Arkady	Berenstein	University of Oregon
Bhargav	Bhatt	Institute for Advanced Study
Manuel	Blickle	Johannes Gutenberg-Universitat Mainz
Mats	Boij	Royal Institute of Technology (KTH)
Jacob	Boswell	Purdue University
Holger	Brenner	Universitat Osnabrueck
Morgan	Brown	University of Michigan
Ragnar-Olaf	Buchweitz	University of Toronto
Kenneth	Chan	University of Washington
C-Y.	Chan	Central Michigan University
Huachen	Chen	Ohio State University
Catalin	Ciuperca	North Dakota State University
Helena	Cobo	University of Sevilla
Steven	Cutkosky	University of Missouri
Hailong	Dao	University of Kansas
Omprokash	Das	University of Utah
Tommaso	de Fernex	University of Utah
Alessandro	De Stefani	University of Virginia
Emilie	Dufresne	MSRI - Mathematical Sciences Research Institute
Taylor	Dupuy	University of New Mexico
Lawrence	Ein	University of Illinois at Chicago
David	Eisenbud	University of California
Juan	Elias	University of Barcelona
Florian	Enescu	Georgia State University
Neil	Epstein	George Mason University
Eleonore	Faber	University of Toronto
Andrea	Fanelli	Imperial College, London
Charles	Favre	Ecole Polytechnique
Louiza	Fouli	New Mexico State University
Juan	Fra-as-Medina	University of Michoacan (UMSNH)
Yoshinori	Gongyo	Imperial College, London
Elizabeth	Gross	University of Illinois
Kangjin	Han	Korea Institute for Advanced Study (KIAS)
Nobuo	Hara	Tohoku University
Ines	Henriques	University of California
Daniel	Hernandez	University of Minnesota Twin Cities
TRUONG	HOANG	University of Meiji
Jen-Chieh	Hsiao	Purdue University
Craig	Huneke	University of Virginia
Yoonsuk	Hyun	Korea Institute for Advanced Study (KIAS)

Shihoko	Ishii	University of Tokyo
Srikanth	Iyengar	University of Nebraska
Mark	Johnson	University of Arkansas
Mordechai	Katzman	University of Sheffield
Masayuki	Kawakita	Kyoto University
Yujiro	Kawamata	University of Tokyo
Youngsu	Kim	Purdue University
Janos	Kollar	Princeton University
Miroslav	Kures	Technical University of Brno (VUT)
CHINGJUI	LAI	Purdue University
Chung Ching	Lau	University of Utah
Graham	Leuschke	Syracuse University
Jinjia	Li	University of Louisville
Xia	Liao	Florida State University
Tiankai	Liu	Massachusetts Institute of Technology
Gennady	Lyubeznik	University of Minnesota Twin Cities
Linquan	Ma	University of Michigan
Paolo	Mantero	University of California
Matilde	Marcolli	California Institute of Technology
James	McKernan	Massachusetts Institute of Technology
Vikram	Mehta	Dept. of mathematics, IIT, Bombay
Lance	Miller	University of Utah
Claudia	Miller	Syracuse University
Rosa M.	Miro-Roig	University of Barcelona
Jonathan	Montano	Purdue University
Serena	Murru	University of Sheffield
Mircea	Mustata	University of Michigan
Yusuke	Nakamura	University of Tokyo
Trung	Ngo	Institute of Mathematics
Van	Nguyen	Texas A & M University
Wenbo	Niu	Purdue University
Howard	Nuer	Rutgers University
Luis	Nunez	University of Michigan
Luke	Oeding	University of California
Juan	Perez	University of Michigan
Claudia	Polini	University of Notre Dame
Jeffrey	Poskin	University of Wisconsin
Jenna	Rajchgot	MSRI - Mathematical Sciences Research Institute
Alice	Rizzardo	International School for Advanced Studies (SISSA/ISAS)
sarang	sane	University of Kansas
Akiyoshi	Sannai	Nagoya University
Soumya	Sanyal	University of Missouri
Tobias	Schedlmeier	Johannes Gutenberg-Universitat Mainz
Bernd	Schober	Universitat Regensburg
Karl	Schwede	Pennsylvania State University
Takafumi	Shibuta	Kyushu University
Anurag	Singh	University of Utah

Ilya	Smirnov	University of Kansas
Gregory	Smith	Queen's University
Karen	Smith	University of Michigan
Frank	Sottile	Texas A & M University
Vasudevan	Srinivas	Tata Institute of Fundamental Research
Suresh	Srinivasamurthy	Kansas State University
Hema	Srinivasan	University of Missouri
Axel	Stabler	Johannes Gutenberg-Universitat Mainz
Roberto	Svaldi	Massachusetts Institute of Technology
Peter	Symonds	University of Manchester
Shunsuke	Takagi	University of Tokyo
Hiromu	Tanaka	Kyoto University
Bernard	Teissier	Centre National de la Recherche Scientifique (CNRS)
Pedro	Teixeira	Knox College
Howard	Thompson	University of Michigan
Vijaylaxmi	Trivedi	Tata Institute of Fundamental Research
Kevin	Tucker	Princeton University
Adam-Christiaan	van Roosmalen	University of Regina
Willem	Veys	Katholieke Universiteit Leuven
Adela	Vraciu	University of South Carolina
Hans	Walther	Purdue University
Kei-ichi	Watanabe	Nihon University
Alan Marc	Watson	University of Utah
Emily	Witt	University of Minnesota Twin Cities
Chenyang	Xu	University of Utah
Keyvan	Yaghmayi	University of Utah
Yongwei	Yao	Georgia State University
Santiago	Zarzuela	University of Barcelona
Yuchen	Zhang	University of Utah
Wenliang	Zhang	University of Nebraska
Yi	Zhang	MSRI - Mathematical Sciences Research Institute
Xudong	Zheng	University of Illinois at Chicago
Zhixian	Zhu	University of Michigan

Officially Registered Participant Information

Participants		**126**

Gender		**126**
Male	76.19%	96
Female	18.25%	23
Declined to state	5.56%	7

Ethnicity*		**126**
White	43.65%	55
Asian	36.51%	46
Hispanic	3.97%	5
Pacific Islander	0.00%	0
Black	1.59%	2
Native American	0.79%	1
Mixed	0.79%	1
Declined to state	12.70%	16

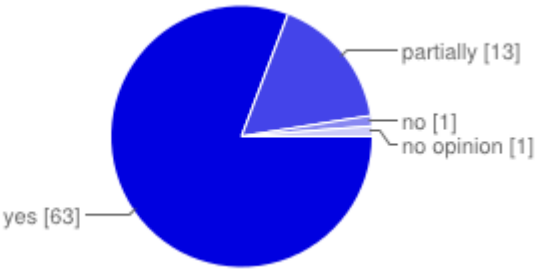
* ethnicity specifications are not exclusive

78 responses

Summary See complete responses

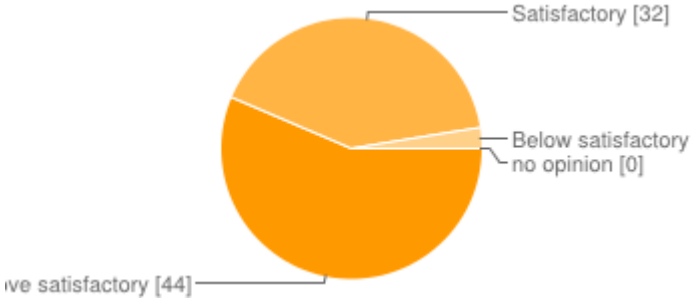
Topic presentation and organization

Did the various topics within the workshop integrate into a coherent picture?



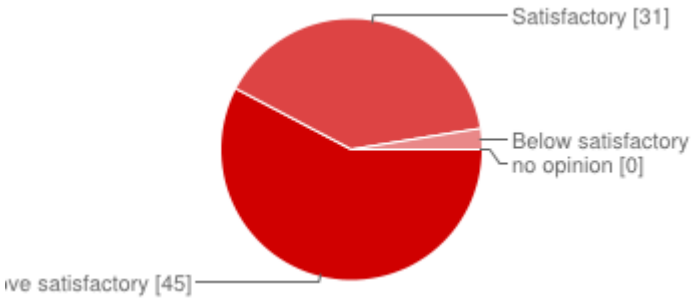
yes	**63**	81%
partially	**13**	17%
no	**1**	1%
no opinion	**1**	1%

Were the speakers generally clear and well organized in their presentation?



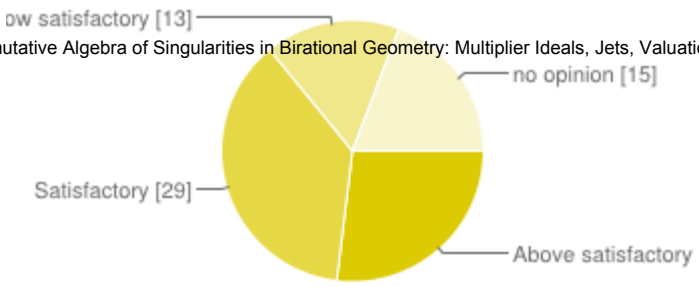
Above satisfactory	**44**	56%
Satisfactory	**32**	41%
Below satisfactory	**2**	3%
no opinion	**0**	0%

Was there adequate time between lectures for discussion?



Above satisfactory	**45**	58%
Satisfactory	**31**	40%
Below satisfactory	**2**	3%
no opinion	**0**	0%

How beneficial were the parallel sessions?



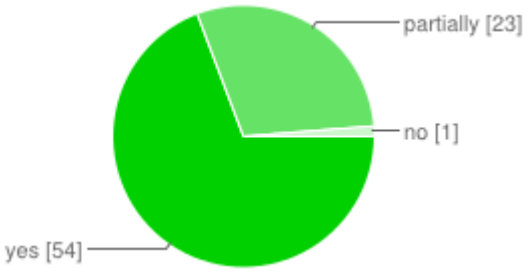
Above satisfactory	**21**	27%
Satisfactory	**29**	37%
Below satisfactory	**13**	17%
no opinion	**15**	19%

Additional comments on the topic presentation and organization

Eliminate the parallel sessions; the conflict with the music concert was painful. The parallel sessions should be taken place in the same building. In my experience, it is hard to do a very good job i ...

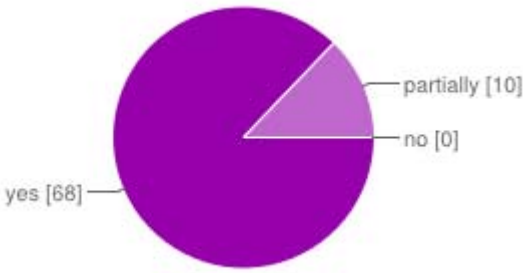
Personal assessment

Was your background adequate to access a reasonable portion of the material?



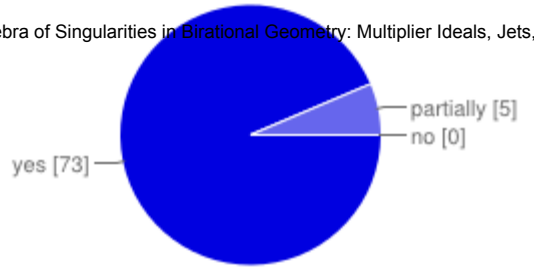
yes	**54**	69%
partially	**23**	29%
no	**1**	1%

Did the workshop increase your interest in the subject?



yes	**68**	87%
partially	**10**	13%
no	**0**	0%

Was the workshop worth your time and effort?



yes	**73**	94%
partially	**5**	6%
no	**0**	0%

Additional comments on your personal assessment

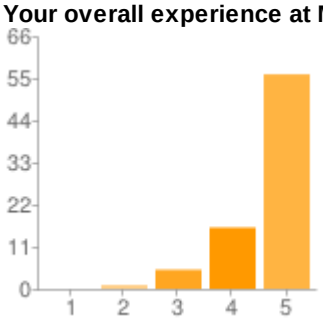
No parallel sessions, it's great the idea of short talks, but not at the same time

I am very enthusiastic about this workshop! It was really useful and interesting

The number of lectures was not so la ...

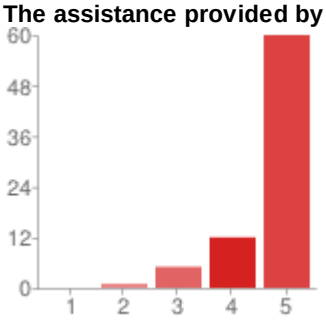
Venue

Your overall experience at MSRI



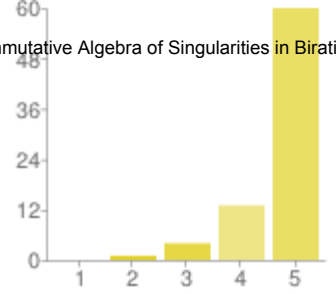
1 -	Not satisfactory	**0**	0%
2		**1**	1%
3		**5**	6%
4		**16**	21%
5 -	Above satisfactory	**56**	72%

The assistance provided by MSRI staff



1 -	Not satisfactory	**0**	0%
2		**1**	1%
3		**5**	6%
4		**12**	15%
5 -	Above satisfactory	**60**	77%

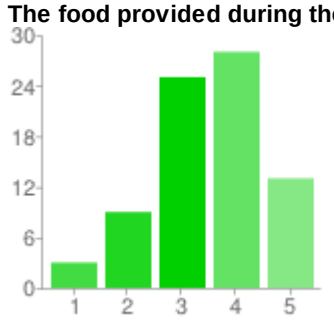
The physical surroundings



Not satisfactoryAbove satisfactory

1 -	Not satisfactory	**0**	0%
2		**1**	1%
3		**4**	5%
4		**13**	17%
5 -	Above satisfactory	**60**	77%

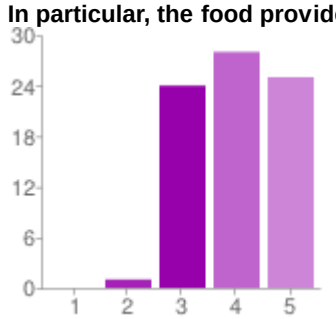
The food provided during the workshop



Not satisfactoryAbove satisfactory

1 -	Not satisfactory	**3**	4%
2		**9**	12%
3		**25**	32%
4		**28**	36%
5 -	Above satisfactory	**13**	17%

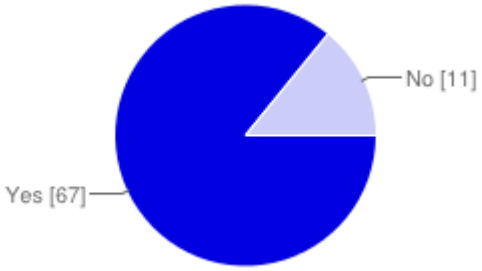
In particular, the food provided during the reception



Not satisfactoryAbove satisfactory

1 -	Not satisfactory	**0**	0%
2		**1**	1%
3		**24**	31%
4		**28**	36%
5 -	Above satisfactory	**25**	32%

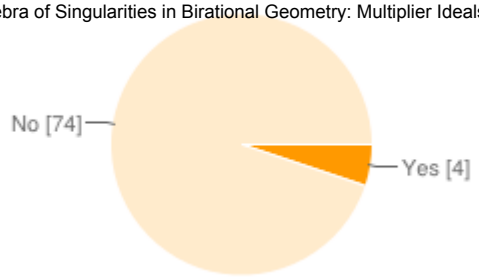
Did you use MSRI's wireless network?



Yes	**67**	86%
No	**11**	14%

Did you experience any difficulties with the network?

Yes	4	5%
No	**74**	95%



If you did experience difficulties with the network, please explain:

website is surprisingly awkward to use In some moments the Internet connection was blinking and this made that the communication with Skype was difficult, but in general no big problems. On the first ...

Additional comments on the venue

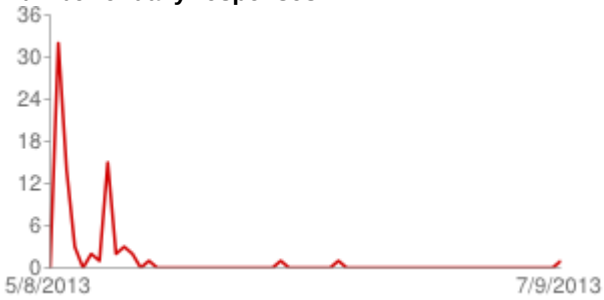
great bagels. wish there coule have been food in morning, too, before the first talks. The rooms for the parallel sessions were below satisfactory. There was not enough room in either location, and ...

Thank you for completing this survey

We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.

more bagel days for morning tea Thank you for organizing this wonderful workshop! Please provide better coffee. Keep doing what you are doing.

Number of daily responses



The Commutative Algebra of Singularities in Birational Geometry: Multiplier Ideals, Jets, Valuations, and Positive Characteristic Methods May 6 - 10, 2013

Additional Survey Responses

Additional comments on the topic presentation and organization

- Eliminate the parallel sessions; the conflict with the music concert was painful.
- The parallel sessions should be taken place in the same building.
- In my experience, it is hard to do a very good job in trying to build connections. I probably never saw a really successful result. This workshop did well, at least I have learned new topics that may relate to my work. I am less sure how much the younger part of the participants got involved in new topics.
- Please no parallel sessions!
- very good
- The parallel sessions were really good and I liked them, the problem was to split them and have to decide missing some I was interested in
- Very well organized, nice and interesting talks. Everything was perfect!
- parallel sessions should be avoided!
- Thank you for organizing a workshop on interactions in algebra and geometry in positive characteristic methods. Very helpful.
- The presence of so many experts in one place and the opportunities to consult with them are invaluable

Additional comments on your personal assessment

- No parallel sessions, it's great the idea of short talks, but not at the same time
- I am very enthusiastic about this workshop! It was really useful and interesting
- The number of lectures was not so large as to make it impossible to attend most of them. This is not always the case at meetings, and I appreciate the balance chosen between structured activities and free time for discussion.
- I started working on many problems, related to the various themes of the conference.
- Thank you for holding a session the interactions in Positive Characteristic methods
- It was VERY beneficial for me

Additional comments on the venue

- great bagels. wish there could have been food in morning, too, before the first talks.
- The rooms for the parallel sessions were below satisfactory. There was not enough room in either location, and the location outside of MSRI was far too small and did not have any working markers! I was even told by a colleague that they missed a talk because it was too crowded. I find it to be in bad taste to have an event in Simons (despite it being a nice, important event) during the workshop, at the workshop
- The location is very beautiful and inspiring!
- The hill line sometimes left the bus stop several minutes before scheduled.
- Please use name tags without safety pins.
- Food during reception gone quick usually

We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.

- more bagel days for morning tea
- Thank you for organizing this wonderful workshop!
- Please provide better coffee.
- Keep doing what you are doing.

Mathematical Sciences Research Institute

Connections for Women:

Noncommutative Algebraic Geometry and Representation Theory

January 24 to January 25, 2013

MSRI, Berkeley, CA, USA

Organizers:

Georgia Benkart (University of Wisconsin)

Ellen Kirkman* (Wake Forest University)

Susan Sierra (Princeton University & University of Edinburgh)

REPORT ON THE MSRI WORKSHOP
"CONNECTIONS FOR WOMEN:
NONCOMMUTATIVE ALGEBRAIC GEOMETRY AND
REPRESENTATION THEORY"
JANUARY 24-25, 2013

Organizers:

- Georgia Benkart (University of Wisconsin-Madison)
- Ellen Kirkman (Wake Forest University)
- Susan Sierra (University of Edinburgh)

1 Scientific description

The Connections for Women Workshop had three overarching goals: (1) to provide an accessible introduction to the main themes of the MSRI semester-long program "Noncommutative Algebraic Geometry and Representation Theory" (NAGRT); (2) to bring together researchers in this program as well as in the year-long program in commutative algebra and the fall program in cluster algebras; and (3) to connect junior researchers, especially women and minorities, to senior researchers. The workshop preceded the five-day "Introductory Workshop" for the NAGRT program that was held at MSRI January 28-February 1, 2013.

Noncommutative algebra impacts virtually every area of algebra and combinatorics as well as geometry, mathematical physics, and statistical mechanics, and has played a crucial role in solving open problems in these areas. The Connections Workshop featured eight hour-long lectures, which focused on fundamental ideas and open problems in noncommutative algebra, geometry, and representation theory. There were four poster sessions, each featuring the work of three or four early-career researchers. Each poster presenter gave a 3-4 minute introduction to their poster to the entire conference audience. A panel discussion focused on issues especially relevant to junior researchers, women, and minorities. Scheduled breaks and a conference dinner for female participants fostered further interaction and connections.

In the opening lecture of the workshop, *Open Questions in Noncommutative Algebra and Noncommutative Algebraic Geometry*, James Zhang outlined general ideas and questions that he regards as basic to a better

understanding of noncommutative algebras and noncommutative algebraic geometry. His "star" rating indicated the anticipated difficulty of the questions, with a single star for questions that might not be too difficult to answer, to five-star open problems that are likely to be quite difficult to answer now. The questions below illustrate the range and difficulty of the problems posed in the talk:

(1) Increase our understanding of the different notions of dimension for noncommutative rings. *** In particular, if A is (right and left) Noetherian, is the Gelfand-Kirillov dimension of A (GKdim A) finite? *** If GKdim A is finite and A is Noetherian, must the GKdim A be an integer?" (This is true when GKdim $A \leq 3$.)

(2) What should an automorphism (symmetry) of a noncommutative space be? ** Find all the Hopf actions on $k_q[x_1, \cdots, x_n]$.

(3) *** Find new constructions of noncommutative algebras.

(4) * Find new invariants of algebras that help to understand the structure of the algebra. Find homological identities that relate various homological invariants (for example the Nakayama automorphism is related to other invariants).

(5) **** Is every Noetherian noncommutative local regular ring a domain?

(6) ***** Construct all Noetherian connected graded algebras A with GKdim A finite.

(7) **** Classify the Artin Schelter (AS) regular algebras of dimension 4.

(8) ** Is every AS regular algebra Noetherian? If the field is finite, is a Noetherian AS regular algebra necessarily finitely generated as an algebra over its center?

Zhang concluded by mentioning that Artin's conjectures on the structure of noncommutative surfaces are important basic problems, and work on these conjectures is a very active area of research.

In the study of Lie algebras, the Poincaré-Birkhoff-Witt (PBW) basis of the universal enveloping algebra plays an essential role. The second lecture, *Poincaré-Birkhoff-Witt Theorems*, by Sarah Witherspoon discussed the usefulness of having a PBW basis in diverse problems; for example, in computing cohomology. She cited work by Ginzburg and Kumar in 1993 which showed that $H^*(U_q(\mathfrak{g})) = \mathrm{Ext}^*_{U_q(\mathfrak{g})}(\mathbb{C}, \mathbb{C})$ is finitely generated by us-

ing a PBW basis of the quantum group $U_q(\mathfrak{g})$. Every finite-dimensional pointed Hopf algebra A with an abelian group of group-like elements has a PBW basis, and this result was used by Mastnak, Pevtsova, Schauenberg, and Witherspoon (2010) to show that $H^*(A)$ is finitely generated. Related open problems include: "Prove or find a counterexample to a 2004 conjecture of Etingof and Ostrik: if A is a finite-dimensional Hopf algebra (or more generally a tensor category), then $H^*(A)$ is finitely generated." Investigations of various noncommutative deformations of skew group algebras (e.g. Hecke algebras, symplectic reflection algebras, graded Hecke algebras, and Drinfeld orbifold algebras) often involve finding a PBW basis and using it to determine important structural information about the algebra.

The third lecture, *Kazhdan-Lusztig Polynomials, Geometry and Categorification*, by Catharina Stroppel focused on the classical representation theory of complex simple Lie algebras $\mathfrak{g}$, but from a geometric and categorical perspective. The problem of determining all irreducible modules is beyond reach except for small examples; in particular a fairly complete description has been achieved only for $\mathfrak{sl}_2$. Instead, an approach that has been adopted is to determine the annihilators of the irreducible modules, the so-called primitive ideals. This has led to the well-known result of Duflo which says these ideals are the annihilators of highest weight modules. Stroppel asked, "Do new categorification techniques help?" She explained how the representation theory of the Hecke algebra of the associated Weyl group, the Kazhdan-Lusztig basis, and the Kazhdan-Lusztig polynomials can shed light on representations of $\mathfrak{g}$.

In the final lecture of the first workshop day, Graham Leuschke discussed the question *What should noncommutative resolutions of singularities be?* A variety Y is a resolution of singularities of a variety X if there is a map $\pi : Y \to X$ with (1) π birational (2) π proper, and (3) Y nonsingular. He suggested that algebra might replace geometry in studying such resolutions, but commutative algebra seems inadequate for this task. Instead he proposed using noncommutative algebras. If R is a Gorenstein local ring, Λ is an R-order (that is a module-finite R-algebra with $\Lambda \otimes_R K \cong \mathrm{Mat}_n(K)$), and Λ and R have the same finite global dimension, then Λ can be regarded as a noncommutative resolution of singularities. These conditions are related to the notion (due to Van den Bergh) of a noncommutative crepant resolution of a Gorenstein ring R. He concluded with a discussion of open questions, including a conjecture of Bondal and Orlov that states "Two crepant resolutions of singularities of the same variety have equivalent bounded derived

categories" (which is known to hold for X of dimension 3 by work of Van den Bergh). A related question is "Are all crepant resolutions, both the commutative and noncommutative ones, derived equivalent?"

The second day's lectures started with the talk *What are the Noncommutative Projective Surfaces?* by Susan Sierra. She discussed the problem of classifying connected graded domains of Gelfand-Kirillov dimension 3, including Artin's conjecture on the birational classification. She reported on progress that she and others have made on this problem, and posed several open questions. If R is a connected graded noetherian domain of GKdim 3, one forms its *function skewfield* $D(R)$ by taking degree 0 elements in the graded quotient ring $Q_{gr}(R)$. In 1995 Artin conjectured, roughly, that function skewfields of connected graded domains of GKdim 3 fall into three broad families: algebras that are finite over their centres; skew polynomial extensions $K(t;\sigma,\delta)$, where K is a field of transcendence degree 1; and the *Sklyanin function field* $D(E,\sigma)$, obtained as a localization of the 3-dimensional Sklyanin algebra $A(E,\sigma)$. To date, there has been little progress on the conjecture, although conjecturally there are potential approaches through deformation theory, through valuations, and through studying point schemes. Sierra posed questions relating to all of these approaches. Sierra reported that there has been more progress on classifying algebras falling within various cases of the conjecture. Birationally commutative algebras of GKdim 3 (that is, those whose function skewfield is commutative) were classified by Rogalski-Stafford and Sierra. Chan proved an algebra with a 2-dimensional parameter space of "fat points" must be birationally PI, although the finer classification of birationally PI algebras remains open. There are some initial results on algebras birational to the Sklyanin function field by Rogalski, Stafford, and Sierra. Finally, the "q-ruled" case, where $D = K(t;\sigma,\delta)$ may be amenable to more functorial techniques developed by Chan and Nyman.

In her talk, *The Interplay of Algebra and Geometry in the Setting of AS-regular Algebras*, Michaela Vancliff focused on the problem of classifying Artin-Schelter regular algebras. Since AS-regular algebras are noncommutative analogues of commutative polynomials, they should have a geometry, and she described the geometry that appeared in the work of Artin, Tate, and Van den Bergh. Generic AS-algebras of dimension 3 were classified by Artin, Tate and Van den Bergh using the geometry of the point scheme, but this classification does not extend to dimension 4, where she believes a line scheme may also be necessary. Vancliff described her work using graded skew Clifford algebras to reclassify most of the quadratic algebras of dimen-

sion 3, and some of the quadratic algebras of dimension 4. She concluded with a list of problems related to graded skew Clifford algebras and the classification of AS-regular algebras of dimension 4 using a line scheme and a point scheme.

Cherednik algebras, and more generally symplectic reflection algebras, are noncommutative deformations of skew group rings of complex reflection groups. In his lecture, *Some Geometry and Combinatorics Around the Representations of the Cherednik Algebras*, Iain Gordon discussed some of the geometry and combinatorics related to these algebras and groups. A reflection group G acting on a vector space V induces an action on the cotangent bundle $T^*V = V \otimes V^*$, which is a symplectic space, and understanding the geometry of the induced orbit space, which is always a singular variety but has mild "symplectic singularities," is a problem of current interest. If there is a symplectic resolution X, (which is related to the existence of a crepant resolution), there is an equivalence between the derived categories $D^b(\mathbb{C}[T^*V] \rtimes G)$ and $D^b(X)$. Hence any two such symplectic resolutions X_1 and X_2 have equivalent derived categories. But it was shown by Bellamy in 2009 that such a symplectic resolution exists only in type A. Attached to a complex reflection group G are the bigraded q-Catalan and rational q-Catalan "numbers" of G, which are actually Laurent polynomials. They were introduced by Garcia and Haiman to understand the $n!$ conjecture (now the $n!$ theorem proved by Haiman). Setting the parameter t equal to 0 in the bigrading leads to a noncommutative crepant resolution. Rational Cherednik algebras reveal new properties of Hecke algebras and the combinatorics of the Hilbert scheme related to the rational q-Catalan numbers. A current exciting goal is to understand "deformation quantization of symplectic varieties and localization", which involves viewing the rational Cherednik algebras as sheaves of algebras on symplectic resolutions.

In the final conference talk, *An Introduction to Cluster Algebras*, Lauren Williams gave a introductory overview of how cluster algebras work. Cluster algebras were the theme of the MSRI fall semester program, and Williams' lecture served to tie that topic to the spring semester topic of noncommutative algebra. Cluster algebras are a class of commutative rings introduced by Fomin and Zelevinsky in the early 2000s to study dual canonical bases and positivity questions in quantum group theory. They are generated by cluster variables and mutation relations. Cluster algebras of finite type can be classified by the finite Dynkin diagrams. Cluster algebras provide a unifying algebraic and combinatorial framework for investigating a wide array

of mathematical topics such as Grassmannians, tropical calculus, invariant theory, polyhedral combinatorics, and Poisson geometry.

2 Poster Presentations

Fourteen early-career participants presented posters, which were displayed during the coffee breaks. Each presenter gave a 3-4 minute summary of their topic and main results just prior to having their poster on display. Several participants commented that this format was very effective in giving presenters an opportunity to introduce their work. The posters presenters and their titles are as follows:

- Martina Balagovic, York University, *Representations of Rational Cherednik Algebras in Positive Characteristic*
- Olga Bershtein, Tallinn University of Technology, Tallinn, Estonia and Institute for Low Temperature Physics and Engineering, Kharkov, Ukraine, *Geometrical Realizations of Quantum Harish-Chandra Modules*
- Jiarui Fei, University of California, Riverside, *Moduli of Representations*
- Johanna Hennig, University of California San Diego, *A Generalization of Lie's Theorem*
- Mee Seong Im, University of Illinois at Urbana-Champaign, *Invariants and Semi-invariants of Arbitrary Filtered Quiver Varieties*
- Martina Lanini, The University of Melbourne, *The Stable Moment Graph and Periodic Structures in the Affine Category $\mathcal{O}$*
- Joanna Meinel, Max Planck Institute for Mathematics, Bonn, *Primitive Ideals and Primitive Quotients of Generalizations of Weyl Algebras*
- Manizheh Nafari, University of Toledo, *Regular Graded Skew Clifford Algebras that are Twists of Regular Graded Clifford Algebras*
- Emily Norton, Boston College, *Symplectic Reflection Algebras of Elementary Abelian p-Groups Viewed as Ore Extensions*

- Natasha Rozhkovskaya, Kansas State University, *Commutative Subalgebras coming from Duality of Actions*
- Špela Špenko, Institute of Mathematics, Physics and Mechanics, Ljubljana, Slovenia, *On the Image of a Noncommutative Polynomial*
- Amy Stout, University of San Diego, *Non-regular Algebras of Dimension 3*
- Mary Clair Thompson, Auburn University, *Asymptotic Results in Noncompact Semisimple Lie Groups*
- Padmini P. Veerapen, University of Texas, Arlington, *Point Modules over Regular Graded Skew Clifford Algebras*

3 Panel

The panel discussion,"Maintaining Momentum", was moderated by Ellen Kirkman, and the panelists were

- Lourdes Juan (Professor, Texas Tech) (Differential Galois Theory, Algebraic Groups, Computer Applications)
- Gail Letzter (NSA) (Representation Theory of Lie Algebras and Quantum Groups)
- Anne Shepler (Assoc. Professor, North Texas) (Cohomology and Representation Theory)
- Monica Vazirani (Assoc. Professor, UC-Davis) (Algebraic Combinatorics)
- Chelsea Walton (Moore Instructor/NSF Postdoctoral Fellow – MIT) (Noncommutative Algebra)

By design, the panelists were chosen to represent different stages of their careers, different career trajectories, and different family situations. Panelists discussed the following questions:

1. What advice would you give to women beginning a career in mathematics?
2. What obstacles have you experienced in maintaining an active research program – and what solutions have you discovered?

3. Have you found productive collaborations – if yes, how did these collaborations begin? Are there problems to avoid in establishing collaborations?

4. How have you found new questions and areas of interest beyond your thesis research?

There were about 15 minutes of comments and questions from the floor. Discussions continued over the dinner for female participants, where participants were were asked to sit next to someone they didn't know.

4 Comments

The organizers received many positive comments regarding the workshop, including the following comments from a female graduate student who had attended the workshop:

"In my opinion, that workshop was one of the most helpful things I've ever participated in during my graduate career, and I just want to say thank you for organizing it and for providing encouragement to bewildered young mathematicians like myself.

I especially liked the selection of questions you posed during the panel – I have seen panels before on this topic which were not quite as helpful, and I think it was because there wasn't such a good set of questions/topics which could lead the discussion. I am wondering if you still have the list of questions which you posed? It might help me if I ever organize a similar event in the future, if that is okay with you."

Organizers

First Name	Last Name	Institution
Georgia	Benkart	University of Wisconsin
Ellen	Kirkman	Wake Forest University
Susan	Sierra	University of Edinburgh

Speakers

First Name	Last Name	Institution
Iain	Gordon	University of Edinburgh
Graham	Leuschke	Syracuse University
Catharina	Stroppel	Universität Bonn
Michaela	Vancliff	University of Texas at Arlington
Lauren	Williams	University of California, Berkeley
Sarah	Witherspoon	Texas A&M University
James	Zhang	University of Washington
Susan	Sierra	University of Edinburgh

Mathematical Sciences Research Institute

Connections for Women:
Noncommutative Algebraic Geometry and Representation Theory

January 24 - 25, 2013

Schedule

Thursday, January 24, 2013			
9:00AM - 9:15AM	Simons Auditorium		Welcome
9:15AM - 10:05AM	Simons Auditorium	James Zhang	Open Questions in Noncommutative Algebra and Noncommutative Algebraic Geometry
10:15AM - 10:30AM	Simons Auditorium	Martina Lanini, Joanna Meinel, Emily Norton	Poster Previews
10:30AM - 11:00AM	Atrium		Tea
11:00AM - 11:50AM	Simons Auditorium	Sarah Witherspoon	Poincaré-Birkhoff-Witt Theorems
12:00PM - 1:30PM	Atrium		Lunch
1:30PM - 2:20PM	Simons Auditorium	Catharina Stroppel	Kazdhan-Lusztig polynomials, geometry and categorification
2:30PM - 2:45PM	Simons Auditorium	Jiarui Fei, Mee Seong Im, Natalia Rojkovskaia	Poster Previews
2:45PM - 3:15PM	Atrium		Tea
3:15PM - 4:05PM	Simons Auditorium	Graham Leuschke	What Should a Non-commutative Resolution of Singularities Be?
4:15PM - 5:15PM	Atrium	Lourdes Juan, Gail Letzter, Anne Shepler, Monica Vazirani, Chelsea Walton	Panel Discussion: Building and Sustaining Momentum (Moderated by Ellen Kirkman)
6:00PM - 8:00PM	Taste of the Himalayas		Dinner

Friday, January 25, 2013			
9:00AM - 9:50AM	Simons Auditorium	Susan Sierra	What Are the Noncommutative Projective Surfaces?
10:00AM - 10:15AM	Simons Auditorium	Olga Bershteyn, Spela Spenko, Mary Clair Thompson	Poster Previews
10:15AM - 10:45AM	Atrium		Tea
10:45AM - 11:35AM	Simons Auditorium	Michaela Vancliff	The Interplay of Algebra and Geometry in the Setting of AS-Regular Algebras
11:45AM - 12:00PM	Simons Auditorium	Johanna Hennig, Manizheh Nafari, Amy Stout, Padmini Veerapen	Poster Previews
12:00PM - 12:10PM	MSRI Entrance		Photo Session
12:10PM - 1:40PM	Atrium		Lunch
1:40PM - 2:30PM	Simons Auditorium	Iain Gordon	Some Geometry and Combinatorics around the Representations of Cherednik Algebras
2:30PM - 3:00PM	Atrium		Tea
3:00PM - 3:50PM	Simons Auditorium	Lauren Williams	An Introduction to Cluster Algebras

Participants

First Name	Last Name	Institution
Martina	Balagovic	University of York
Charlie	Beil	Simons Center for Geometry and Physics, Stony Brook University
Georgia	Benkart	University of Wisconsin
Olga	Bershteyn	Tallinn Technical University
Florian	Block	University of California
Ragnar-Olaf	Buchweitz	University of Toronto
Kenneth	Chan	MSRI - Mathematical Sciences Research Institute
Maria	Chlouveraki	Université Versailles/Saint Quentin-en-Yvelines
Hailong	Dao	University of Kansas
Galyna	Dobrovolska	University of Chicago
Emilie	Dufresne	MSRI - Mathematical Sciences Research Institute
Eleonore	Faber	University of Toronto
Banafsheh	Farang-Hariri	Instiut mathematique Elie Cartan
Jiarui	Fei	University of California
Sian	Fryer	University of Manchester
Emanuele	Ghedin	University of Oxford
Iain	Gordon	University of Edinburgh
Natalia	Gorfinkel	Moscow State University
Jessica	Hamm	Temple University
Pamela	Harris	University of Wisconsin
Johanna	Hennig	University of California, San Diego
Reiner	Hermann	Universität Bielefeld
Mee Seong	Im	University of Illinois at Urbana-Champaign
Andrew	Jaramillo	University of California
Jack	Jeffries	University of Utah
Lourdes	Juan	Texas Tech University
Tina	Kanstrup	Aarhus University
Gizem	Karaali	Pomona College
Youngsu	Kim	Purdue University
Ellen	Kirkman	Wake Forest University
Martina	Lanini	University of Melbourne
Gail	Letzter	NSA - National Security Agency
Graham	Leuschke	Syracuse University
Matilde	Marcolli	California Institute of Technology
Joanna	Meinel	Max-Planck-Institut für Mathematik
Claudia	Miller	Syracuse University
Maria	Monks	UC Berkeley Math Faculty
Manizheh	Nafari	University of Toledo
Van	Nguyen	Texas A & M University
Emily	Norton	Boston College
Bregje	Pauwels	University of California
Aleksandr	Pavlov	University of Toronto
Jeremy	Pecharich	MSRI - Mathematical Sciences Research Institute
Manuel	Reyes	Bowdoin College
Alice	Rizzardo	International School for Advanced Studies (SISSA/ISAS)
Natasha	Rozhkovskaya	Kansas State University
Steven	Sam	University of California
Antonio	Sartori	Universität Bonn
Lisa	Schneider	University of California

Liana	Sega	University of Missouri
Anne	Shepler	University of North Texas
Peri	Shereen	University of California
Susan	Sierra	University of Edinburgh
Gregory	Smith	Queen's University
Spela	Spenko	University of Ljubljana
Suresh	Srinivasamurthy	Kansas State University
Friederike	Steglich	Friedrich-Alexander-Universität Erlangen-Nürnberg
Amy	Stout	University of San Diego
Catharina	Stroppel	Universität Bonn
Ryo	Takahashi	Nagoya University
Mary Clair	Thompson	Auburn University
Matthew	Tucker-Simmons	University of California
Bolor	Turmunkh	University of Illinois at Urbana-Champaign
Michaela	Vancliff	University of Texas at Arlington
Monica	Vazirani	University of California
Padmini	Veerapen	University of Texas
Friedrich	Wagemann	Universite de Nantes
Chelsea	Walton	Massachusetts Institute of Technology
Linhong	Wang	Southeastern Louisiana University
Lauren	Williams	University of California, Berkeley
Sarah	Witherspoon	Texas A&M University
Emily	Witt	University of Minnesota Twin Cities
James	Zhang	University of Washington

Officially Registered Participant Information

Participants		**73**

Gender		**73**
Male	32.88%	24
Female	67.12%	49
Declined to state	0.00%	0

Ethnicity*		**73**
White	67.12%	49
Asian	17.81%	13
Hispanic	4.11%	3
Pacific Islander	0.00%	0
Black	1.37%	1
Native American	0.00%	0
Mixed	5.48%	4
Declined to state	4.11%	3

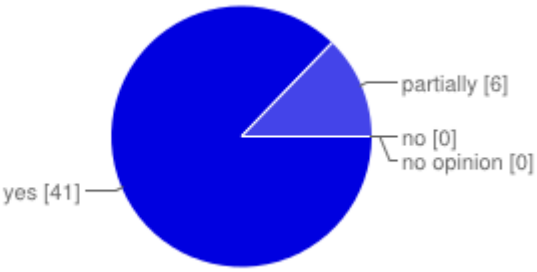
* ethnicity specifications are not exclusive

47 responses

Summary See complete responses

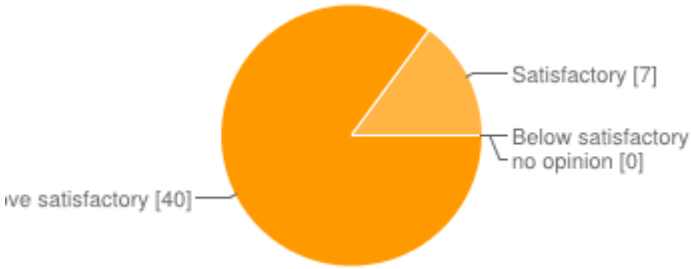
Topic presentation and organization

Did the various topics within the workshop integrate into a coherent picture?



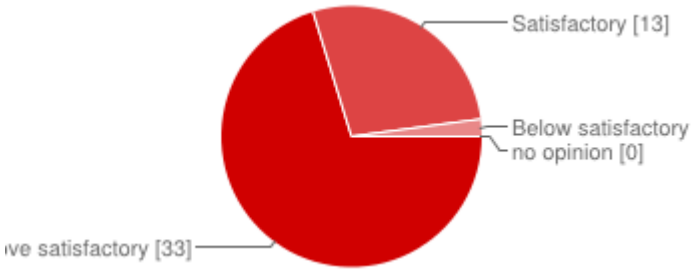
yes	**41**	87%
partially	**6**	13%
no	**0**	0%
no opinion	**0**	0%

Were the speakers generally clear and well organized in their presentation?



Above satisfactory	**40**	85%
Satisfactory	**7**	15%
Below satisfactory	**0**	0%
no opinion	**0**	0%

Was there adequate time between lectures for discussion?



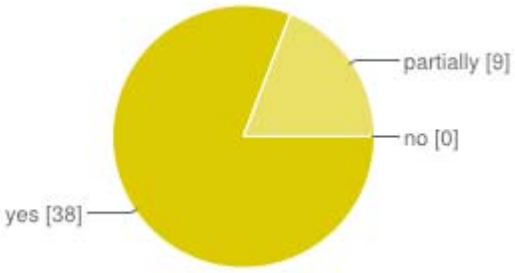
Above satisfactory	**33**	70%
Satisfactory	**13**	28%
Below satisfactory	**1**	2%
no opinion	**0**	0%

Additional comments on the topic presentation and organization

Excellent talks! Too many talks A bit more time for the posters would have been nice I really liked the poster

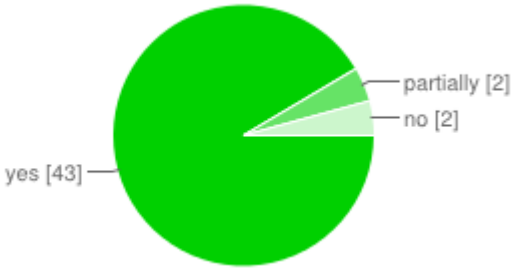
Personal assessment

Was your background adequate to access a reasonable portion of the material?



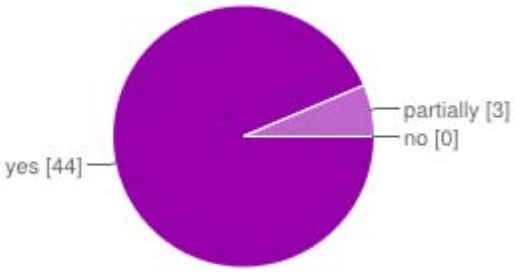
yes	**38**	81%
partially	**9**	19%
no	**0**	0%

Did the workshop increase your interest in the subject?



yes	**43**	91%
partially	**2**	4%
no	**2**	4%

Was the workshop worth your time and effort?

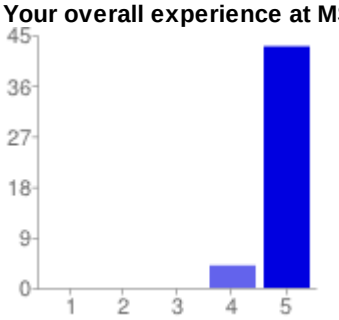


yes	**44**	94%
partially	**3**	6%
no	**0**	0%

Additional comments on your personal assessment

I am so happy I went! The poster previews gave participants a chance to "meet" the early-career mathematicians, and having 3-4 posters up at a time during the breaks gave the other participants a cha ...

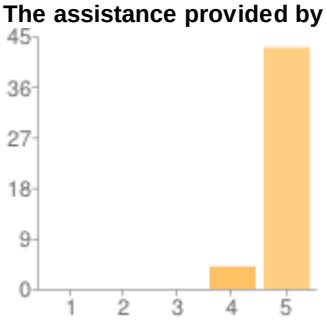
Your overall experience at MSRI



Not satisfactoryAbove satisfactory

1 -	Not satisfactory	**0**	0%
2		**0**	0%
3		**0**	0%
4		**4**	9%
5 -	Above satisfactory	**43**	91%

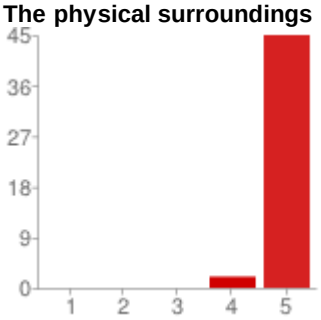
The assistance provided by MSRI staff



Not satisfactoryAbove satisfactory

1 -	Not satisfactory	**0**	0%
2		**0**	0%
3		**0**	0%
4		**4**	9%
5 -	Above satisfactory	**43**	91%

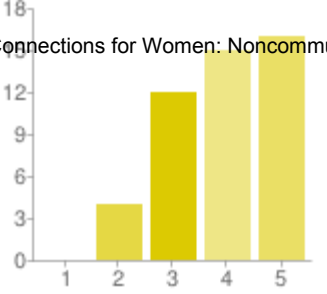
The physical surroundings



Not satisfactoryAbove satisfactory

1 -	Not satisfactory	**0**	0%
2		**0**	0%
3		**0**	0%
4		**2**	4%
5 -	Above satisfactory	**45**	96%

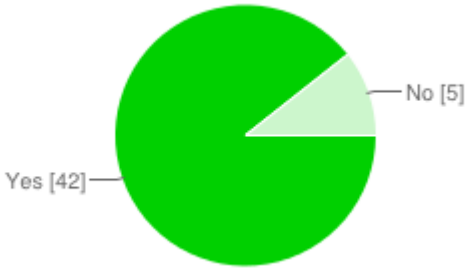
The food provided during the workshop



Not satisfactoryAbove satisfactory

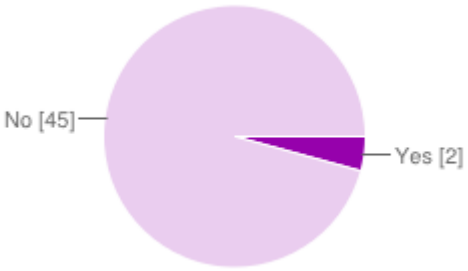
1 -	Not satisfactory	**0**	0%
2		**4**	9%
3		**12**	26%
4		**15**	32%
5 -	Above satisfactory	**16**	34%

Did you use MSRI's wireless network?



Yes	**42**	89%
No	**5**	11%

Did you experience any difficulties with the network?



Yes	**2**	4%
No	**45**	96%

If you did experience difficulties with the network, please explain:

The IP address assigned to my laptop seemed to change regularly; this made it difficult to SSH into my home university's servers, as their security protocol grants access to IP addresses individuall ...

Additional comments on the venue

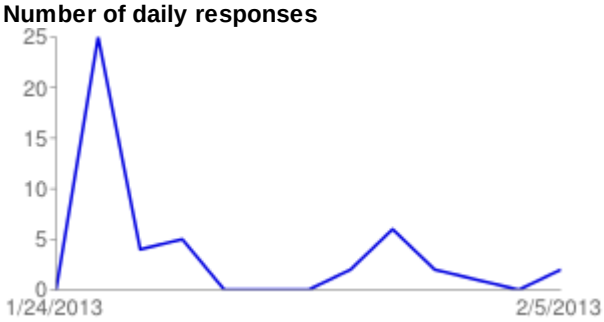
no cell phone signal The venue is very nice! It is just a bit difficult to reach MSRI coming from downtown Berkeley, (signposting for) a footpath would be great! Amazing and beautiful. I wish the cha ...

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 organizers did a wonderful job. Please have name tags without safety pins. Use clip-ons or lanyards instead. I spent time during tea breaks and meals meeting and talking to many experts in the are ...

Number of daily responses



Connections for Women Workshop
Noncommutative Algebraic Geometry and Representation Theory
January 24 & 25, 2013

Additional Survey Responses

Additional comments on the topic presentation and organization

- Excellent talks!
- Too many talks
- A bit more time for the posters would have been nice
- I really liked the poster preview 5-minute verbal presentations. They made the poster sessions more interesting for me.
- I like to have this workshop once a year.
- would it be online for later revisit as a vedio or audio file?
- Amazing program--the topics and the speakers were all wonderful.
- Speakers made a special effort to give background and to discuss possible open problems. There was a good selection of topics presented.
- Everything was very good.
- Appreciated time in between talks to meet with others and discuss mathematics; topics organized very well; excellent organization; ecstatic at the chance to meet young and senior women in mathematics!

Additional comments on your personal assessment

- I am so happy I went!
- The poster previews gave participants a chance to "meet" the early-career mathematicians, and having 3-4 posters up at a time during the breaks gave the other participants a chance to learn more about the work of these graduate students and postdocs. The panel gave good insights into strategies for starting and maintaining a successful career.
- I was a speaker, so not really the target audience
- Lot of new project idea arose as a result of this conference

Additional comments on the venue

- no cell phone signal
- The venue is very nice! It is just a bit difficult to reach MSRI coming from downtown Berkeley, (signposting for) a footpath would be great!
- Amazing and beautiful. I wish the chalkboards came a little lower--shorter speakers had a tough time reaching them.
- The busses could be more frequent
- Regarding the food: I requested information beforehand about availability of vegan food but heard nothing back; some labelling/information would be useful. The coffee is also generally a bit weak!
- Long erasers don't work nearly as well as the normal-size ones.
- The erasers in the Simons Halll are a problem: By the last talk of the day the blackboards are so covered with chalk dust that one can hardly read what is written onto them.

We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.

- The organizers did a wonderful job.
- Please have name tags without safety pins. Use clip-ons or lanyards instead.

- I spent time during tea breaks and meals meeting and talking to many experts in the area. I have skimmed and/or read various experts' papers before coming to MSRI and discussing their results with them helped me to understand their papers better. Not only that, I have spent time with people in the evenings and we discussed how Cherednik algebras and spherical subalgebras are connected to quantum Hamiltonian reductions. I had many other meaningful mathematics discussions all throughout my time here at MSRI. It was good meeting familiar faces and discussing mathematics with new faces.
- Great workshop!

Mathematical Sciences Research Institute

Introductory Workshop:
Noncommutative Algebraic Geometry and Representation Theory

January 28 to February 1, 2013

MSRI, Berkeley, CA, USA

Organizers:

Michael Artin (Massachusetts Institute of Technology - MIT)

Michel Van den Bergh* (Vrije Universiteit Brussel)

Toby Stafford (University of Manchester)

INTRODUCTORY WORKSHOP ON "NONCOMMUTATIVE ALGEBRAIC GEOMETRY AND REPRESENTATION THEORY".

1. Organizers

- Michael Artin (Massachusetts Institute of Technology - MIT).
- Toby Stafford (University of Manchester).
- Michel Van den Bergh (Fund for Scientific Research Flanders).

2. Scientific description

Just as commutative algebra is closely related to algebraic geometry, experience has taught us that many classes of noncommutative algebras can be best understood by attaching some kind of geometric intuition to them. However, unlike the commutative case there is as yet no uniform geometric way to think about noncommutative algebras.

The workshop was part of the MSRI program "Non-commutative Algebraic Geometry and Representation Theory" which has focussed on the various especially useful geometric models for noncommutative algebras that have appeared in recent years, as well as their interactions.

The main purpose of the introductory workshop was to serve as the foundation for this parent program. Thus the workshop provided a number of short lecture series to introduce postdocs, graduate students and non-experts to some of the major themes of the program. A number of lectures were direct introductions to specific topics but other lectures were broader in scope and provided background information.

As many participants to our workshop also attended the preceding two day "Connection for Women" workshop we made sure that the programs of the two workshops were well integrated. In a number of cases the CfW lectures served as broad introductions to the more in depth lectures of our workshop.

3. Presentations

The subjects covered in our workshop were

- Hochschild cohomology.
- Growth Functions of Infinite Dimensional Algebras
- Noncommutative algebraic geometry
- Derived Categories
- D-Module Theory
- Deformation-Quantization
- Noncommutative Resolutions of Singularities
- Noncommutative motives
- Symplectic Reflection Algebras

With hindsight we can say this was an appealing mix of topics. The workshop has attracted many participants working in related areas, many in early stages of their carreer

In general we have organized the lecture series in such a way that there was a natural flow of ideas going from one lecture series to the next. For example the topic "Derived categories" was scheduled early on since it is relevant for many other topics.

Our choice for the first lecture of the workshop fell on Ragnar Buchweitz since he is known to be an excellent speaker. He didn't fail and presented a nice lecture series on Hochschild cohomology, which is roughly speaking the basis for non-commutative calculus. Buchweitz stressed in particular the relation with the center of the derived category and the still unsolved problems in this area.

Jason Bell introduced the audience to the notion of growth functions. These are important since they provide the foundation for dimension theory for non-commutative algebras. He surveyed recent progress and discussed in particular Smoktunovicz's[1] beautiful work. He also touched on several famous unsolved problems among which was Michael Artin's conjectural classification of division algebras of transcendence degree two, one of the motivating problems in noncommutative algebraic geometry.

Subsequently Paul Smith introduced the subject of noncommutative algebraic geometry (NCALG) itself. Although self contained his lectures could be viewed as following up on overview lectures on various aspects of NCALG during the CfW workshop by Vancliff and Zhang.

Next Amnon Yekutieli started a clear and concise introduction to derived categories, with a main emphasis on Grothendieck duality. Grothendieck duality is one of the few features of commutative algebraic geometry that can be transferred virtually unmodified to the non-commutative case.

Since deformation quantization provides important examples of noncommutative algebras which have geometric intuition attached to them it was important to have a lecture series devoted to this subject. It was Vasily Dolgushev's task to explain this difficult material to the audience which he did admirably. After explaining the usual Maurer-Cartan formalism and stating Kontsevich celebrated formality formula (which basically started the subject) he talked about Willwacher's spectacular recent work on graph complexes and the Grothedieck-Teichmuller Lie algebra. Despite enormous progress some key conjectures remain open though.

Before a fully packed room (obviously many non-workshop participants had sneaked in) David Ben-Zvi gave a beautiful series of lectures on D-modules. He was able to cover an enormous amount of ground (essentially covering all major theorems) without sacrificing clarity. Nice pictures and intuitive explanations made the material accessible to non-experts. This was clear from the enthousiastic comments which could be heard after the lectures.

[1]Agatha Smoktunovicz was supposed to be one of the key participarts in our NAGRT program but unfortunately practical matters made it impossible for her to attend.

It was noticed first by physicists and later also by mathematicians that some (commutative) singularities have a resolution which is non-commutative. Expanding on his lecture in the CfW workshop Graham Leuschke explained the concept of a non-commutative resolution in detail, in particular why its definition is the way it is. He gave many examples of noncommutative resolutions "in the real world".

Mathilde Marcolli gave a beautiful survey of her joint work with Tabuada on noncommutative motives. Noncommutative motives were introduced by Kontsevich in a somewhat informal way. The theory was put on firm footing in the PhD thesis of Keller's student Tabuada. Marcolli illustrated the similarities between commutative motives and noncommutative motives, in particular highlighting noncommutative analogues of Grothendieck's standard conjectures. Intriguingly it turns out that it is not known if truly noncommutative motives exist. In other words it might be that all noncommutative motives are actually commutative, but that would be a sensational result in itself.

The last series of the conference was a survey by Maria Chlouveraki on symplectic reflection algebras. These represent concrete examples of noncommutative algebras where many of the techniques presented in the earlier lectures can be employed. They are deformations of skew group rings over polynomial algebras, they are often non-commutative resolutions, in other cases they can be studies using $\mathbb{Z}$-algebra as introduced in noncommutative algebraic geometry, the theory makes extensive use of D-modules etc.... Again Maria Chlouveraki's lectures followed up on a broad survey given by Iain Gordon during the CfW workshop.

Organizers

First Name	Last Name	Institution
Michael	Artin	Massachusetts Institute of Technology
Michel	Van den Bergh	Vrije Universiteit Brussels
Toby	Stafford	University of Manchester

Speakers

First Name	Last Name	Institution
Jason	Bell	University of Waterloo
David	Ben-Zvi	University of Texas
Ragnar-Olaf	Buchweitz	University of Toronto
Maria	Chlouveraki	Université de Versailles
Vasily	Dolgushev	Temple University
Graham	Leuschke	Syracuse University
Matilde	Marcolli	California Institute of Technology
Sholto	Smith	University of Washington
Amnon	Yekutieli	Ben Gurion University of the Negev

Introductory Workshop: Noncommutative Algebraic Geometry and Representation Theory

January 28 - February 1, 2013

Schedule

Monday, January 28, 2013			
9:00AM - 9:15AM	Simons Auditorium		Welcome
9:15AM - 10:30AM	Simons Auditorium	Ragnar-Olaf Buchweitz	Variations on Hochschild cohomology I
10:30 AM - 11:00 AM	Atrium		Tea
11:00AM - 12:15PM	Simons Auditorium	Jason Bell	Introduction to Growth and growth functions I
12:15PM - 2:00PM	Atrium		Lunch
2:00PM - 3:15PM	Simons Auditorium	Paul Smith	Introduction to non-commutative algebraic geometry I
3:15PM - 3:45PM	Atrium		Tea
3:45PM - 5:00PM	Simons Auditorium	Amnon Yekutieli	Introduction to Derived Categories I

Tuesday, January 29, 2013			
9:15AM - 10:30AM	Simons Auditorium	Ragnar-Olaf Buchweitz	Variations on Hochschild cohomology II
10:30AM - 11:00AM	Atrium		Tea
11:00AM - 12:15PM	Simons Auditorium	Amnon Yekutieli	Introduction to Derived Categories II
12:15PM - 2:00PM	Smons Auditorium		Lunch
2:00PM - 3:15PM	Smons Auditorium	Paul Smith	Introduction to non-commutative algebraic geometry II
3:15PM - 3:45PM	Atrium		Tea
3:45PM - 4:30PM	Smons Auditorium	Vasiliy Dolgushev	Deformation Quantization I
4:30 PM - 6:20 PM	Atrium		Reception

Wednesday, January 30, 2013			
9:15AM - 10:30AM	Simons Auditorium	David Ben-Zvi	Introduction to D-modules I
10:30AM - 11:00AM	Atrium		Tea
11:00AM - 12:15PM	Smons Auditorium	Vasiliy Dolgushev	Deformation Quantization II

Thursday, January 31, 2013			
9:15AM - 10:30AM	Simons Auditorium	David Ben-Zvi	Introduction to D-modules II
10:30AM - 11:00AM	Atrium		Tea
11:00AM - 12:15PM	Simons Auditorium	Graham Leuschke	Non-commutative desingularizations and MCM modules I
12:15PM - 2:00PM	Atrium		Lunch
2:00PM - 3:15PM	Simons Auditorium	Matilde Marcolli	Noncommutative motives and their applications I
3:15PM - 3:45PM	Atrium		Tea
3:45PM - 5:00PM	Simons Auditorium	Maria Chlouveraki	Symplectic reflection algebras I

Friday, February 01, 2013			
9:15AM - 10:30AM	Simons Auditorium	Jason Bell	Introduction to Growth and growth functions II
10:30AM - 11:00AM	Atrium		Tea
11:00AM - 12:15PM	Simons Auditorium	Matilde Marcolli	Noncommutative motives and their applications II
12:15PM - 2:00PM	Atrium		Lunch
2:00PM - 3:15PM	Simons Auditorium	Graham Leuschke	Non-commutative desingularizations and MCM modules II
3:15PM - 3:45PM	Atrium		Tea
3:45PM - 5:00PM	Simons Auditorium	Maria Chlouveraki	Symplectic reflection algebras II

Speakers

First Name	Last Name	Institution
Katie	Ansaldi	University of Notre Dame
Mike	Artin	Massachusetts Institute of Technology
Martina	Balagovic	University of York
Sean	Ballentine	University of Maryland
Helene	Barcelo	MSRI - Mathematical Sciences Research Institute
Hanno	Becker	Universität Bonn
Charlie	Beil	Simons Center for Geometry and Physics, Stony Brook University
Jason	Bell	University of Waterloo
Georgia	Benkart	University of Wisconsin
David	Benson	University of Aberdeen
David	Ben-Zvi	University of Texas
Olga	Bershteyn	Tallinn Technical University
Bryan	Bischof	Kansas State University
Mats	Boij	Royal Institute of Technology (KTH)
Ragnar-Olaf	Buchweitz	University of Toronto
Thomas	Cassidy	Bucknell University
Kenneth	Chan	University of Washington
Harrison	Chen	UC Berkeley Math Faculty
Maria	Chlouveraki	Université de Versailles
Lars	Christensen	Texas Tech University
Lee	Cohn	University of Texas
William	Crawley-Boevey	University of Leeds
Steven	Cutkosky	University of Missouri
Hailong	Dao	University of Kansas
Galyna	Dobrovolska	University of Chicago
Vasily	Dolgushev	Temple University
Emilie	Dufresne	MSRI - Mathematical Sciences Research Institute
David	Dynerman	University of Wisconsin
Michael	Ehrig	Universität Bonn
Eleonore	Faber	University of Toronto
banafsheh	farang-hariri	Université de Nancy I (Henri Poincaré)
Jiarui	Fei	University of California
Sian	Fryer	University of Manchester
Jason	Gaddis	University of Wisconsin-Milwaukee
Iordan	Ganev	University of Texas
Emanuele	Ghedin	University of Oxford
Kenneth	Goodearl	University of California
Reiner	Hermann	Universität Bielefeld
Justin	Hilburn	University of Oregon
Alexander	Hoffnung	Temple University
Cody	Holdaway	University of Washington
Jen-Chieh	Hsiao	Purdue University
Mee Seong	Im	University of Illinois at Urbana-Champaign
Alexander	Ivanov	St. Petersburg State University
Srikanth	Iyengar	University of Nebraska
Andrew	Jaramillo	University of California
Jack	Jeffries	University of Utah
Theo	Johnson-Freyd	University of California
Tina	Kanstrup	Aarhus University

Youngsu	Kim	Purdue University
Ryan	Kinser	Northeastern University
Ellen	Kirkman	Wake Forest University
Martina	Lanini	University of Melbourne
Gail	Letzter	NSA - National Security Agency
Graham	Leuschke	Syracuse University
Matilde	Marcolli	California Institute of Technology
Cristian	Martinez	University of Utah
Joanna	Meinel	Max-Planck-Institut für Mathematik
Andrew	Misseldine	Brigham Young University
Andrew	Morrison	ETH Zürich
zahra	mozafar	Isfahan University of Technology
Daniel	Murfet	University of California
Manizheh	Nafari	University of Toledo
Thomas	Nevins	University of Illinois at Urbana-Champaign
Van	Nguyen	Texas A & M University
Emily	Norton	Boston College
Adam	Nyman	Western Washington University
Masahiro	Ohno	University of Electro-Communications
Bregje	Pauwels	University of California
Aleksandr	Pavlov	University of Toronto
Jeremy	Pecharich	MSRI - Mathematical Sciences Research Institute
Alexander	Polishchuk	University of Oregon
guillaume	pouchin	University of Edinburgh
Nicholas	Proudfoot	University of Oregon
Brent	Pym	University of Toronto
You	Qi	Columbia University
Theo	Raedschelders	Vrije Universiteit Brussel
Claudiu	Raicu	Princeton University
Ali	Rajaei	Tarbiat Modares
Manuel	Reyes	Bowdoin College
Alice	Rizzardo	International School for Advanced Studies (SISSA/ISAS)
Ilan	Roth	UC Berkeley Math Faculty
Natasha	Rozhkovskaya	Kansas State University
Steven	Sam	University of California
Antonio	Sartori	Universität Bonn
Ian	Shipman	University of Michigan
Gautam	Sisodia	University of Washington
Sholto	Smith	University of Washington
Gregory	Smith	Queen's University
Elaine	So	University of Pennsylvania
Spela	Spenko	University of Ljubljana
Suresh	Srinivasamurthy	Kansas State University
Hema	Srinivasan	University of Missouri
Toby	Stafford	University of Manchester
Friederike	Steglich	Friedrich-Alexander-Universität Erlangen-Nürnberg
Greg	Stevenson	Universität Bielefeld
Catharina	Stroppel	University of Chicago
Peter	Symonds	MSRI - Mathematical Sciences Research Institute
Goncalo	Tabuada	Massachusetts Institute of Technology
Hiroyuki	Terakawa	Tsuru University

Kevin	Tucker	Princeton University
Matthew	Tucker-Simmons	University of California
Michel	Van den Bergh	Limburgs Universitair Centrum
Michaela	Vancliff	University of Texas at Arlington
monica	vazirani	University of California
Padmini	Veerapen	University of Texas
Friedrich	Wagemann	Universite de Nantes
Chelsea	Walton	Massachusetts Institute of Technology
Linhong	Wang	Southeastern Louisiana University
Ben	Webster	Northeastern University
Zhaoting	Wei	University of Pennsylvania
Jerzy	Weyman	Northeastern University
Jason	Williams	Spanish Town High
Sarah	Witherspoon	Texas A&M University
Emily	Witt	University of Minnesota Twin Cities
Amnon	Yekutieli	Ben Gurion University of the Negev
Shilin	Yu	Pennsylvania State University

Officially Registered Participant Information

Participants		**117**

Gender		**117**
Male	67.52%	79
Female	30.77%	36
Declined to state	1.71%	2

Ethnicity*		**117**
White	68.38%	80
Asian	18.80%	22
Hispanic	1.71%	2
Pacific Islander	0.00%	0
Black	0.85%	1
Native American	0.00%	0
Mixed	1.71%	2
Declined to state	8.55%	10

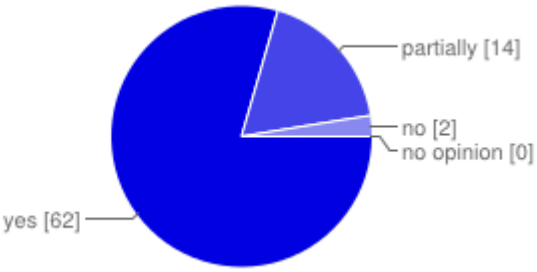
* ethnicity specifications are not exclusive

78 responses

Summary See complete responses

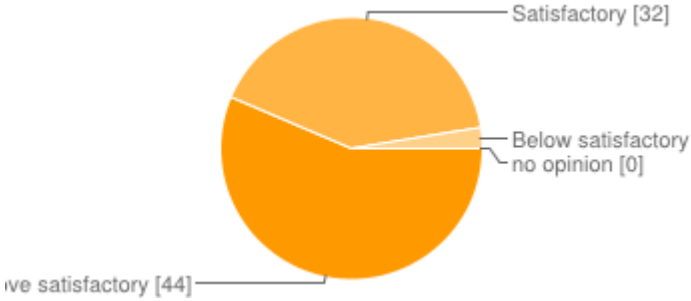
Topic presentation and organization

Did the various topics within the workshop integrate into a coherent picture?



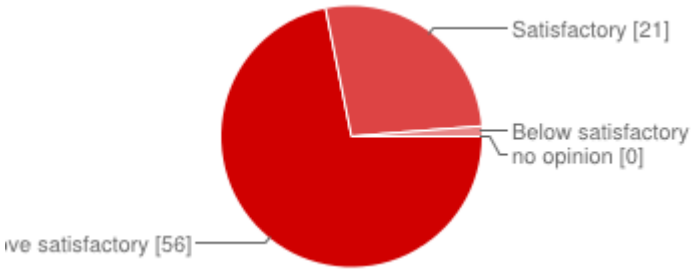
yes	**62**	79%
partially	**14**	18%
no	**2**	3%
no opinion	**0**	0%

Were the speakers generally clear and well organized in their presentation?



Above satisfactory	**44**	56%
Satisfactory	**32**	41%
Below satisfactory	**2**	3%
no opinion	**0**	0%

Was there adequate time between lectures for discussion?



Above satisfactory	**56**	72%
Satisfactory	**21**	27%
Below satisfactory	**1**	1%
no opinion	**0**	0%

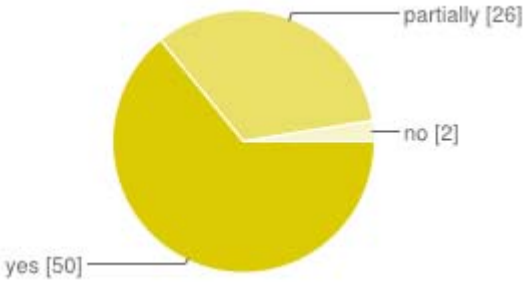
Additional comments on the topic presentation and organization

Idea with extra shuttle up and down the hill where MSRI stands was

excellent there was a certain amount of unevenness in the level at which the talks were pitched. Also the schedule (60min+15min) wa ...

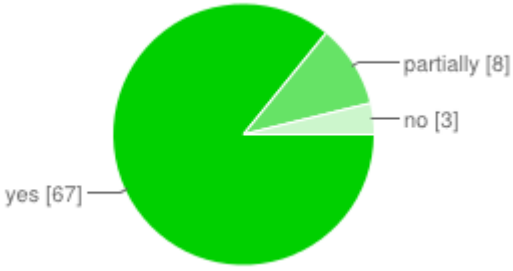
Personal assessment

Was your background adequate to access a reasonable portion of the material?



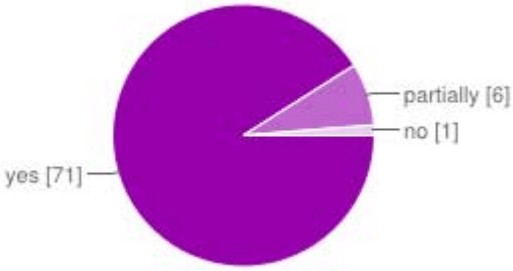
yes	**50**	64%
partially	**26**	33%
no	**2**	3%

Did the workshop increase your interest in the subject?



yes	**67**	86%
partially	**8**	10%
no	**3**	4%

Was the workshop worth your time and effort?

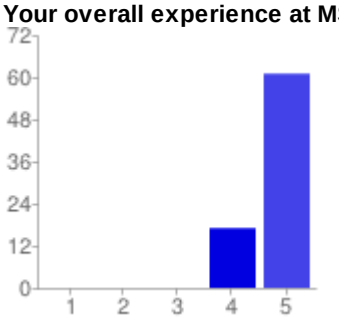


yes	**71**	91%
partially	**6**	8%
no	**1**	1%

Additional comments on your personal assessment

There should be a graduate student specific workshop there were several talks concerning the theme of my current investigations Many of the lectures were well pitched to a graduate student level, but ...

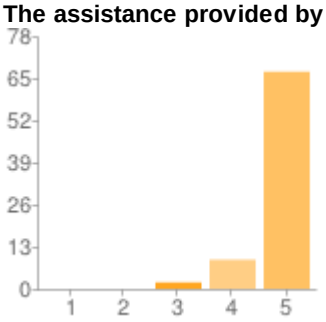
Your overall experience at MSRI



Not satisfactoryAbove satisfactory

1 -	Not satisfactory	**0**	0%
2		**0**	0%
3		**0**	0%
4		**17**	22%
5 -	Above satisfactory	**61**	78%

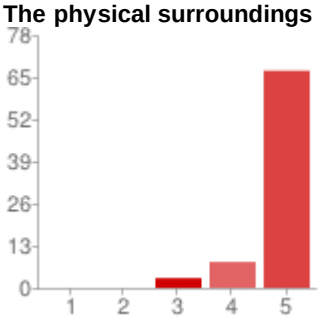
The assistance provided by MSRI staff



Not satisfactoryAbove satisfactory

1 -	Not satisfactory	**0**	0%
2		**0**	0%
3		**2**	3%
4		**9**	12%
5 -	Above satisfactory	**67**	86%

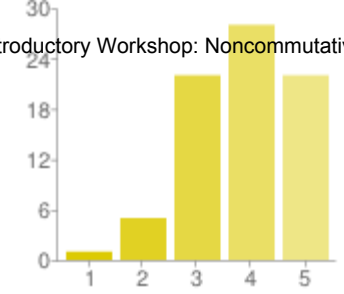
The physical surroundings



Not satisfactoryAbove satisfactory

1 -	Not satisfactory	**0**	0%
2		**0**	0%
3		**3**	4%
4		**8**	10%
5 -	Above satisfactory	**67**	86%

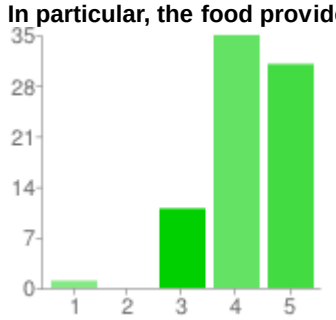
The food provided during the workshop



Not satisfactoryAbove satisfactory

1 -	Not satisfactory	**1**	1%
2		**5**	6%
3		**22**	28%
4		**28**	36%
5 -	Above satisfactory	**22**	28%

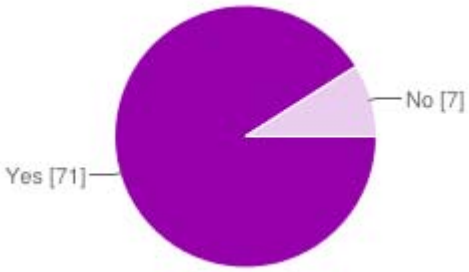
In particular, the food provided during the reception



Not satisfactoryAbove satisfactory

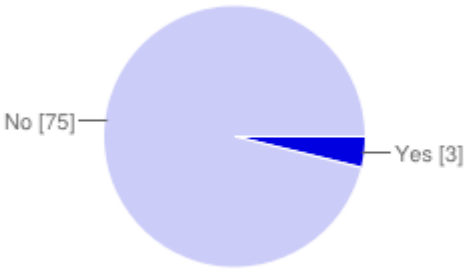
1 -	Not satisfactory	**1**	1%
2		**0**	0%
3		**11**	14%
4		**35**	45%
5 -	Above satisfactory	**31**	40%

Did you use MSRI's wireless network?



Yes	**71**	91%
No	**7**	9%

Did you experience any difficulties with the network?



Yes	**3**	4%
No	**75**	96%

If you did experience difficulties with the network, please explain:

in the building or near the building, sometimes there was no connection. food service could be improved

Additional comments on the venue

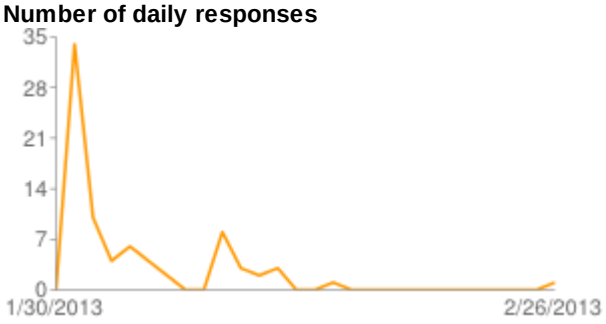
It was nice to have a charter bus. I found atmosphere in MSRI absolutely fantastic! Again, food could have done with labelling: vegetarian, vegan, food allergies/intolerances, etc. the temperature in t ...

Thank you for completing this survey

We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.

Very inspiring! suggestions: (1) name tags with clips or lanyards rather than pins (2) small erasers, since the large ones are unwieldy and when they are old and bent they don't erase well If the work ...

Number of daily responses



Introductory Workshop
Noncommutative Algebraic Geometry and Representation Theory
January 28 to February 1, 2013

Additional Survey Responses

Additional comments on the topic presentation and organization

- Idea with extra shuttle up and down the hill where MSRI stands was excellent
- there was a certain amount of unevenness in the level at which the talks were pitched. Also the schedule (60min+15min) was a bit confusing, even to some of the speakers and session chairs
- I would say that some lectures were not on an introductory level
- One person's "introductory" material can be anothers "advanced" report.
- Topics were very intertesting and were nicely presented with a digestible amount of material.
- Breaks between talks were too long
- nice selection
- The topic presentations were very good; they gave a quick overview of the subject. Tea breaks and meals were definitely good times to talk to various people about the lectures and about related mathematics that I have been thinking about.
- The starting time was quite early in the morning, compared to most conferences I've been to. I would have preferred to start a half hour later or so.
- The time between lectures was too much
- Great!

Additional comments on your personal assessment

- There should be a graduate student specific workshop
- there were several talks concerning the theme of my current investigations
- Many of the lectures were well pitched to a graduate student level, but some started at far too high a level for what should have been an introductory course.
- It was slightly more out of my field than expected
- i had several conversations during the workshop which were very valuable to me mathematically. i also enjoyed just meeting lots of other people and being inspired by the energy and the ideas around. thank you for this wonderful opportunity.
- nice overviews and also high quality

Additional comments on the venue

- It was nice to have a charter bus.
- I found atmosphere in MSRI absolutely fantastic!
- Again, food could have done with labelling: vegetarian, vegan, food allergies/intolerances, etc.
- the temperature in the lecture hall was either much too cold or much too warm.
- The temperature in the Simon's Auditorium left a lot to be desired. On Monday, it was far too cold, and by Friday it was far too hot. Perhaps the thermostat needs to be changed or relocated?
- Please use name tags without safety pins. The blackboards in Simons hall get very dirty towards the end of a session. Perhaps better erasers could help?
- I didn't attend the reception.
- i'd just like to compliment the lunch caterers on their clam chowder (friday). it was delicious. and, the sunsets from msri are phenomenal.
- Mick was a great assistant throughout the workshop. Thank you.

We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.

- Very inspiring!
- suggestions: (1) name tags with clips or lanyards rather than pins (2) small erasers, since the large ones are unwieldy and when they are old and bent they don't erase well
- If the workshop was during summer, it was better.
- I found the food better during the second half of the week. (I liked this caterer better.)
- I'm largely satisfied with the workshop. I found lectures and speakers on the last three days more inspiring and enlightening than those during the first two days.
- Thank you very much!

MSRI Mathematical Sciences Research Institute

Interactions between Noncommutative Algebra, Representation Theory, and Algebraic Geometry

April 8 to April 12, 2013

MSRI, Berkeley, CA, USA

Organizers:

Victor Ginzburg (University of Chicago)

Iain Gordon (University of Edinburgh, UK)

Markus Reineke (Bergische Universität Wuppertal, Germany)

Catharina Stroppel* (University of Bonn, Germany)

James Zhang (University of Washington)

Report on the MSRI workshop "Interactions between Noncommutative Algebra, Representation Theory, and Algebraic Geometry" April 08, 2013 – April 12, 2013

October 25, 2013

Organizers

- Victor Ginzburg (University of Chicago, USA)
- Iain Gordon (University of Edinburgh, UK)
- Markus Reineke (Bergische Universität Wuppertal, Germany)
- Catharina Stroppel (University of Bonn, Germany)
- James Zhang (University of Washington, USA)

1. Scientific description

Noncommutative algebraic geometry is a rapidly developing field with deep connections to noncommutative algebra, representation theory, algebraic geometry, Lie theory, noncommutative differential geometry and mathematical physics. During the last 25 years, many remarkable achievements have been accomplished in this area by leading mathematicians such as Michael Artin, John Tate, Michel Van den Bergh, Maxim Kontsevich, Toby Stafford, Alexey Bondal, Dmitri Orlov and others. To promote recent significant developments, the MSRI hosted a half-year program on "Noncommutative Algebraic Geometry and Representation Theory" (NAGRT) from January 2013 to May 2013.

This workshop is one of the main workshops in the NAGRT program. As suggested by the title, it emphasizes interactions between related areas and encourages experts from all over the world to exchange new ideas and to work together. In recent years there have been increasing interactions between noncommutative algebraic geometry and other subjects. The workshop reflects this trend by inviting researchers from different and intimately connected research areas.

During the last couple of years, a group of mathematicians, including many young mathematician, have made important contributions to the subject, and several extremely difficult and long-standing open questions have been settled

using ideas from noncommutative algebraic geometry. Here are a few examples. Susan Sierra and Chelsea Walton proved that the universal enveloping algebra of the Witt algebra is not noetherian, solving a 23-year-old open problem of Lance Small and Carolyn Dean. Their elegant proof uses new ideas from noncommutative algebraic geometry. Sierra-Walton's result is a great achievement in this area. Sierra and Daniel Rogalski solved an open question by providing an example of a noetherian Koszul algebra of global dimension 4 that fails to be Artin-Schelter regular. We would like to mention another excellent result in a slightly different research direction: Pavel Etingof and Walton proved that if a semisimple Hopf algebra acts inner-faithfully on a commutative domain, then the Hopf algebra must be a group algebra, answering a question of Ellen Kirkman and James Kuzmanovich. This surprising result suggests that "finite and noncommutative" quantum groups can only act on noncommutative spaces. Last year, Jason Bell and Rogalski proved that, under some mild hypotheses, division algebras not satisfying a polynomial identity contain the free algebra of two generators, which solves a conjecture of Stafford and Leonid Makar-Limanov. Very recently, Milen Yakimov and Ken Goodearl resolved three open questions in (quantum) cluster algebras. The first one is Berenstein-Zelevinsky conjecture (2005) that states that the quantized coordinate rings of double Bruhat cells in any finite dimensional simple Lie groups admit explicit quantum cluster algebra structures. Secondly Yakimov-Goodearl showed that the upper quantum cluster algebra coincides with the quantum cluster algebra. Thirdly, by using Poisson structures on polynomial algebras and the semiclassical limits of quantum nilpotent algebras, they proved that the upper cluster algebras of Berenstein-Fomin-Zelevinsky for double Bruhat cells are equal to the corresponding cluster algebras. Their work is one of the best achievements in the study of cluster and quantum cluster algebra during the last of couple years. Yakimov also proved two other conjectures. He settled the Launois-Lenagan conjecture (2005) and the Andruskiewitsch-Dumas conjecture (2004) affirmatively, both of which compute the full automorphism group of a family of quantized algebras.

The aim of the workshop is to present most fascinating recent achievements and to promote new research directions and open questions in noncommutative algebraic geometry, representations theory and neighboring areas. The workshop covers many important topics such as noncommutative projective geometry, cluster algebras and quantum cluster algebras, noncommutative resolutions of singularities, symplectic reflection algebras, noetherian Hopf algebras, Koszul algebras, categorifications, Iwasawa algebras, noncommutative motives, Hilbert schemes, D-module theory, deformation quantization and so on. Several talks offered introductions and surveys to some newly developed research topics. The organizers had made their best efforts to encourage young mathematicians and mathematicians from underrepresented groups to participate in the workshop. As a result, mathematicians from underrepresented groups were more heavily represented at our workshop than at typical conferences in the same subject. Further, a large group of graduate students and postdoctoral fellows participated in the workshop.

2. Highlights of presentations

The workshop consists of a collection of excellent lectures centered at noncommutative algebraic geometry, representation theory and their interactions with algebraic geometry and noncommutative algebras.

There are several talks about noncommutative algebraic geometry. Van den Bergh's lecture on derived categories of Grassmannians in arbitrary characteristic was based on his joint work with Ragnar-Olaf Buchweitz and Graham Leuschke. Van den Bergh is the inventor of the noncommutative crepant resolution (NCCR), which has a great impact in research in both commutative algebraic geometry and noncommutative algebraic geometry. In Colin Ingalls' talk, he proved that the logarithmic centers of NCCRs are Kawamata log terminal. This is an example of interactions between commutative and noncommutative algebraic geometry. Raf Bocklandt gave a lecture on noncommutative projective geometry through the looking glass. Sierra talked about her joint work with Walton on their solution of non-noetherian property of the universal enveloping algebra of the Witt algebra. Rogalski talked about the classification of subalgebras of 3-dimensional Sklyanin algebras and associated noncommutative projective surfaces. Daniel Murfet had lectured on Clifford actions on DG categories. The study of noncommutative projective surfaces or connected graded domains of Gelfand-Kirillov dimension three produces a large family of new noncommutative algebras and introduces several effective techniques and solves several long-standing open questions.

A few very interesting lectures discussed different aspects of noncommutative algebras. Sarah Witherspoon's lecture was on Poincare-Birkhoff-Witt Theorems and group actions in positive characteristic. Ken Brown's lecture was about noncommutative unipotent groups and infinite dimensional Hopf algebras. There were two talks about cluster algebras and quantum cluster algebras, one by Hiraku Nakajima and the other by Yakimov. Yakimov's talk was based on his joint work with Ken Goodearl in which they resolved three open questions in (quantum) cluster algebras. The speakers reiterated the connection between noncommutative algebra and noncommutative algebraic geometry.

There were quite a few important talks in representation theory with its connection to noncommutative algebraic geometry. David Nadler talked about elliptic character sheaves. Peng Shan talked about categorifications and rational Cherednik algebras. Gwyn Bellamy's results were on vanishing cycles for mirabolic D-modules. Buchweitz talked about the McKay Correspondence for anti-canonically embedded Fano Varieties. Konstantin Ardakov's lecture was on the localisation of p-adic representations of p-adic Lie groups. Goncalo Tabuada was talking about noncommutative motives. Alexei Oblomkov's topic was on cohomology of the elliptic affine Springer fibres and the rational Cherednik algebras. Ivan Loseu talked about the classification of Procesi bundles and the resolution of symplectic quotient singularities and Roman Bezrukavnikov talked about noncommutative Hilbert schemes and stable pairs on elliptic curves. These talks collectively gave an overview of the recent developments in representation theory using the geometric approach.

Organizers

First Name	Last Name	Institution
Victor	Ginzburg	University of Chicago
Iain	Gordon	University of Edinburgh, UK
Markus	Reineke	Bergische Universität Wuppertal, Germany
Catharina	Stroppel	University of Bonn, Germany
James	Zhang	University of Washington

Speakers

First Name	Last Name	Institution
Konstantin	Ardakov	School of Mathematical Sciences, Queen Mary, University of London
Gwyn	Bellamy	University of Glasgow
Roman	Bezrukavnikov	Massachusetts Institute of Technology
Raf	Bocklandt	University of Amsterdam
Ken	Brown	University of Glasgow
Ragnar-Olaf	Buchweitz	University of Toronto
Colin	Ingalls	University of New Brunswick
Ivan	Losev	Northeastern University
Daniel	Murfet	University of California
Hiraku	Nakajima	Kyoto University
Alexei	Oblomkov	University of Massachusetts, Amherst
daniel	rogalski	University of California, San Diego
Peng	Shan	Massachusetts Institute of Technology
Susan	Sierra	University of Edinburgh
Sarah	Witherspoon	Texas A&M University
Milen	Yakimov	Louisiana State University

Mathematical Sciences Research Institute

Interactions between Noncommutative Algebra, Representation Theory, and Algebraic Geometry

April 8 to April 12, 2013

Schedule

Monday, April 8, 2013			
9:15 AM - 9:30 AM	Simons Auditorium		Welcome
9:30 AM - 10:30 AM	Simons Auditorium	Sarah Witherspoon	Poincare-Birkhoff-Witt Theorems and group actions in positive characteristic
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00 PM	Simons Auditorium	Milen Yakimov	Quantum cluster algebra structures on quantum nilpotent algebras
12:00 - 2:00 PM	Atrium		Lunch
2:00 - 3:00 PM	Simons Auditorium	Colin Ingalls	Centres of NCCRs are KLT
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:30 PM	Simons Auditorium	Hiraku Nakajima	Cluster algebras and singular supports of perverse sheaves

Tuesday, April 9, 2013			
9:30 AM - 10:30 AM	Simons Auditorium	Raf Bocklandt	Noncommutative projective geometry through the looking glass
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00 PM	Simons Auditorium	Daniel Murfet	Clifford actions on DG categories
12:00 - 2:00 PM	Atrium		Lunch
2:00 - 3:00 PM	Simons Auditorium	Susan Sierra	The enveloping algebra of the Witt algebra is not noetherian
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:30 PM	Simons Auditorium	Daniel Rogalski	Classifying Orders in the Sklyanin Algebra
4:30 PM - 6:20 PM	Atrium		Reception

Wednesday, April 10, 2013			
9:00 AM - 10:00 AM	Simons Auditorium	Ivan Loseu	On Procesi bundles
10:00 AM - 10:30 AM	Atrium		Tea
10:30 AM - 11:30 AM	Simons Auditorium	Ken Brown	Noncommutative unipotent groups
11:30 AM - 12:30 PM	Simons Auditorium	Michel Van den Bergh	Derived categories of Grassmannians in arbitrary characteristic

Thursday, April 11, 2013			
9:30 AM - 10:30 AM	Simons Auditorium	David Nadler	Elliptic character sheaves
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00 PM	Simons Auditorium	Peng Shan	Categorifications and Rational Cherednik Algebras
12:00 - 2:00 PM	Atrium		Lunch
2:00 - 3:00 PM	Simons Auditorium	Gwyn Bellamy	Vanishing Cycles for Mirabolic D-modules
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:30 PM	Simons Auditorium	Ragnar-Olaf Buchweitz	The McKay Correspondence for anti-canonically embedded Fano Varieties

Friday, April 12, 2013			
9:30 AM - 10:30 AM	Simons Auditorium	Konstantin Ardakov	Rigid analytic quantisation and p-adic representations of p-adic Lie groups
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00 PM	Simons Auditorium	Gonçalo Tabuada	Noncommutative motives
12:00 - 2:00 PM	Atrium		Lunch
2:00 - 3:00 PM	Simons Auditorium	Alexei Oblomkov	Cohomology of the elliptic Affine Springer Fibres and the rational Cherednik algebras
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:30 PM	Simons Auditorium	Roman Bezrukavnikov	TBA

Participants

First Name	Last Name	Institution
Tarig	Abdelgadir	Korea Institute for Advance Study
Mohammed	Alkadhi	Al-Imam Muhammad Ibn Saud University --- Riyadh, Saudi Arabia
Benjamin	Antieau	University of California
Andrea	Appel	Northeastern University
Konstantin	Ardakov	School of Mathematical Sciences, Queen Mary, University of London
Sergey	Arkhipov	Aarhus University
Allen	Bell	University of Wisconsin
Gwyn	Bellamy	University of Glasgow
Oren	Ben-Bassat	University of Oxford
David	Benson	University of Aberdeen
Olga	Bershteyn	Tallinn Technical University
Roman	Bezrukavnikov	Massachusetts Institute of Technology
Manuel	Blickle	Johannes Gutenberg-Universität Mainz
Jonathan	Block	University of Pennsylvania
Raf	Bocklandt	University of Amsterdam
Ken	Brown	University of Glasgow
Ragnar-Olaf	Buchweitz	University of Toronto
Jesse	Burke	University of California
Thomas	Cassidy	Bucknell University
Kenneth	Chan	University of Washington
Maria	Chlouveraki	Université Versailles/Saint Quentin-en-Yvelines
Lee	Cohn	University of Texas
William	Crawley-Boevey	University of Leeds
Maria	Cueto	Johann Wolfgang Goethe-Universität Frankfurt
Galyna	Dobrovolska	University of Chicago
Emilie	Dufresne	MSRI - Mathematical Sciences Research Institute
Michael	Ehrig	Universität Bonn
Juan	Elias	University of Barcelona
Eleonore	Faber	University of Toronto
Jiarui	Fei	University of California
Jason	Gaddis	University of Wisconsin
Iordan	Ganev	University of Texas
Sachin	Gautam	Columbia University
Joel	Geiger	Louisiana State University
Anthony	Giaquinto	Loyola University
Kenneth	Goodearl	University of California
Marton	Hablicsek	University of Wisconsin
Justin	Hilburn	University of Oregon
Cody	Holdaway	University of Washington
Birge	Huisgen-Zimmermann	University of California
Colin	Ingalls	University of New Brunswick
Osamu	Iyama	Nagoya University
Srikanth	Iyengar	University of Nebraska
David	Jordan	University of Texas
Tadeusz	Jozefiak	Mathematical Reviews
Byeong Hoon	Kahng	Seoul National University
Seok-Jin	Kang	Seoul National University
Tina	Kanstrup	Aarhus University
Joseph	Karmazyn	University of Edinburgh
Ellen	Kirkman	Wake Forest University
Jonathan	Kujawa	University of Oklahoma
Rajesh	Kulkarni	Michigan State University

Boris	Lerner	Nagoya University
Graham	Leuschke	Syracuse University
Yiqiang	Li	University at Buffalo (SUNY)
Yuanlin	LI	Brock University
Ivan	Losev	Northeastern University
Jason	Lutz	University of Nebraska
Gennady	Lyubeznik	University of Minnesota Twin Cities
Kevin	McGerty	University of Oxford
George	Melvin	University of California
Claudia	Miller	Syracuse University
Rosa	Miro-Roig	University of Barcelona
Susan	Montgomery	University of Southern California
Daniel	Murfet	University of California
Hiraku	Nakajima	Kyoto University
Amnon	Neeman	Australian National University
Cris	Negron	University of Washington
Andrei	Negut	Columbia University
Van	Nguyen	Texas A & M University
Emily	Norton	Boston College
Alexei	Oblomkov	University of Massachusetts, Amherst
Steffen	Oppermann	Norwegian University of Science and Technology (NTNU)
Hendrik	Orem	University of Texas
Aleksandr	Pavlov	University of Toronto
Jeremy	Pecharich	MSRI - Mathematical Sciences Research Institute
Brian	PIke	University of Toronto
Brent	Pym	University of Toronto
You	Qi	Columbia University
Claudiu	Raicu	Princeton University
Ali	Rajaei	Tarbiat Modares
Andrew	Reynolds	University of Oregon
Alice	Rizzardo	International School for Advanced Studies (SISSA/ISAS)
daniel	rogalski	University of California, San Diego
Pavel	Safronov	University of Texas
Steven	Sam	University of California
Beren	Sanders	University of California
Travis	Schedler	University of Texas
Karl	Schwede	Pennsylvania State University
Peng	Shan	Massachusetts Institute of Technology
Vivek	Shende	Massachusetts Institute of Technology
Ian	Shipman	University of Michigan
Susan	Sierra	University of Edinburgh
Bhairav	Singh	Massachusetts Institute of Technology
Gautam	Sisodia	University of Washington
Gregory	Smith	Queen's University
Sholto	Smith	University of Washington
Frank	Sottile	Texas A & M University
Suresh	Srinivasamurthy	Kansas State University
toby	Stafford	University of Manchester
Greg	Stevenson	Universität Bielefeld
Joshua	Sussan	City University of New York (CUNY)
Peter	Symonds	MSRI - Mathematical Sciences Research Institute
Jaimal	Thind	University of Toronto
Oleksandr	Tsymbaliuk	Massachusetts Institute of Technology
Kevin	Tucker	Princeton University

Adam-Christiaa	van Roosmalen	University of Regina
Michaela	Vancliff	University of Texas at Arlington
monica	vazirani	University of California
Padmini	Veerapen	University of Texas
Liza	Vishnyakova	University of Luxembourg
Friedrich	Wagemann	Universite de Nantes
Uli	Walther	Purdue University
Chelsea	Walton	Massachusetts Institute of Technology
Benjamin	Webster	Northeastern University
Zhaoting	Wei	University of Pennsylvania
Michael	Wemyss	University of Edinburgh
Jerzy	Weyman	Northeastern University
Sarah	Witherspoon	Texas A&M University
Emily	Witt	University of Minnesota Twin Cities
Milen	Yakimov	Louisiana State University
Shilin	Yu	Pennsylvania State University
James	Zhang	University of Washington
Yi	Zhang	MSRI - Mathematical Sciences Research Institute

Officially Registered Participant Information

Participants		**124**

Gender		**124**
Male	75.81%	94
Female	20.16%	25
Declined to state	4.03%	5

Ethnicity*		**124**
White	66.94%	83
Asian	19.35%	24
Hispanic	0.00%	0
Pacific Islander	0.00%	0
Black	2.42%	3
Native American	0.00%	0
Mixed	1.61%	2
Declined to state	9.68%	12

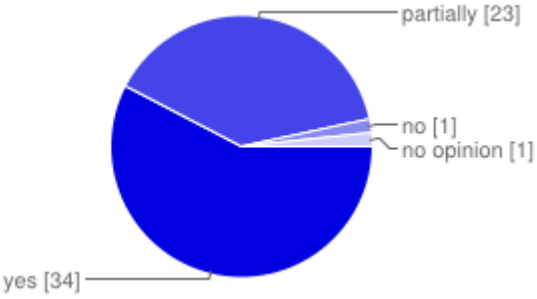
* ethnicity specifications are not exclusive

59 responses

Summary See complete responses

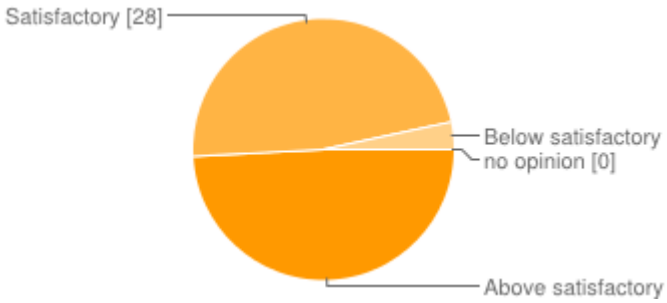
Topic presentation and organization

Did the various topics within the workshop integrate into a coherent picture?



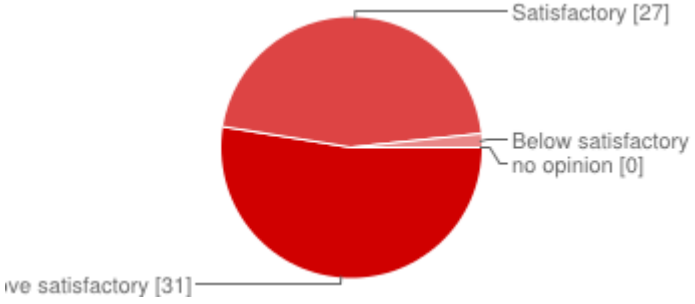
yes	**34**	58%
partially	**23**	39%
no	**1**	2%
no opinion	**1**	2%

Were the speakers generally clear and well organized in their presentation?



Above satisfactory	**29**	49%
Satisfactory	**28**	47%
Below satisfactory	**2**	3%
no opinion	**0**	0%

Was there adequate time between lectures for discussion?



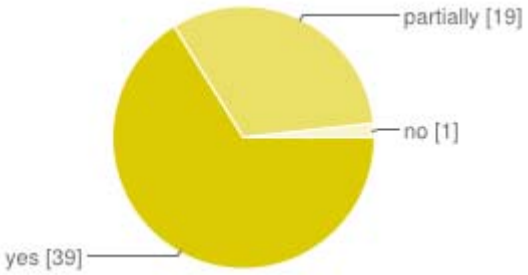
Above satisfactory	**31**	53%
Satisfactory	**27**	46%
Below satisfactory	**1**	2%
no opinion	**0**	0%

Additional comments on the topic presentation and organization

Many speakers assumed they were speaking to experts in their field; a conference with

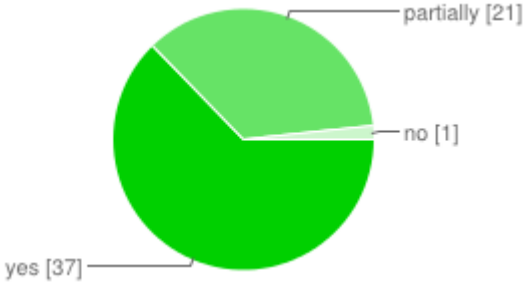
Personal assessment

Was your background adequate to access a reasonable portion of the material?



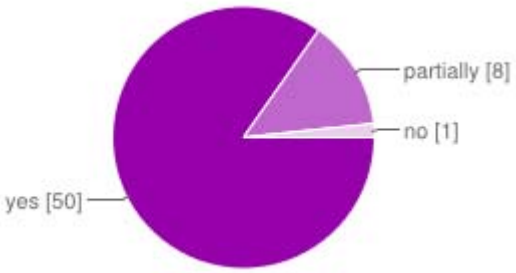
yes	**39**	66%
partially	**19**	32%
no	**1**	2%

Did the workshop increase your interest in the subject?



yes	**37**	63%
partially	**21**	36%
no	**1**	2%

Was the workshop worth your time and effort?

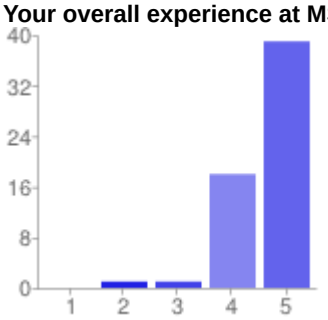


yes	**50**	85%
partially	**8**	14%
no	**1**	2%

Additional comments on your personal assessment

It was particularly impressive to see important results that were obtained as part of the running program (Sierra & Walton, in particular!) I am already fully engaged in (some of) the subject areas ...

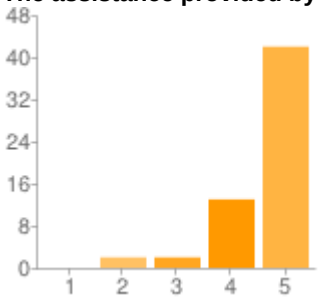
Your overall experience at MSRI



Not satisfactoryAbove satisfactory

1 -	Not satisfactory	**0**	0%
2		**1**	2%
3		**1**	2%
4		**18**	31%
5 -	Above satisfactory	**39**	66%

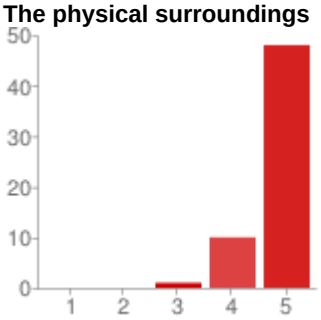
The assistance provided by MSRI staff



Not satisfactoryAbove satisfactory

1 -	Not satisfactory	**0**	0%
2		**2**	3%
3		**2**	3%
4		**13**	22%
5 -	Above satisfactory	**42**	71%

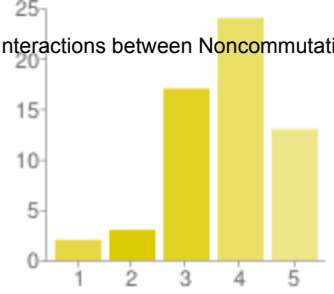
The physical surroundings



Not satisfactoryAbove satisfactory

1 -	Not satisfactory	**0**	0%
2		**0**	0%
3		**1**	2%
4		**10**	17%
5 -	Above satisfactory	**48**	81%

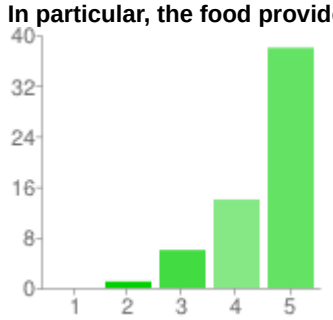
The food provided during the workshop



Not satisfactoryAbove satisfactory

1 -	Not satisfactory	**2**	3%
2		**3**	5%
3		**17**	29%
4		**24**	41%
5 -	Above satisfactory	**13**	22%

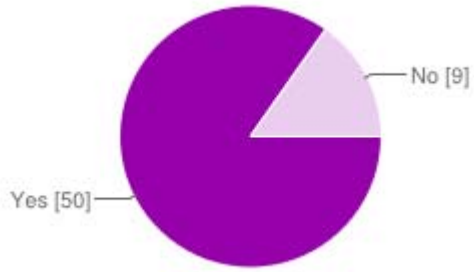
In particular, the food provided during the reception



Not satisfactoryAbove satisfactory

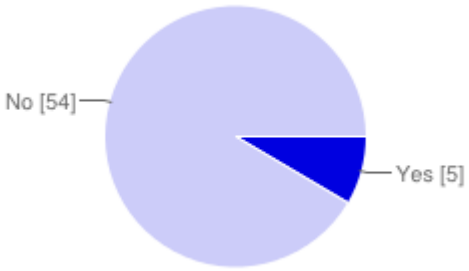
1 -	Not satisfactory	**0**	0%
2		**1**	2%
3		**6**	10%
4		**14**	24%
5 -	Above satisfactory	**38**	64%

Did you use MSRI's wireless network?



Yes	**50**	85%
No	**9**	15%

Did you experience any difficulties with the network?



Yes	**5**	8%
No	**54**	92%

If you did experience difficulties with the network, please explain:

It it slow sometimes. it was sometimes very slow network connection went off often sometimes very slow

Additional comments on the venue

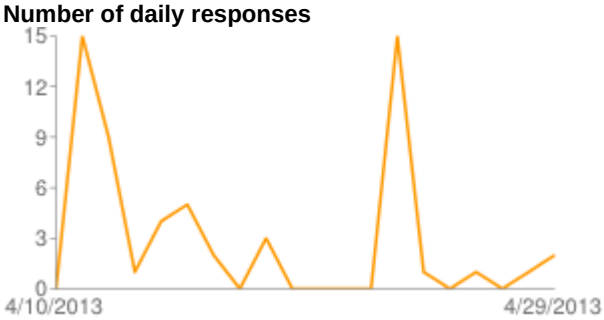
I didn't attend the reception. There should be more fruit in the coffee breaks, and not so many sweet stuff the blackboards in Simon's Auditorium could do with eraser shelves (only the middle board ha ...

Thank you for completing this survey

We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.

(1) Please don't use safety pins for the name tags! I suggest to improve the blackboard and chalk. After the first lecture, the blackboard becomes dirty, and difficult to read. the locks in the women' ...

Number of daily responses



Interactions between Noncommutative Algebra, Representation Theory, and Algebraic Geometry Workshop
April 8 to April 12, 2013

Additional Survey Responses

Additional comments on the topic presentation and organization

- Many speakers assumed they were speaking to experts in their field; a conference with "Interactions" in the name should make more of an effort to speak across boundaries.
- 1st half of week was good while latter half much less clear.

Additional comments on your personal assessment

- It was particularly impressive to see important results that were obtained as part of the running program (Sierra & Walton, in particular!)
- I am already fully engaged in (some of) the subject areas covered, so unlikely to be any change there as a result of the workshop. I felt that the talks covered a very wide range of topics (a good thing), but the starting point a level of technical detail in some of the talks was too high for thos e not specifically involved in that relatively small area, meaning that the majority of those listening were not fully engaged.

Additional comments on the venue

- I didn't attend the reception.
- There should be more fruit in the coffee breaks, and not so many sweet stuff
- the blackboards in Simon's Auditorium could do with eraser shelves (only the middle board has one). some of the light bulbs in the auditorium need to be replaced.
- Re food: I brought my own sandwich, apart from to the reception, so have no comment on food provided apart from at the reception.

We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.

- (1) Please don't use safety pins for the name tags!
- I suggest to improve the blackboard and chalk. After the first lecture, the blackboard becomes dirty, and difficult to read.
- the locks in the women's restroom could do with being fixed. It would be helpful to have some kind of guest access to UCB's wireless to track city buses, look up bus schedules etc.
- I felt that it was unfortunate that a full list of workshop participants was not readily available, given that there is a large number of peopl from all over the world, only at MSRI in most cases for a very short time. Thee was a list on the web, of course, but it was not in a form that I could easily print - I tried!
- It took longer to check out than to check in. And some of the questions were the same. Surely this could be compressed a bit.

Critical Issues in Mathematics Education 2013: Assessment of Mathematical Proficiencies in the Age of the Common Core

April 3 to April 5, 2013

MSRI, Berkeley, CA, USA

Organizers:

Mark Thames* (University of Michigan)

Kristin Umland* (University of New Mexico)

Noah Heller (Math for America)

Alan Schoenfeld (University of California, Berkeley)

MATHEMATICAL SCIENCES RESEARCH INSTITUTE
Report on the 2013 *Critical Issues in Mathematics Education* Workshop "Assessment of Mathematical Proficiencies in the Age of the Common Core"

The tenth *Critical Issues in Mathematics Education* (CIME) workshop took place at MSRI April 3-5, 2013. This was the second time we addressed student assessment in this workshop series. The first was the inaugural workshop. A changing landscape made the return to assessment timely. This 2013 workshop addressed many of the same themes as the first, but took advantage of developing understandings of mathematical proficiencies and the significant impetus for rich and coherent assessments afforded by recent adoptions of the Common Core State Standards in Mathematics (CCSSM). In keeping with CIME goals, participants were recruited from communities of mathematicians, K-12 teachers, and mathematics education researchers, in roughly equal numbers. The extensive involvement of *Math for America* teachers, a co-sponsor of this year's workshop, proved particularly successful.

Mathematicians	K-12 Teachers	Mathematics Education Professionals
• MSRI academic sponsors • Mathematicians involved in teacher education • Research mathematicians	• Teachers • School and district administrators and staff	• Teacher educators • Professional development providers • Education researchers • Curriculum and assessment developers

A significant innovation of this year's workshop was investment in working groups that developed, reviewed, and revised items of hard-to-assess mathematical proficiencies. In planning this work, we took advantage of a growing understanding of what it takes to work productively across professional communities. Sessions and handouts were designed to introduce participants to key assessment issues and to provide resources for developing robust items. For two and a half days, participants worked together on the development of both formative and summative assessments of critical aspects of mathematical proficiency.

The workshop addressed three organizing questions.

(1) What are fundamental problems of assessing students' mathematical proficiency, aligned with a comprehensive perspective on what it means to learn, know, and use mathematics?
(2) What norms and structures need to be developed to work productively across traditionally distinct professional communities?
(3) What is involved in vetting assessment items in ways that contribute to developing shared professional knowledge?

The Wednesday evening session set the stage for the work of the conference. After welcoming everyone, Alan Schoenfeld, from the University of California, Berkeley, painted a picture of the current assessment context in the United States and then, with examples, offered an overview of critical issues we face. Deborah Ball and Hyman Bass from the University of Michigan framed current thinking about mathematical proficiencies, both as represented in the mathematical practices of the Common Core State Standards and in documents such as the National Research Council 2001 report, *Adding it Up*. Ball then conducted an interview with a sixth grader that

engaged all of us in thinking more carefully about the issue of proficiency in the complex environment of engaging a (communicative, bilingual, perceptive, engaged) student with challenging ideas. Deborah posed tasks related to fractions, number lines, and discrete mathematics. To conclude the evening, Kristin Umland, from the University of New Mexico, described her experiences with the Illustrative Mathematics project, which is creating 2000 tasks to illustrate the Common Core standards using a structured online environment. She sketched plans for the working groups, and groups met to introduce themselves and to get oriented to the work they would be doing together during the conference.

Thursday morning, Bill McCallum and Jason Zimba used their experiences as two of the three lead writers for the Common Core standards in mathematics to explore what it might take to dissolve boundaries — not just between groups of people, but between ways in which different types of expertise are deployed. They proposed a move away from an assembly line model for assessment development, with mathematicians, teachers, policymakers, and psychometricians responsible for injecting their specific expertise into a product handed down the line, to one where a growing network of discerning individuals thoughtfully deliberates about what an item is meant to elicit, whether it does, and reasons for saying it does what is claimed, and where these different experts respectfully negotiate and find balance among competing concerns. They discussed pitfalls for building assessments for the Common Core, such as overly attending to whether items discriminate (reliably rank students), without keeping an eye on whether students are learning the simple basics of their grade. They also discussed tensions in the standards that are inherited by assessment efforts, such as figuring out how to integrate content and practices and maintaining mathematical integrity while making decisions about when to split ideas into components to be measured separately and when to leave them as an integrated whole. They gave examples of these dynamics playing out inside the details of specific items, which helped to orient everyone to the nature of the conversations of the working groups.

Short presentations by three teachers and a principal, all associated with Math for America, helped to orient our work to the ways in which assessment affects interactions among teachers and students around content in schools. David Baiz, an 8th grade teacher in an East Harlem public school, made a call for professional community and described how high-stakes summative assessments drive what standards look like in practice. In particular, he described the reality of high-stakes tests as they play out in the lives of 8th graders, for whom test scores may mean having to attend summer school or becoming labeled for the remainder of their K-12 schooling. Eyal Wallenberg and Melanie Smith engaged us in a lively object lesson on what it means to implement high-level, complex tasks that provide opportunities for students to engage in practices of the Common Core. They provided a candidate task and asked us to consider challenges in implementing the task with students. They described approaches they use to help their students learn to persevere and to construct viable arguments and critique the reasoning of others. For instance, they are explicit with students about the importance of persevering in mathematics and what it looks like when it happens: everyone on the team demands to understand; if you listen to the team you hear people explaining their thinking; and work continues even when an initial strategy does not work. With vivid examples, they described a rubric they use, written comments they give, a process of “live tweeting” observations on a smart board while teams are working, and debriefing group work by replaying short clips they take with their phones of students working, using the clips to have students give “warm and specific” feedback to other students about things they heard. They have students give themselves feedback on their progress related to making sense and persevering and have them set goals for themselves. Although most of their focus was on formative assessment, Eyal and Melanie also described challenges they face in their classrooms with summative assessment of

mathematical practices. They offered an evocative account of the demanding work of teaching mathematical practices. Then, Jonathan Osler, a principal in Alameda, described ways in which he strives to be explicit about instruction and assessment of mathematical practices as a means of attending to equity in the implementation of the Common Core.

Before lunch, Eva Baker, co-director of the *Center for Research on Evaluation, Standards, and Student Testing* (CRESST), provided a tour of the assessment of complex human practices. She situated our work in a larger landscape, sketched key challenges, and set some priorities for us to keep in mind. She moved us away from thinking about format, to attending to clear evidence of the domain performance we want to assess and arguments for whether test performance provides trustworthy evidence of domain performance. She pointed out that the major threat to validity was how a test would be used and whether people were preparing for the test in ways that undermined its validity. She also warned us about trying to create unique, one-of-a-kind tasks, and instead encouraged us to think about producing prototypes that could be replicated and repurposed. She provided depth and detail about the psychometric complexities of assessing complex human practice and shared tools developed at CRESST to support such work.

After lunch, short presentations by Mike Briscoe at *Student Achievement Partners*, Willy Solano-Flores at University of Colorado, Boulder, and Ann Shannon, an independent consultant, expanded on themes identified by Baker. Briscoe shared tools for considering the alignment of summative assessments with the Common Core standards. Solano-Flores described the value of doing cognitive interviews with students to more carefully consider the validity of items with different populations of students. And Shannon described the nature of formative assessment tasks that provide access to student thinking in ways that can inform instruction. All of these presentations served as resources for drafting items in the working groups.

The 25 working groups were formed with a mix of people from different communities and according to shared interest in either formative or summative assessment at the elementary, middle school, secondary, or college level. They met two to three times each day to carry out structured assignments in support of item development. The tools provided to groups represent a recent innovation in efforts to create productive cross-community learning organizations. Building on ideas from the Institute for Healthcare Improvement, Tony Bryk has argued that the problems of education require new approaches to collective work across key constituent communities.[1] Putting people in the same room is only a first step. Improvement also requires a change in mind-set, creation of new infrastructure, and changing patterns of authority and power. The CIME working groups were designed with these in mind. Starting in small groups, participants identified what they wanted to assess, drafted an assessment item, and wrote a commentary that makes features of the item explicit.

1. The purpose of the item, both what it assesses and the context in which it is to be used.
2. Likely student responses, how they are to be evaluated, and why performance is evidence of what was to be assessed.
3. Additional information helpful to interpreting the item and understanding key design features.

[1] See, for example, Bryk, A. S., Gomez, L. M., & Grunow, A. (2010). Getting ideas into action: Building networked improvement communities in education. Carnegie Foundation for the Advancement of Teaching, Stanford, CA, essay, retrieved from http://www.carnegiefoundation.org.

In their working groups, participants drafted items and commentaries, reviewed the work of other groups, and coalesced into larger groups to further vet candidate items. We used a clone of the online platform of the Illustrative Mathematics Project to provide a structured environment for posting tasks, writing commentaries, and providing feedback.

The commentaries and review criteria provided important boundary objects for structuring the cross-community work.[2] To help disrupt patterns of authority and power, we recruited teachers to serve as facilitators of the working groups and familiarized them with the online environment and plan for group work before the conference. On Friday, we engaged in public vetting of items and reflected on our experiences in the working groups and our shifting mind-sets about each other, assessment, and the nature of this collaborative work. Assessment development takes far more time and investment than can be accomplished in a three-day meeting, but we produced nearly 50 items, with about half of these reviewed in mid-sized groups and half of these vetted in larger forums.

The sessions on Wednesday evening and Thursday morning provided orientation for the small group work on items, as the sessions ranged across perspectives of different constituents, provided examples, and raised key design parameters and tensions among them. On Thursday afternoon and Friday morning we also heard from the two major assessment consortia, *Partnership for Assessment and College Readiness* (PARCC), represented by Instructional Supports & Educator Engagement director Doug Sovde, and *Smarter Balanced Assessment Consortium* (SBAC), represented by Mathematics director Shelbi Cole and Executive director Joe Willhoft. Each presentation described aspects of mathematical proficiency that were deemed hard to assess, but which were priorities of the consortia and described both progress made in overcoming challenges and remaining challenges.

On Friday, Marcus Hung, an Algebra Project teacher at Thurgood Marshall Academic High School in San Francisco, Maria Martinello, a consultant specializing in assessment of English learners, and Judit Moschkovich of the University of California, Santa Cruz, helped us consider assessment challenges that arise in relation to issues of diversity and equity. This was followed by a session in which Diane Briars, president-elect of the National Council of Teachers of Mathematics, expanded the conversation to the larger national policy environment.

To pull together the different constituent perspectives, Deborah Ball interviewed six participants on Friday afternoon:

- Noah Heller, Math for America, New York
- Sara Rezvi, Urban Assembly Institute of Math and Science for Young Women, Brooklyn
- Dev Sinha, Department of Mathematics, University of Oregon
- Diane Schaefer, Consultant (previously with the Rhode Island Department of Education)
- Tony Smith, Oakland Unified School District, Superintendent
- Phil Daro, Consultant (a lead writer for the Common Core standards)

They addressed five questions.

[2] For a discussion of ways that boundary objects support productive cross-community collaboration, see: Star, S. L., & Griesemer, J. R. (1989), Institutional ecology, "translations" and boundary objects: Amateurs and professionals in Berkeley's Museum of Vertebrate Zoology, 1907-39, *Social Studies of Science, 19*(3), 387-420; and Akkerman, S. F. & Bakker, A. (2011), Boundary crossing and boundary objects, *Review of Educational Research, 81*(2), 132-169.

1. What are your top-three "caution points" — things that have to be addressed to ensure the development of assessments of mathematical proficiency that support improvement?
2. In light of these concerns, what are lessons learned from the past and aspirations for the future?
3. Given the range of mathematical proficiencies, which are your key "indicators"?
4. What are really smart ways to think about growth — in ways that can inform agendas?
5. What "infrastructure" will most help us work together productively on assessment?

In the closing session, Alan Schoenfeld reminded us of the importance of assessment to the improvement of education and also of the potential damage that assessment, when it goes wrong (which it does, easily and often), can inflict on students, teachers, schools, and districts. He pointed out that responsibility for seeing that it goes right is shared among many different constituencies, including those represented at the workshop. Given this reality, he observed that our progress at the conference on appreciating the challenges and hearing from and bridging across communities provides important groundwork for assessment efforts. He encouraged us to make use of these lessons as we returned to our varied professional lives.

To make the content of this workshop available to a larger audience, MSRI maintains a web page with links to descriptions of all ten workshops. Included are slides and video from presentations, schedules, and lists of participants.
http://www.msri.org/web/msri/education/for-k-12-educators/critical-issues

Organizers

First Name	Last Name	Institution
Noah	Heller	Math for America
Alan	Schoenfeld	University of California
Mark	Thames	University of Michigan
Kristin	Umland	University of New Mexico

Speakers

First Name	Last Name	Institution
David	Baiz	Global Technology Preparatory
Eva	Baker	University of California
Hyman	Bass	University of Michigan
Diane	Briars	National Council of Supervisors of Mathematics
Michael	Briscoe	Student Achievement Partners
Shelbi	Cole	Smarter Balanced Assessment Consortium
philip	daro	common core
William	McCallum	University of Arizona
Cameron	Mcleman	University of Michigan
Judit	Moschkovich	University of California
jonathan	osler	alameda unified school district
Deborah	Schifter	Education Development Center
Melanie	Smith	Urban Assembly School for Law and Justice
Guillermo	Solano-Flores	University of Colorado
Eyal	Wallenberg	Urban Assembly School for Law and Justice
Jason	Zimba	Student Achievement Partners

Critical Issues in Mathematics Education 2013: Assessment of Mathematical Proficiencies in the Age of the Common Core

April 3 to April 5, 2013

Schedule

Wednesday, April 03, 2013			
4:00PM - 4:30PM	Atrium		Registration and Refreshments
4:30PM - 4:35PM	Simons Auditorium	Robert Bryant	Welcome
4:35PM - 5:15PM	Simons Auditorium	Alan Schoenfeld	Setting the stage: An introduction to the fundamental challenges of assessment
5:15PM - 6:45PM	Simons Auditorium	Deborah Ball & Hyman Bass	The challenge of assessing mathematical proficiency: A student interview
6:45PM - 7:15PM	Simons Auditorium	Kristin Umland	Combining our expertise: Working together on assessment tasks
7:15PM - 7:45PM	Simons Auditorium		Introduction to Working Groups

Thursday, April 04, 2013			
7:30AM - 8:30AM	Atrium	speaker	Light Breakfast
8:30AM - 9:30AM	Simons Auditorium	Bill McCallum & Jason Zimba	Dissolving the boundaries
9:30AM - 10:45AM			Working Groups
10:45AM - 11:30AM	Simons Auditorium	Eyal Wallenberg, Melanie Smith, David Baiz, & Jonathan Osler	Assessment in practice: Use, needs, and examples
11:30AM - 12:30PM	Simons Auditorium	Eva Baker	Assessing complex human practices
12:30PM - 1:30PM	Atrium		Lunch
1:30PM - 2:15PM	Simons Auditorium	Mike Briscoe, Guillermo Solano-Flores, & Ann Shannon	Assessment ABCs: Purpose, design, and examples
2:15PM - 3:30PM			Working Groups
3:30PM - 4:15PM	Simons Auditorium	Doug Sovde	PARCC: Challenges taken on and progress to date
4:15PM - 5:30PM			Working Groups
5:30PM - 7:00PM	Atrium		Reception

Friday, April 05, 2013			
7:30AM - 8:30AM	Atrium		Light Breakfast
8:30AM - 9:15AM	Simons Auditorium	Maria Martiniello & Judit Moschkovich	Diversity and equity: Assessment challenges and examples
9:15AM - 10:45AM			Working Groups
10:45AM - 11:30AM	Simons Auditorium	Shelbi Cole	SBAC: Challenges taken on and progress to date
11:30AM - 12:30PM	Atrium		Lunch/review (part 1)
12:30PM - 1:30PM	Atrium		Lunch/review (part 2)
1:30PM - 2:15PM	Simons Auditorium	Diane Briars	Broadening the conversation: Issues and concerns
2:15PM - 2:30PM	Atrium		Break
2:30PM - 3:30PM	Simons Auditorium		Large Group Reports
3:30PM - 4:45PM	Simons Auditorium		Working collectively to assess proficiency: Panel interview
4:45PM - 5:30PM	Simons Auditorium	Alan Schoenfeld	Making progress on assessing proficiency

Participants

First Name	Last Name	Institution
Morgan	Alconcher	University of California
Mohammed	Aminyar	East Side Community High School
Bruce	Amundson	Bishop O'Dowd High School
Cynthia	Anhalt	University of Arizona
Karen Arth	Arth	California State University
David	Baiz	Global Technology Preparatory
Eva	Baker	University of California
Carrie	Bala	Wasatch High School
Erin	Baldinger	Stanford University
Scott	Baldridge	Louisiana State University
Hyman	Bass	University of Michigan
Kaushik	Basu	University of California
Jerry	Becker	Southern Illinois University
Kate	Belin	Fannie Lou Hamer Freedom High School
Ashli	Black	Illustrative Mathematics
Michael	Boardman	Pacific University
Nathan	Bonheimer	High School of Economics and Finance
Alicia	Bowman	Menlo Park City Schools District
Priscilla	Bremser	Middlebury College
Diane	Briars	National Council of Supervisors of Mathematics
Michael	Briscoe	Student Achievement Partners
Ramona	Burton	Oakland Unified School District
margaret	cagle	Los Angeles Unified School District
Fabiana	Cardetti	University of Connecticut
Guadalupe	Carmona	University of Texas
Micxhelle	Chenal-Ducey	Tulare County Office of Education
Tina	Cheuk	Stanford University
Thomas	Clark	University of Nebraska
Nell	Cobb	DePaul University
Shelbi	Cole	Smarter Balanced Assessment Consortium
Ricardo	Cortez	Tulane University
William	Crombie	Algebra Project, Inc.
Cheryll	Crowe	Eastern Kentucky University
Jerome	Dancis	University of Maryland
philip	daro	common core
CHARLENNE	DELEON~CUEVAS	The Young People's Project
Kenan	Delgado	Oakland Unified School District
Keith	Devlin	Stanford University
Jacqueline	Dewar	Loyola Marymount University
Dennis	Dougherty	Bishop O'Dowd High School
Lew	Douglas	University of California
James	Dunseith	Validus Preparatory Academy
David	Eisenbud	University of California
James	Epperson	University of Texas
christina	eubanks-turner	University of Louisiana--Lafayette
Geneva	Europa	Aspire Public Schools
Juan Carlos	Fernandez	North Davis Preparatory Academy

Kelly	Gaddis	Bard College
Kate	Garfinkel	Berkeley High School
sol	garfunkel	COMAP
sayonita	ghosh hajra	University of Georgia
Sandra	Gilliam	Colorado College
Emiliano	Gomez	University of California
deidre	grevious	Oakland Unified School District
Gregory	Guayante	El Camino High School
Noah	Heller	Math for America
Aloysius	Helminck	North Carolina State University
Aaron	Hill	University of North Texas
Julie	Ho	Freelance/Consultant
Rebecca	Horwitz	Aspire Public Schools
Debbie	Houghton	Hurricane Elementary School
Marcus	Hung	June Jordan School for Equity
Jennifer	Johnson	Princeton University
Thomas	Judson	Stephen F. Austin State University
Cathy	Kessel	consultant
Yeon	Kim	University of Michigan
James	King	University of Washington
Carol	Kinney	NYC DOE Bronx Envision Academy
William	Kronholm	Whittier College
Oh Hoon	Kwon	University of Wisconsin
Brigitte	Lahme	Sonoma State University
Yvonne	Lai	University of Michigan
Xuhui	Li	California State University
Cynthia	Lima	University of Texas
Robin	Lovell	Oakland Unified
Miroslav	Lovric	McMaster University
Guadalupe	Lozano	University of Arizona
Guadalupe	Lozano	University of Arizona
Allison	Lucas	Berkeley Unified School District
Michael	Lundin	Central Washington University
Lori	MacDonald	Berkeley Unified School District
James	Madden	Louisiana State University
Adelita	Martinez	Stanislaus County Office of Education
Samuel	Martinez	Parlier Unified School District
Betty	Mayfield	Hood College
Karen	Mayfield-Ingram	Lawrence Hall of Science
William	McCallum	University of Arizona
Ben	McCarty	University of Memphis
Lee	McEwan	Ohio State University
Cameron	Mcleman	University of Michigan
Julie	McNamara	University of Michigan
Robert	Megginson	University of Michigan
Devin	Metzinger	Southwestern College
Judit	Moschkovich	University of California
Robert	Moses	The Algebra Project, Inc.
Gretchen	Muller	Oakland Unified School District

Michael	Myers	David C. Hinson Sr. Middle School
Julia	Nagle	S. D. Bechtel, Jr. Foundation
Michael	Nakamaye	University of New Mexico
Robert	Newton	University of Florida
Joseph	Ochiltree	International High School at LaGuardia Community College
JANNELLE	OLIVIER	Olympian High School
jonathan	osler	alameda unified school district
Mark	Oursland	Central Washington University
Jeanette	Palmiter	Portland State University
Celia	Pascual	Oakland Unified School District
Joanne	Philhower	Michigan State University
Henri	Picciotto	Urban School of San Francisco
Kathleen	Pitvorec	University of Illinois
matthew	rasband	Albany High School
Christopher	Rasmussen	Wesleyan University
Sara	Rezvi	Math for America
Thomas	Rike	Oakland High School
Tom	Roby	University of Connecticut
Nathaniel	Rounds	Reasoning Mind
Melissa	Rowker	City Year
Evan	Rushton	Franklin High School
Ashley	Salisbury	Utah State University
Diane	Schaefer	Consultant
Deborah	Schifter	Education Development Center
Alan	Schoenfeld	University of California
Daniel	Schultz-Ela	Colorado Mesa University
David	Scott	University of Puget Sound
Mallika	Scott	University of California
Sarah	Selling	Stanford University
Meghan	Shaughnessy	University of Michigan
Dev	Sinha	University of Oregon
Marianne	Smith	Marianne Smith, Consultant
Melanie	Smith	Urban Assembly School for Law and Justice
Katherine	Socha	Math for America
Guillermo	Solano-Flores	University of Colorado
Suresh	Srinivasamurthy	Kansas State University
Kathy	Sun	Stanford University
Daniel	Teague	North Carolina School of Science and Mathematics
Mark	Thames	University of Michigan
Susan	Troutman	Rice University
Kristin	Umland	University of New Mexico
Veronica	Valerio	Berkeley Unified School District
Eyal	Wallenberg	Urban Assembly School for Law and Justice
Mary	WEST	LESLEY UNIVERSITY SCH OF EDUCATION
Diana	White	University of Colorado
Brandy	Wiegers	San Francisco State University
Joseph	Willhoft	Smarter Balanced Assessment Consortium
Cynthia	Williams	Harris-Stowe State College
W Stephen	Wilson	Johns Hopkins University

Fara	Wolfson	Marblehead Public Schools
Risa	Wolfson	Consultant
Kim	Wuellner	St Johns County School District
Zeev	Wurman	Stanford University
Jason	Zimba	Student Achievement Partners

Officially Registered Participant Information

Participants		150

Gender		150
Male	48.00%	72
Female	52.00%	78
Declined to state	0.00%	0

Ethnicity*		150
White	64.67%	97
Asian	10.67%	16
Hispanic	8.67%	13
Pacific Islander	0.00%	0
Black	6.00%	9
Native American	0.67%	1
Mixed	6.67%	10
Declined to state	2.67%	4

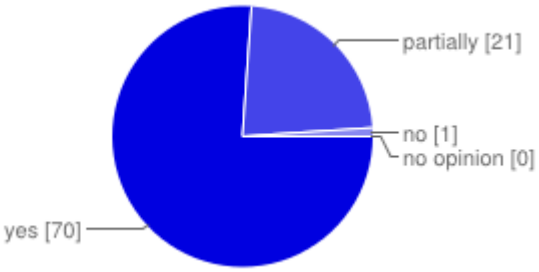
* ethnicity specifications are not exclusive

92 responses

Summary See complete responses

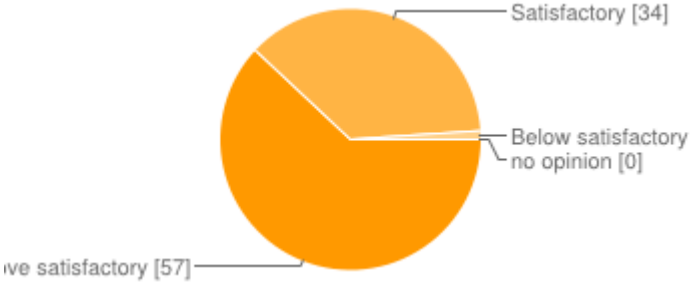
Topic presentation and organization

Did the various topics within the workshop integrate into a coherent picture?



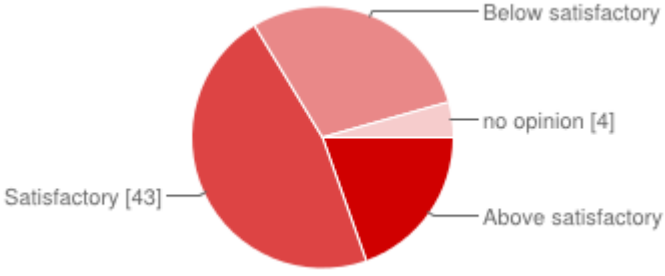
yes	**70**	76%
partially	**21**	23%
no	**1**	1%
no opinion	**0**	0%

Were the speakers generally clear and well organized in their presentation?



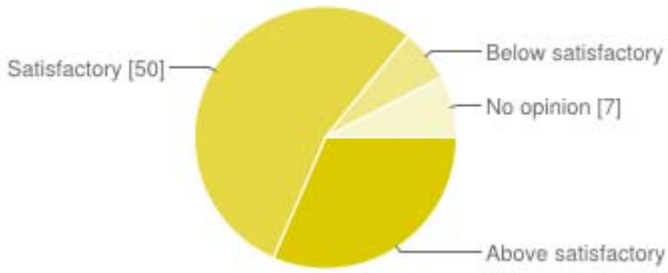
Above satisfactory	**57**	62%
Satisfactory	**34**	37%
Below satisfactory	**1**	1%
no opinion	**0**	0%

Was there adequate time between lectures for discussion?



Above satisfactory	**18**	20%
Satisfactory	**43**	47%
Below satisfactory	**27**	29%
no opinion	**4**	4%

In terms of their effectiveness, the working groups were:

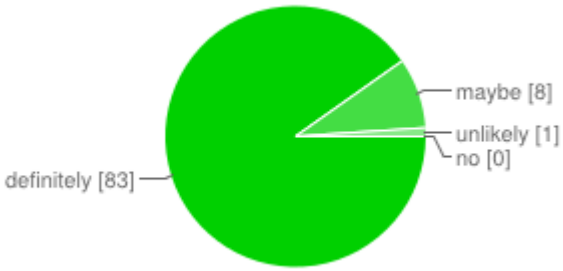


Above satisfactory	**29**	32%
Satisfactory	**50**	54%
Below satisfactory	**6**	7%
No opinion	**7**	8%

What was most valuable about the working groups, and how could the working groups be improved?

different perspectives and different levels of experience were great slight improvement would have been to make expectations for the task more clear It was great to work with people who have different backgrounds for one purpose and experience to communicate them. I missed the first day of the conference so I don't think I can speak with authority on how the groups were introduced or how our charge was given. I was confused during the the first meeting on Thursday about what we were trying to accomplish and why. I think having a model of the reviewing an item with the question set you pro ...

Would you return for another CIME workshop at MSRI if funding were available?



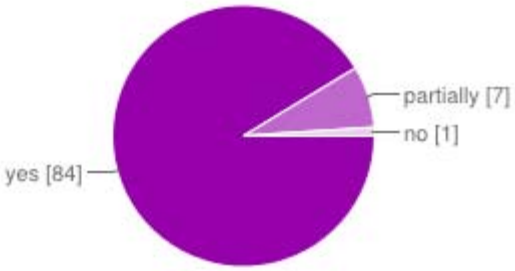
definitely	**83**	90%
maybe	**8**	9%
unlikely	**1**	1%
no	**0**	0%

Additional comments on the topic presentation and organization

presentations were very well chosen The presentations by teachers were far more engaging than the lectures of researchers. It was interesting to note that researchers on teacher practice do not put ...

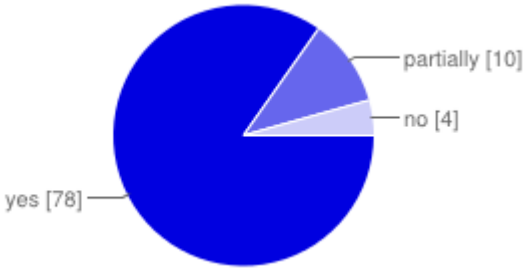
Personal assessment

Was your background adequate to access a reasonable portion of the material?



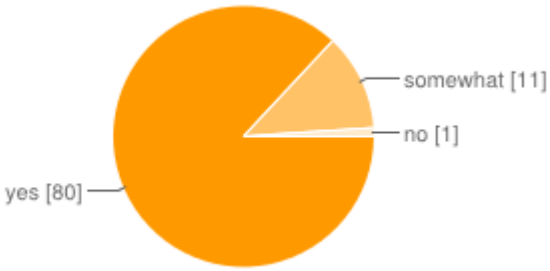
yes	**84**	91%
partially	**7**	8%
no	**1**	1%

Did the workshop increase your interest in the subject?



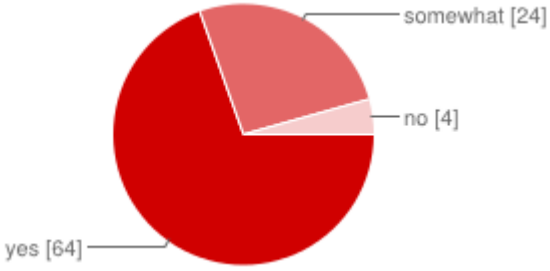
yes	**78**	85%
partially	**10**	11%
no	**4**	4%

Were the discussions in which you engaged between sessions interesting and useful?



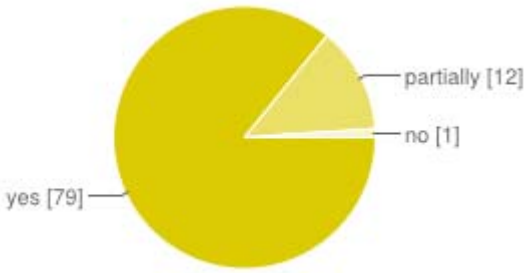
yes	**80**	87%
somewhat	**11**	12%
no	**1**	1%

Did you make productive connections with others who share your interests or with people whose work differs from yours?



yes	**64**	70%
somewhat	**24**	26%
no	**4**	4%

Was the workshop worth your time and effort?



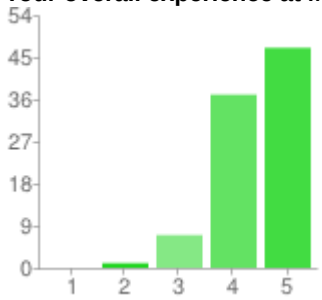
yes	**79**	86%
partially	**12**	13%
no	**1**	1%

Additional comments on your personal assessment

I wasn't able to be there for the full 2/5 days, which made the whole thing less successful for me. I would have liked more time for informal conversations. As a shy person, I did not network/interac ...

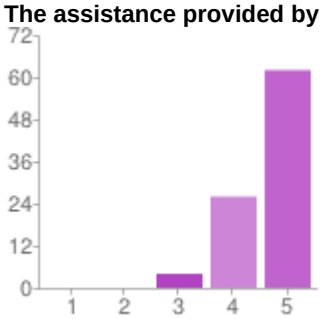
Venue

Your overall experience at MSRI



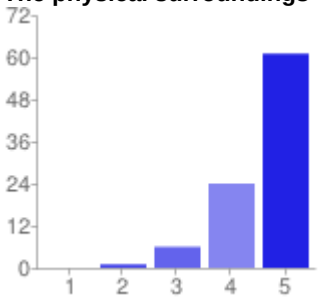
1 -Not satisfactory	**0**	0%
2	**1**	1%
3	**7**	8%
4	**37**	40%
5 -Above satisfactory	**47**	51%

The assistance provided by MSRI staff



1 -Not satisfactory	**0**	0%
2	**0**	0%
3	**4**	4%
4	**26**	28%
5 -Above satisfactory	**62**	67%

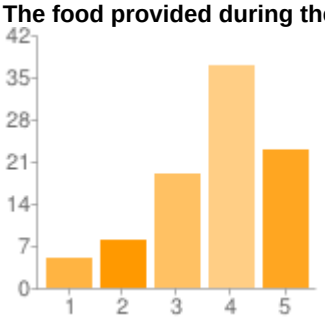
The physical surroundings



Not satisfactoryAbove satisfactory

1 -Not satisfactory	**0**	0%
2	**1**	1%
3	**6**	7%
4	**24**	26%
5 -Above satisfactory	**61**	66%

The food provided during the workshop



Not satisfactoryAbove satisfactory

1 -Not satisfactory	**5**	5%
2	**8**	9%
3	**19**	21%
4	**37**	40%
5 -Above satisfactory	**23**	25%

Additional comments on the venue

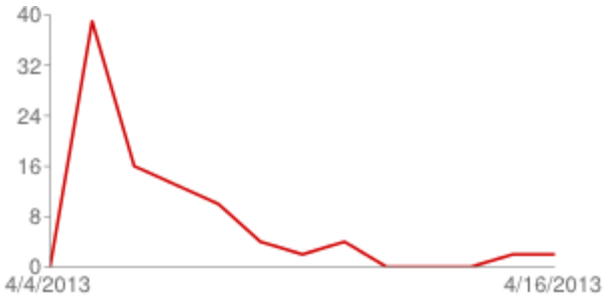
MSRI is always lovely. Time each evening to walk around and see sights might be more welcome and productive. The first full day was a bit too long. It was very challenging to be in one room all day t ...

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! This was an extremely beneficial workshop on many levels! I did mention in a large group earlier that it might be helpful to have equity presentations (specifically regarding language of ...

Number of daily responses


40
32
24
16
8
0
4/4/2013
4/16/2013

Critical Issues in Mathematics Education 2013:
Assessment of Mathematical Proficiencies in the Age of the Common Core
April 3 to 5, 2013

Additional Survey Responses

Additional comments on the topic presentation and organization

- presentations were very well chosen
- The presentations by teachers were far more engaging than the lectures of researchers. It was interesting to note that researchers on teacher practice do not put that practice into their presentation.
- Well-organized but needed breaks on Thursday
- Ball's interview was too long. We could have benefitted by more discussion on the issues surrounding verbal assessment.
- I feel that some presentations were magnificent (Eyal and Melanie's for example) and others were lackluster and not worth the time. I feel that if the conference is truly about bettering understanding through presentations, then the presentations should be verified as worth the time of participants. If slides are a bunch of text, and the speaker is less than engaging. There should be some type of vetting process to ensure that time is being used as well as possible, since we were constantly running late or low on time. I also feel that teacher group leaders were left somewhat in the dark in what their actual purpose was in effectively leading the small working groups. I would have appreciated a protocol, and perhaps some insight as to what the working groups were to accomplish before attending the conference. Finally, I feel that there is a law of diminishing returns in terms of packing in multiple presentations and assuming people will engage with all speakers for 12 hours. Instead, I think if there was more time to ask questions, I believe it would have lead to richer discussions and ideas which then could have been taken into the working groups to work off of as a jumping point.
- Great. This was a great topic and very important.
- Eva's talk need more examples to be comprehensible to this audience.
- The speakers were "generally" clear and well organized, but I got very little out of Eva Baker's presentation. I don't know who her intended audience was, but it didn't include me. In a later session, Deborah Ball rephrased one of Baker's points, which I appreciated, because I certainly didn't get it the first time.
- Needs: Additional Breaks, more forced interaction between participants, a way to gather questions/comments (twitter-type feed) to increase participation from the audience during post-presentation discussion.
- One of the highlights of my year.
- As is always the case, some of the presentations were great and others not as good. I guess I would probably like to have more time to meet the teachers although of course it was nice to spend time with many of the people (university faculty mostly) who I know mainly by name but have rarely spent time with.
- Most of the speakers were excellent and engaging, but a couple of boring ones colored my thinking. It was a shame that some really interesting people only had 12 minutes to talk, while some less-interesting ones had an hour.
- Most of the presenters were great. However, a few presentations were inadequate and in the future it might be worth vetting the quality of all presentations a little. Also, more time for questioning and breaks would have been great.
- Thank you
- It was too ambitious. People need breaks. 1) to reset 2) to process
- needed more breaks

- The equity presenters generally didn't have enough time to present their cases. Fewer and longer might have been more successful. Important to pay attention to this, but then 12 minutes is not really enough.
- Some presenters spoke too softly.
- Lots of fascinating useful stuff.
- Some of the talks did not add value to the working sessions. While perhaps valuable in another context (i.e. a math teacher conference), they added little value to our working sessions ("the assessment in practice speakers). Ann Shannon should have been given the entire time slot in that session, rather than the other speakers. D Ball's student session was of terrific value at the beginning. While I realize that Math For America sponsored the event, there were too many people representing MFA, and not variety in teacher perspective.
- excellent distribution across the key constituencies
- Topic was very timely and important.
- It would have helped to have more of the "big picture" up front
- Make sure speakers know they're talking to the wide range of people that were brought in. Some people sounded like they were just talking to the math ed. people in the room.
- Would like more time to synthesize info and then discuss things said by teh speakers
- I think the conference will provide some food information about how to form "teams" to address the problem of item writing and assessing their value and potential value in evaluation.
- I would invite others to attend this program.
- The presentation topics were interesting and informative. It would have been great if we'd had time between each presentation to debrief with others about what we had heard and to ask questions to others. It was challenging to switch from one presentation to another in a manner of minutes, without having time to transition. It felt like brain overload at times because some of the presentations were very different and did not connect well with ones before or after it.
- I would have liked a longer opportunity to hear from the Math for America team, and to AnnSheldon. It was unfortunate that sharing time with other presenters eclipsed what might have been more relevant.
- Need more emphasis on specific grade levels and student's needs. More ELL content.
- It would be helpful to have copies of the power points ahead of time to refer to while presentations are taking place. It was difficult to see many of the slides.
- I learned a lot. Thanks!
- I love CIME and have attended each year since it's inception. This year was a nice return to working groups and to having an assignment to complete - which was especially motivating and successful (and that I have missed) from year 1.
- More time to review and comment on the developed assessments.
- I thought the presenters were well selected - I benefited tremendously from math professors, teachers, interest groups like Teacher for Amercia and Assessment companies.

Additional comments on your personal assessment

- I wasn't able to be there for the full 2/5 days, which made the whole thing less successful for me
- I would have liked more time for informal conversations.
- As a shy person, I did not network/interact enough with people I would have loved to meet. This is mainly my fault, but structures to force interaction would be appreciated by personality types like mine.
- I would like to have had the email addresses for the participants.
- As the delegate from my school, I have a lot to bring back.
- Thanks!
- It might be good to encourage groups to finish off the task that we started-- it might not happen in some cases but it would be good to get people to exchange contact info and maybe stay in touch...
- Amazing experience. I came away with a new view of implementation and writing of Common Core assessments and curricula.

- Thank you for organizing this workshop! I had no idea that these CIME events existed. I wish you had a better way of advertising them.
- Unfortunately, living nearby makes it hard to separate work from conference, and I was unable to attend much of the conference
- The opportunity to mix and mingle with non-mathematidians (I'm a mathematician) was the most important aspect. I met lots of people and had good conversations. I didn't agree with everyone, but it was better to have the conversations than not.
- As a veteran teacher, I was embarrassed by the teacher perspective on the panel. This was a professional workshop, and as such classroom teachers need to be selected to showcase their mathematical competence, organizational skills, and attention to professionalism and political savvy, rather than taking the time to berate working conditions, compensation, and griping! This did not elevate the status of the teaching profession.
- Excellent PD for me as a researcher in the field
- The connections made with other people concerned with the Common Core and evaluation was very useful.
- It would have been nice to have structured group times with others not in our working groups. The only times to chat with others was during the few breaks or lunch because the schedule was so jam-packed. We had plenty of opportunities to talk with those in our working groups, but not a lot of time to talk with others. It would have been helpful had there been debriefing sessions after a few presentations where we could talk with others not in our working groups.
- I commend the organizers for incorporating group work. Active involvement was a great way to model CC values
- Always appreciate MSRI's contribution to K-12 education.
- Less time on working groups
- Over the years I've been to a lot of MSRI conferences. There are a lot of good aspects in the MSRI conferences and many people work hard to make them happen. Unfortunately, that hard work is often undermined by poor advertising. This year was a happy exception--and I hope that trend continues. Still, announcements for the upcoming conference are never sent to attendees of prior conferences. If the conferences are about building a community of people working in math education, this goal is undermined by poor advertising. It seems that attendees are a generally different group each year. Perhaps I have mistaken the goal expressed by one of the speakers in a past year: ========== [W]e need a serious professional community of people engaged in the mathematical education of teachers. We need to build a professional infrastructure, treating problems of teacher education in a coherent way and establishing scientific norms and methods. We need to devise ways to accumulate knowledge and create a professional enterprise with standards of scientific rigor. The MSRI workshop as well as other events suggest that there are seeds of such a professional community which is not yet institutionalized. The workshop participants represent the small pockets of professional work inside departments or inside schools which do not have the critical mass and do not provide the basis for the systemic professional enterprise that is needed. Can this potential coalesce into a powerful and coherent professional community? (booklet on 2007 conference)
- Enjoyed listening to the expertise brought to the workshop. I would have liked someone from the National Board for Professional Teaching Standards to help support instruction targeted at the common core.
- It is so exciting to see and meet everyone who is so passionate about teaching math and people who have been involved in transforming Math education for decades.

Additional comments on the venue

- MSRI is always lovely.
- Time each evening to walk around and see sights might be more welcome and productive. The first full day was a bit too long.
- It was very challenging to be in one room all day to listen to the presentation. I wish there some choices in presentations.
- There must be a way to arrange better transportation for those who have to stay at downtown hotels.

- Not enough places to sit at lunch on a rainy day.
- Not enough breakout/small group space. The projector image seemed to lose contrast and some slides were hard to view.
- Parking is very difficult, this venue is not accessible to anyone with any issues walking up the stairs.
- More chairs in the atrium.
- The sandwiches were covered in disgusting mayo/mustard/ick. Please avoid.
- Amazing!
- It was hard to cram all those people into the available space for lunch, meeting in small groups, etc. Many of us ended up sitting on the floor a lot...
- It's a long hike from the parking lot; beautiful location, but not super accessible easily; water would have been nice, as well as more accessible snack options
- Schedule was not properly made, there should be breaks and not enough food was there for lunch. But reception was great
- So beautiful!!
- transportation to MSRI was difficult
- Food was still an issue--ran out on Day 1.
- Spaces for the working groups not ideal. Tables would have been nice. But the MSRI venue is so special, this was a small inconvenience.
- Beautiful location and gracious people!
- need parking for handicapped people!!
- The venue was challenging for working in small groups. It was easiest when the groups were quite small (appoximately 5-6).
- Obviously, more space for working groups would have been great, but I think everything went very smoothly.
- The facilities (meeting space, technology, copying and other services were outstanding. The MSRI is an excellent facility for a conference such as this.
- I was disappointed in the food being offered. I expected there to be more meal-type foods, especially since we were working so late in the evening. The fact that snacks were not allowed in the auditorium made it difficult for those who are diabetic or have low blood sugar because they had to miss presentations to leave the room to have a snack. The lack of breaks between presentations made it very challenging for some to have time to eat the snacks they needed. The food seemed very light to sustain individuals all day. It would have been nice to have a sitdown meal with everyone at least once during the workshop to have time to talk over the presentations and to network. It seemed at the end of the day, everyone was so tired, there wasn't much time left for socializing or making connections. We were very limited on space, so it made it challenging at times to find somewhere to sit to eat or to talk with others. Conversations was difficult at times because the rooms were small and everyone was trying to have conversations, so it made it difficult to hear folks near you. I did greatly appreciate the shuttle from campus to the workshop. It was very convenient and provided additional time to talk with others.
- Thanks so much for the incredible reception. ...and also for the inclusion of fruit, yogurt, and such all of the 'food moments'.
- More break times to check email, talk with colleagues, bathroom breaks, etc.
- Parking is extremely difficult to access. Having to walk down to Lawrence Hall Of Science and then back up for parking pass was frustrating.
- A little awkward physically when meeting in the groups.
- Thank you!!!

We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.

- Thank you! This was an extremely beneficial workshop on many levels! I did mention in a large group earlier that it might be helpful to have equity presentations (specifically regarding language of assessments) PRIOR to writing our assessment tools. As i looked at various groups' tasks, I

was struck by the complexity of the language and wondered if we might have framed our work differently if we were all being more sensitive to the language demands of the tasks.
- I truely thank MSRI and all the sponsors for this opportunity! I had a great experience attending the workshop!
- More breaks! More time for discussion!
- Please remove the downtown berkeley inn from your list of suggested hotels. It literally stinks. It's unsafe (outside elevator without security). when I left this morning, a transient was sleeping in the elevator.
- Evaluation forms with more space for comments.
- Once in a while a convener has to interrupt a speaker who has gone way over his/her time limit. I would rather have seen Ann Shannon's videos than the ends of the talks of the people who preceded her.
- Thank you for a wonderful experience and conference. I appreciate the work everyone put in to this.
- It would be nice to have city and place of employment on name tags
- I am already looking forward to next year.
- Really nice mix of perspectives; such an important message and I expect that the conference will become more relevant and important over the next couple of years.
- Please establish an electronic mailing list!
- The MSRI support was outstanding (as always).
- I didn't have any experience with the MSRI staff, and wanted to say N/A to that question, but there was no N/a option. I couldn't submit my survey without answering that question, so I just marked "3"
- It was an interesting format. I am still thinking about what might have improved the collaborative time. For me, getting started was confusing and took significant time. The last two group reports did not add much (for me).
- Let everyone know that the lectures will be up on the MSRI website and get them there quickly.
- Too much packed into a short amount of time. No time to process the information in the sessions before we were asked to go to working groups and write problems.
- Excellent and inspiring conference
- I found the assorted literature (proceedings of earlier conferences, brochures, etc. both interesting and useful. The opportunity for talking and discussing confrence presentations and work in the subgroups was very good. Good connections among ideas and other people were very good.
- This was my first workshop at MSRI. I was very pleased with the overall workshop and felt like I left with a lot of information. I also feel I could contact others from the workshop if I have questions in the future. I would definitely attend another workshop if it related to my research interests. I would also forward information to others if I thought they would be interested. I like that we heard from folks from all backgrounds, especially the current classroom teachers. It was also informative to hear from both assessment consortia and the CCSSM writers. This was an interesting group of folks brought together and it made the experience even more enjoyable. There were many folks I would never have met or had a chance to talk with had I not attended this workshop. I'm hoping we will have access to the presentations in the near future for future reference. I greatly appreciate MSRI providing me with funding because I never would have been able to attend if they had not helped me out. The week was a whirlwind, but it was interesting, challenging, informative, and fun. Thank you for the great experience!
- This is vital and exciting work. Thank you for your leadership!!
- This was an incredible opportunity. Thank you.
- Thanks for your hard work!
- Thank you for all of the hard work!

What was most valuable about the working groups, and how could the working groups be improved?

- different perspectives and different levels of experience were great. slight improvement would have been to make expectations for the task more clear

- It was great to work with people who have different backgrounds for one purpose and experience to communicate them.
- I missed the first day of the conference so I don't think I can speak with authority on how the groups were introduced or how our charge was given. I was confused during the the first meeting on Thursday about what we were trying to accomplish and why. I think having a model of the reviewing an item with the question set you provided would have been helpful.
- The process we engaged in was extremely beneficial. It was not so much about dissolving boundaries related to our areas of expertise as much as it was an exercise in group work and consensus-building. It might have been helpful for group leaders to focus on "task" and redirect group if a precise formative assessment was the only desired outcome. It seemed that we all agreed that our process was beneficial and the dialogue was rich. Perhaps not what MSRI intended, but for participants we each had positive "take-aways."
- Most valuable: 1. experts sharing perspectives, issues, and methods 2. colleagues from various places sharing diverse experiences. Ways to improve: more specific examples of assessment items
- The working groups were a great place to generate discussion, concerns, and excitement. As a high school teacher, it was great to talk with other motivated h.s. teachers and those academics that were here to collaborate.
- Small group interactions were superior to the expanded groups.
- Some working groups might have benefited from a focused charge.
- The discussions brought out important issues about assessment. It was rewarding seeing the complexity of some of the items which were often more sophisticated than I expected.
- I loved working with people with different kinds of expertise than mine. It great to create task that included many perspectives.
- More diversity in terms of people in the groups. More focused tasks.
- The working groups provided a nice opportunity to talk to other participants in the workshops. But I thought that the format was very rushed and constrained, so that it was difficult for ideas to develop.
- This was a good exercise to see how it is to work in diverse groups to create items for difficult to assess topics.
- The process could have been more clearly explained. The schedule was unclear with two different times for lunch on Friday, etc.
- The working groups were the most valuable aspect of the workshop, to my surprise. This was because we were talking about concrete things. I think it would have been helpful to spend much more time in the general sessions discussing concrete examples of specific questions and the issues that might arise from them before going to the working groups. For example the discussion of the y-intercept problem came up several times and seemed to give a context where people could say more specific and useful things. General lists of abstract features in social science jargon were not very helpful, comprehensible or interesting to me. For me it would have been very helpful to have those ideas illustrated with well-chosen examples. When mathematicians teach math they have to resist the urge to present the abstract general case. Save that for the journals. If the purpose of the workshop is to break boundaries between various professionals of varying expertise, it seems to me that this is best done with concrete examples that allow these various points of view to interact. This happened more in the working groups, but the general sessions did not promote this very well, at least for me. It would have been helpful to offer a pool of specific working group projects, as a starting point for the group discussions. We were lucky that one of the group members proposed something reasonable, but it could very easily have bogged down in unproductive wrangling (not that we did not spend plenty of time on that despite the best efforts of the group leaders).
- Our group did not involve a mix of constituencies (we were all teachers). So from the point of the view of the goals of the conference, it was not ideal. Still, it was interesting to work together on the task. Overall: I appreciated that teachers had a significant presence as presenters.
- The working group set-up demanded that we focus on the assessment of specific standard(s) and gave us a feel for the work in the weeds that we couldn't have gotten any other way. The need to attend to detail, collaborate, make the most of constructive criticism, and put ourselves in the

places of students and teachers was quite valuable.It would have been nice to know what will happen to our tasks -- will they actually be reviewed further, or was this simply an academic exercise, as it were?

- I appreciate the extent of time for collaboration. I felt however that the organization and structure was not well defined
- Having voices from different subsets of the education space was very informative. The aggregate knowledge of the groups were very powerful. We felt rushed and had to define our task. The task of "assessing a proficiency that is difficult to assess" may have needed a better framing. If it was framed, I missed it. The goals for each working group session were well defined and kept the group working productively, once we had an idea. Creating the initial idea and breaking into subgroups all felt awkward, but we had fun.
- exchange of information
- I liked the working groups, but I would have liked to worked in a slightly smaller group to start. It also would have been helpful to have as a first activity a chance to critique some premade assessments, to prep for making our own.
- More clear task to focus us; we spent too long trying to decide what to do. Most valuable - meeting and learning from some different people.
- Meeting other educators and the discussions involved in creating assessments.
- Talking with other professionals from various fields
- Increasing engagement with key issues
- The chance to collaborate with peers. I arrived late to the first meeting so I didn't get to hear the short bios. It would have been nice to have each participant fill out a short bio during registration and have a list of the participants with the bios posted on the workshop website.
- It was valuable to see in action educators from "top" to "bottom" working together. The peer review aspect of the exercises was quite valuable.
- It was great to be able to talk to people from a variety of backgrounds about something I have spent a lot of time working on recently. It would have been nice for me to be able to talk to more teachers and try to get them involved in IM which is something that they can work on whenever they have a free moment and their help is really needed.
- Valuable: Shared expertise, instant feedback to improve ideas, different perspectives. Improved: More clear goal to help groups orient faster to the work
- The most valuable thing were the ideas from people with different views and backgrounds. The way to improve the groups would be to give a little more time, and to have a little better space.
- Talking with and working with other math educators.
- I really liked working in our smaller (4-person) working group. Everyone's voice could be heard, and we all participated. When we were in an entire (example: Group 11) group, or in a Red or Blue group, those with the loudest or most insistent voices tended to take over. It was not really clear to me what the purpose of the working groups was. Was it, as someone said to me, consciousness raising? What will happen to those assessment items we created? Was creating them a goal, or was it just the process? I didn't think that was clearly explained.
- It was great to work with experts from the various fields. The discussions that came from the working groups were incredible. However, as mentioned in our large group, it would have been good to debrief or have time to process the presentations in our groups before putting the information given into action.
- Bringing together people from different perspectives was valuable. I think a framework or protocol for designing tasks would have improved the focus of discussions and quality of the tasks created.
- As a mathematician, I think the most valuable aspect was the opportunity to exchange ideas with educators about issues surrounding the CCSS, since the students affected by the standards will soon be our students.
- I wasn't able to see the process through, as I only participated in 2 of the sessions with my group. I really like the idea of the working groups, and focusing on collective task creation. It holds the potential to help us generate a collective understanding of quality performance tasks, and get us, collaboratively, to reflect on the core mathematics students should engage in during school. It

also provides an opportunity to get to know other mathie colleagues better by working together on an assignment. What I observed was that there were very different opinions about what constitutes a "task", and a lot of confusion about our charge. Our group lacked focus, and my sense was that we were focused more on skill-based procedural activities than a true performance task. I'm hoping the group was able to come up with a task that would engage students in productive struggle and go after some important mathematics--I would have liked to see the project through, but couldn't. Perhaps a little more front-end work with our group leader, so she were better prepared to facilitate the group process would have been helpful.

- I was able to see different perspectives from different members representing different communities. I learned how difficult it is to create a task. Also it is important to be patience and try to understand what others are saying in the group. I learned from my group members. When the groups were joined together, the discussion was not at all helpful. But later on when many groups came together during lunch time, it was somewhat productive discussion.
- Maybe I'm just saying this because I'm a teacher . . . but I would have run the working groups more like a class. The end goal was unclear. An exemplar would have been helpful. The role of the facilitator was ambiguous, they should have been formally trained in their role and supported in such before and throughout the conference. Expectations of HW completion were unreasonable. Space was not ideal, but there was obviously nothing we could do about that . . . Maybe try a different kind of jigsaw for the final share out (which was cancelled I guess?? That was never clear to me. I don't think you should have cancelled just because all of the adults were complaining!!). Anyway, it would have been cool to assign each person in each of the medium groups (green, red, etc.) a letter (maybe a Greek letter to get all mathy) and then all the alphas get together and share out (whip around style), all the betas get together, all the gammas get together, etc. That way, we learn what the other working groups did, but it's not this huge monster thing. Additionally, if people know that this is where things are going, they will be more accountable to pay attention/participate. More protocols would have been helpful for SURE! Group work is HARD!! Adults need just as much careful scripting of the LP (if not more!) than kids.
- Working groups would be improved with clearer protocols and objectives.
- Need to have clearer goals and more working group time scheduled
- Time to collaborate and talk through the process. The first larger group reporting time was enough, but I think the organizers felt this to be true as well. Also, we worked in a group of 3, which was a good size for sharing ideas. At least one other group with 4 members reported the same thing. The larger group of 6 or 8 was too many to work on a single assessment item.
- Most valuable: 1. Working with a variety of stakeholders gave a broader picture of strategies and challenges. The initial one on one discussions in the small groups allowed very personal insights, and as the groups grew larger, a broader perspective emerged. All in all, an excellent structure. 2. The task was "group worthy" both as a learning experience and the usefulness of the final product. This was the best audience participation opportunity of any conference I have attended.
- Collaborating with others was valuable. Having white board space or chart paper would help. Also, all participants should be asked to bring laptops or tablets.
- It was a nice mix of people and when they were small there was lots of useful communication. As they got bigger, they broke down in terms of functionality.
- They gave us a chance to solicit opinions from professionals across disciplines, which cast a wider net when it came to judging the task of assessment writing. It also brought a hands-on spirit to the conference, which was very helpful because most of us learn by doing.
- I could suggest having at least one math education person in each group, and possibly a representative from the assessment consortium, so we can have a perspective of both the classroom and the logistics when we write assessments.
- Problems could have been written by the organizing committee, or ideas could have been generated and then the working groups could have made them better. Too much time was spent thinking of a problem. While the directions were to bring problems we are working on and materials with us, I wasn't working on any problems and didn't want to add weight to my suitcase to bring books. It is always great at MSRI when we work in groups with mathematicians, math educations, and teachers. I learn so much from the others.

- My working group was very good and I can say that I learned a lot from my partners. We are sharing resources and information, so the collaboration among us just started...
- The working groups were an excellent opportunity for people from various expertise to work on a specific task, which brought out different points of view. The differences were not necessarily overcome but getting to know each other was perhaps valuable for the future work that we all will be doing in bringing the CCSSM into the use and intended effects.
- Improvement: Assign working groups to purposefully mix participants with different professional roles. Have them define their roles when they register so that you won't have to depend on people filling out surveys. Having the working groups was a good innovation.
- It was valuable to be able to have time to talk with and collaborate with others. I wondered whether a slightly different set up, focused on using existing tasks rather than writing our own, would have been useful. It would have been helpful to provide more framing at the start of each of the working group times. While instructions were written up (very helpful), my group often spent a good chunk of time trying to figure out what to do once we got into the working groups.
- It would have helped to have had greater clarity around (a) working group goals, and (b) outreach to workshop participants in advance to better facilitate our work as we get started.
- Opportunity to talk to others with different perspectives about how to assess students' mathematical proficiency.
- I have a lot of "satisfactory"s above despite thinking that the conference was, as a whole, very excellent. Working groups are somewhat innately problem-riddled...one possibility for preventing the worst of personality conflicts (not that I think there were many) is to select groups as early as possible and let people email contact ahead of time.
- Excellent conference. Great selection of speakers, relevant to the topic. It was very enriching to have a variety of expertise within groups that highlight the difficulties of developing "good" assessments, and the importance of bringing together such variety of points of view beyond the conversation, into the design of assessment tasks.
- Thinking carefully about the standards and issues that come up when assessing them.
- We got stuff done, leveraging each other's expertise well and effectively.
- Seeing and meeting people who create the assessments and how far removed from the classroom they are.
- The most valuable aspect was walking away with a product that can be used after the workshop.
- Although it was very nice to have discussions in small group settings, the goals of the working groups were not explicit enough to make all of the time in the groups productive. Because the group leaders were not a part of the planning process, it seemed hard for them to keep the groups on track. It might have been helpful to have a bit more context included in the assessment designing assignment, and more attention to building common language around what formative assessment should be. Additionally, it was unrealistic to expect participants to work on edits to the assessments after the conference ended for the day. Once the working groups moved to the "medium size" it was really too big for productive conversation. Also, it seemed that although much thought was taken to determine the small groups, the medium groups were not so well structured. For example, my secondary formative assessment group was paired with an elementary summative assessment group, making conversation even more difficult. It was a wise choice to have the color-groups facilitated and to eliminate moving to a whole group discussion.
- The in-depth discussion of various problems/items that can be used to assess learning were particularly interesting an useful. This bridged item difficulty, cognitive demand, open-ness, several or many correct answers to problems, appropriate grade level, prior knowledge, and other aspects, and how they fit with the Common Core. The Common Core served as a focus for creating and revising items for evaluation. Also, the distinction between formative and summative evluation was clarifed in various cases of items. How could the work of the Working Groups be improved? No suggestions in particular, but if I really was "forced" to suggest something, it might be that it might be useful in a plenary session, at the beginning of the conference, to 'work through' an example of item preparation and weighing its importance in terms of whether or not it measures what it was thought to measure, how it 'fits' to the Common Core, an example of a good item and an example of a 'bad' item (and how it might be modified into a more usable form or format).

- The various levels of expertise and passion. I loved that both Pure Mathematicians and Educational Mathematicians were together.
- I enjoyed working with individuals from different backgrounds. It made the conversation interesting and the task more productive. I would not have learned as much had I been working in a group of individuals only having a similar background to my own. I did not feel like we had enough time to work together to write a complete task. The allotted feedback times were not long enough and did not provide for enough discussion to improve our items. By only having written feedback, it made revisions difficult because the other groups did not know how we came to our task or the rationale behind it. It would have been easier if we'd had more time to talk with other groups and receive oral feedback so we could explain our reasoning and they could better articulate their questions.
- It was most valuable to work closely with others who had different backgrounds (I am a mathematician and I worked most closely with a math teacher). It was very beneficial.
- The facilitator Tried to have people Collaborate however someone did sort of take over the process who didn't know math. I thought our product was less than satisfactory. On the bright side, I really think the configuration of mathamaticians, teachers, & professors is the right one. Just need more training to work together.
- The opportunity to work with colleagues from across the country. This gave me a valuable perspective on how people are experiencing the changes in math education on a national level. A few of the university level participants seemed to drift off (not attend), or did not participate actively/productively in the working groups. That said, I learned a great deal from meeting with the policy experts and academics during informal (discussions over food, in passing, etc.).
- I appreciated the opportunity to work in small teams over time. Especially salient was the opportunity to communicate virtually with our partner team. Their comments were insightful and moved us further along.
- The process lost some focus when we merged for the third time. The leadership made a good call to cancel the final round and encourage a time of discussion instead.
- A person in our midst rather rudely inquired about the actual purpose of the group work, intimating that it did not seem like a good use of time. On the contrary, I, and I believe others in our entire original team of ten, felt like it provided an opportunity to really dig in to the assessment issues, to understand experientially the difficulty of writing excellent tasks, and to make connections with some other participants with whom I never would have gotten the chance to know!
- The idea of structuring the conference around a constructivist exercise in item writing
- was very ambitious. Because of our space limitations, it was often hard to reconnect between sessions. Also, the commitment to completing the task varied. This model needs re-thinking; shorter time frame for items? More structure from coordinators of groups?
- People need to be informed ahead of time of the outcomes so that they can come prepared with resources and laptops. The web-site was not user friendly and extremely frustrating at times. We had to spend too much of our time on this versus being able to spend time on more meaningful things. There also needs to be adequate "space" provided to be able to collaborate/discuss/work on the task more effectively. We never really understood the intended outcome of our task until Friday. We thought the intention was to have these great mathematical discussions around the task(s)/assessment items themselves not necessarily that we needed to have a finished product.
- Better organization of working groups, specifically more diversity. Self-organized groups tend to be monocultures. In my own group there were 5 mathematicians and one teacher.
- The leadership in the breakout group was critical because they provided structure to the group's work.
- The discussions, hearing everyone's input was very valuable. Also, how much time it takes to write a good task that is clear to others, not just the writers.
- Most valuable = 1) working dynamic was open, inquisitive and productive. Framing of working group time and expectations by coordinators facilitated this; 2) a participant joined our group midday on day 2 and added a new view and insights that enabled us to move our thinking. It was a plus that he was able to move into our group midway. Improved = Not sure if possible, but a little more time for discussion of presentations in working groups (or Q&A after each). Everything

on schedule was valuable and so it was hard to find time to reflect back on ideas presented, questions raised in light of them.

- Make sure that there are all the different stake holders in each group. My group only had high school teachers and a graduate student.
- I was actually only able to attend the first evening's sessions, and was not part of a working group. However, I did recruit several colleagues and heard from them that the working groups were very valuable. One concern was the lack of clarity of the task at hand (writing of assessment items) - especially at the elementary level.
- Enjoyed the diversity of groups and how much everyone brought to the table. I think the smaller groups worked best. Once three were joined it was almost too big.
- The purpose of the working groups was not discussed. One person thought we were being "milked" for our ideas. I've worked enough in assessment to think that rather unlikely. My conjecture was that it was a conscious-raising exercise. One of the later talks did mention the idea that designing good assessment is hard. However, in my experience, the realization that designing assessment is hard tends to come after seeing what students do with the tasks. This would be difficult to orchestrate in a conference.
- Most valuable was the broad group of people. Could be improved by keeping us in medium groups for longer engagement.
- The most valuable aspect of the working group was the communication and collaboration on what formulates "good" assessment. Specifically, after the assessments were created it was supportive to have other groups discuss the assessments together. I would have liked to have spent additional time talking about how students might respond to the assessments created and what assessment of the student(s) can be made from those responses. I would of also like to have had the whole group come together to discuss the assessment items in some way.
- The diversity of math experiences of the working group I found to be most valuable. The expectations of the task seem to me are not very explicit. Different people had a different interpretation what we were trying to accomplish.

MSRI Mathematical Sciences Research Institute

Circle on the Road Spring 2013

March 8 to March 10, 2013

MSRI, Berkeley, CA, USA

Organizers:

Amanda Serenevy (Riverbend Community Math Center)

Dave Auckly (Kansas State University)

Jonathan Farley (Research Institute for Mathematics)

Hector Rosario (University of Puerto Rico, Mayaguez)

Mark Saul (John Templeton Foundation)

Diana White (University of Colorado Denver)

Final Report on the 2013 Circle on the Road Conference

Organized by the National Association of Math Circles, an organization of the Mathematical Sciences Research Institute

March 8 – 10, 2013

"(An) Awesome collaborative experience of living, breathing, doing, talking, thinking math with an inspiring and wonderfully diverse group of kindred spirits! It provided a much needed perspective that helped reinforce and fuel and improve my continuing local efforts." This is the energy and enthusiasm that inspired the 2013 Circle on the Road Workshop.

The workshop took place in the Department of Mathematics at University of Puerto Rico, Mayagüez. The conference organizers were Hector Rosario of the University of Puerto Rico, Mayagüez; Amanda Serenevy of Riverbend Community Math Center; Brandy Wiegers of San Francisco State University; Diana White of University of Colorado, Denver; Dave Auckly of Kansas State University; Jonathan Farley of the Research Institute For Mathematics; Mark Saul of Courant Institute of Mathematical Sciences New York University.

The goal of this workshop was to provide support to new and experienced Math Circle leaders, particularly in Puerto Rico, where interest in math outreach programs for students is high but no Math Circles currently exist. This year, we worked hard to include the American Institute of Mathematics in our plans so that we could serve leaders of Math Circles for teachers as well as leaders of Math Circles for students. We also included several members of the Math Education community to foster collaboration and to orient Math Circle leaders to the new Common Core State Standards for mathematics being adopted at this time around the country. The workshop included information for leaders about both logistics and content creation for Math Circles. The workshop schedule is below.

Friday, March 8, 2013

Meet in the Luis Monzón building in room 201

9:30 – 10:00 AM Meeting for Lead Presenters for Julia Robinson Mathematics Festival

10:00 – 10:30 AM Registration and Snacks

10:30 – 10:45 AM Welcome and Introductory Remarks

10:45 – 11:00 AM What are Math Circles? Mark Saul

11:00 – 11:15 AM What are Math Teachers' Circles? Diana White

11:15 AM – 12:00 PM Sample Math Circle. Dave Auckly

12:00 – 12:10 PM Break

12:10 – 12:55 PM Small Group Discussions: Math Circle Experiences and Plans

12:55 – 1:00 PM Before Lunch Announcements

1:00 – 2:30 PM Lunch

2:30 – 3:00 PM The Navajo Nation Math Circle Project, Henry Fowler and Tatiana Shubin

3:05 – 4:00 PM Breakout Sessions: Great Ideas For Math Circle Leaders

- Math Circles for Elementary Students
- Math Circles for Secondary Students
- Math Teachers' Circles

4:00 – 4:15 PM Break

4:15 – 5:00 PM Julia Robinson Teams Meet

5:00 – 6:20 PM Set-up for Julia Robinson Mathematics Festival

6:20 – 6:30 PM Break

6:30 – 6:45 PM Julia Robinson Teams Jigsaw 1 (see what other groups are doing)

6:45 – 7:00 PM Julia Robinson Teams Jigsaw 2

7:00 – 7:15 PM Julia Robinson Teams Jigsaw 3

7:15 – 7:30 PM End of Day Announcements

Saturday, March 9, 2013

Julia Robinson Mathematics Festival

Meet in the Anfiteatro de Enfermería

8:00 – 9:00 AM Prepare for arrival of participants (Breakfast items available)

9:00 – 9:30 AM Participant registration. Puzzles and Games.

9:30 – 10:30 AM Math Circles (Teams A1 through A6 present)

10:30 – 11:00 AM Inter-session Puzzles and Games

11:00 AM – 12:00 PM Math Circles (Teams B1 through B6 present)

12:00 – 1:00 PM Puzzles and Games (Lunch items available)

1:00 – 2:00 PM Math Circles (Teams A1 through A6 present)

2:00 – 2:30 PM Inter-session Puzzles and Games

2:30 – 3:30 PM Math Circles (Teams B1 through B6 present)

3:30 – 4:00 PM End of Day Puzzles and Games

4:00 – 5:00 PM Clean up and Rest

5:00 – 7:00 PM Banquet in the Anfiteatro de Enfermería

Sunday, March 10, 2013

Meet in the Luis Monzón building in room 201

8:00 – 8:30 AM Breakfast Available

8:30 – 9:00 AM Resources and Opportunities Available to Math Circle Leaders

9:00 – 10:30 AM Featured Recreational Mathematics Talk. Chaim Goodman-Strauss

10:30 – 10:45 AM Break

10:45 – 11:45 AM What are the Common Core State Standards for Mathematics. Kristin Umland

11:45 AM – 1:00 PM Lunch

1:00 –2:45 PM Workshop: Matching Math Circle Ideas to the Common Core State Standards. Robert Ronau and Christopher Rakes

2:45 – 2:55 PM Break

2:55 – 3:00 PM Plans for Continued Work With Common Core State Standards. Amanda Serenevy

3:00 – 3:45 PM Rotating round table discussions: recruitment, reaching under-served populations, retaining students, fund-raising, bringing Math Circle ideas into classrooms, evaluation.

3:45 – 4:00 PM Concluding Remarks / Evaluations

Participant Data and Comments

There were 67 adult participants in attendance of the Circle on the Road Workshop, 27% of which were male and 39% of which were female (34% declined to state), representing a variety of institutions at all levels from all over the United States. These adults organized and taught at the COR Julia Robinson Math Festival which was attended by 56 students, teachers and parents from the greater area surrounding Mayagüez, Puerto Rico.

The majority of the Workshop participants represented leaders of new Math Circles, as 67% of them had been involved with Math Circle for less than 2 years. In addition, half of the participants were involved with teacher Math Circles and more than half are working in Math Circles for students of all levels. Many of the participants had attended previous Math Circle events, such as the special sessions hosted by the MAA SIGMAA on Math Circles (MCST) at the Joint Mathematics Meetings and MathFest. That said 43% of participants have never attended any previous Math Circle events. An overwhelming majority of the participants (over 96%) indicated that the Circle on the Road Conference should be repeated in the future and that they would like to attend again while also recommending it to their colleagues.

The most popular sessions from the 2013 Circle on the Road were the featured math speaker (Chaim Goodman-Strauss) and Breakout sessions where the attendants had the chance to meet and discuss good ideas for Math Circle Leaders of different levels. We look forward to incorporating these successful components in the next conference, Circle on the Road 2014, will be held in the Spring of 2014. We are currently finalizing the hosting application for the the 2014 program with the goal of having the program location and dates finalized by June, 2013.

In Summary: "*The CoR conferences provide an opportunity for teachers, mathematicians and professionals passionate about math and math education to share their ideals and diversity in how different individuals organize and run math circles, and this makes the math circle movement strong and robust.*"

More information about this workshop including videos and files shared at the Workshop is available online, https://www.mathcircles.org/content/circle-road-2013

Participants

First Name	Last Name	Institution
Ivette	Arroyo	Bayamon Military Academy
David	Auckly	Mathematical Sciences Research Institute
Louis	Beaugris	Kean College of New Jersey
Robert	Berkman	City & Country School/Manhattan Country School
Lhianna	Bodiford	Self-employed
Skona	Brittain	SB Family School
gloria	Brooks	San Benito County Office of Education
Mark	Brown	MidAmerica Nazarene University
Anna	Burago	Prime Factor Math Circle
Jamylle	Carter	Diablo Valley College
Diana	Diez	WALKS Elementary School
Marta	Eso	The Hotchkiss School
Addie	Evans	San Francisco State University
Henry	Fowler	Dine College
Elena	Galaktionova	University of South Alabama
Daniela	Ganelin	Art of Inquiry
Anna	Ganelina	Supernus Pharmaceuticals
Lorraine	Garrison	York International School
Laura	Givental	Bay Area Elementary Math Circles
Chaim	Goodman-Strauss	University of Arkansas
Angie	Hodge	University of Nebraska Omaha
Nadia	Kennedy	SUNY
Bob	Klein	Ohio University
Jane	Long	Stephen F. Austin State University
Nathalie	Luna	University of Puerto Rico
Kolya	Malkin	University of Washington
Maria	Nemirovskaya	University of Oregon
Mary	OKeeffe	Union College--Union University
Moises	Orengo	University of Puerto Rico
David	Patrick	Art of Problem Solving
Gabriella	Pinter	University of Wisconsin
Christopher	Rakes	University of Maryland Baltimore County
Janice	Rech	University of Nebraska
Harold	Reiter	University of North Carolina
Lauren	Riva	St. Mark's School
Lizbeth	Rivera	Bayamon Military Academy
Victor	Rodriguez	Bayamon Military Academy
Shannon	Rogers	Art of Problem Solving
Robert	Ronau	University of Louisville
Hector	Rosario	University of Puerto Rico
Amanda	Serenevy	Riverbend Community Math Center
Tatiana	Shubin	San Jose State University
Rodi	Steinig	Talking Stick Learning Center
Erwin	Suazo	University of Puerto Rico
Blake	Thornton	Washington University
Kristin	Umland	University of New Mexico
Nancy	Watreas	Riverbend Community Math Center
Diana	White	University of Colorado
Brandy	Wiegers	San Francisco State University

Officially Registered Participant Information

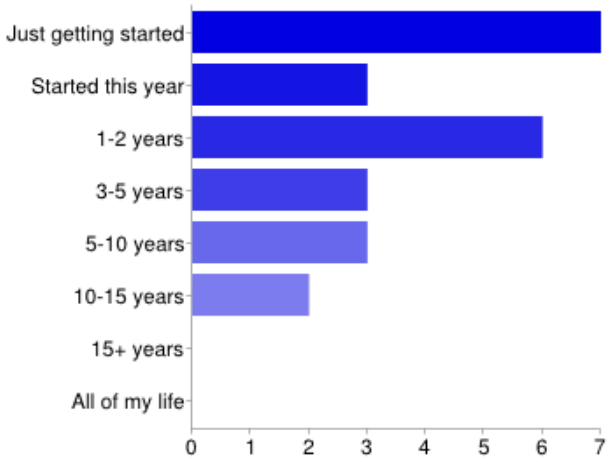
Participants		49

Gender		49
Male	34.69%	17
Female	63.27%	31
Declined to state	2.04%	1

Ethnicity*		49
White	71.43%	35
Asian	0.00%	0
Hispanic	12.24%	6
Pacific Islander	0.00%	0
Black	4.08%	2
Native American	2.04%	1
Mixed	2.04%	1
Declined to state	8.16%	4

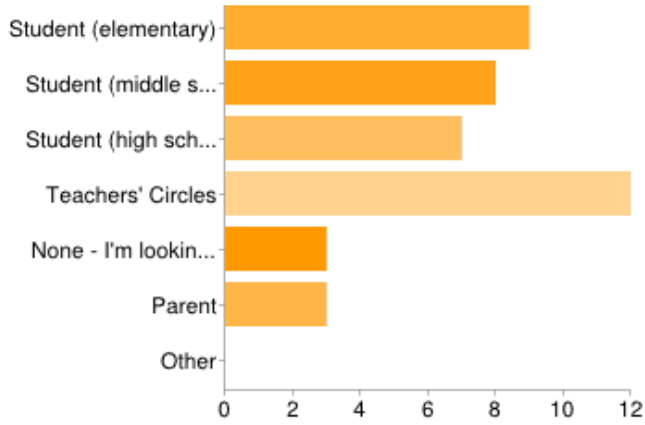
* ethnicity specifications are not exclusive

How many years have you been involved in Math Circles?



Just Getting Started	7	29%
Started This Year	3	13%
1-2 Years	6	25%
3-5 years	3	13%
5-10 Years	3	13%
10-15 years	2	8%
15+ years	0	0%
All of my life	0	0%

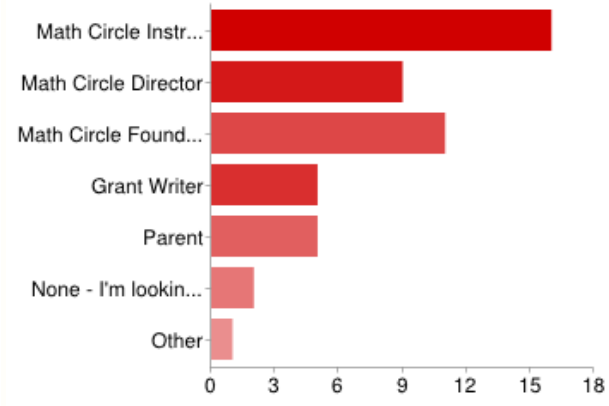
What types of Math Circles are you involved in?



Student (Elem)	9	38%
Student (Middle)	8	33%
Student (HS)	7	29%
Teachers	12	50%
None	3	13%
Parent	3	13%
Other	0	0%

People may select more than one checkbox, so percentages may add up to more than 100%.

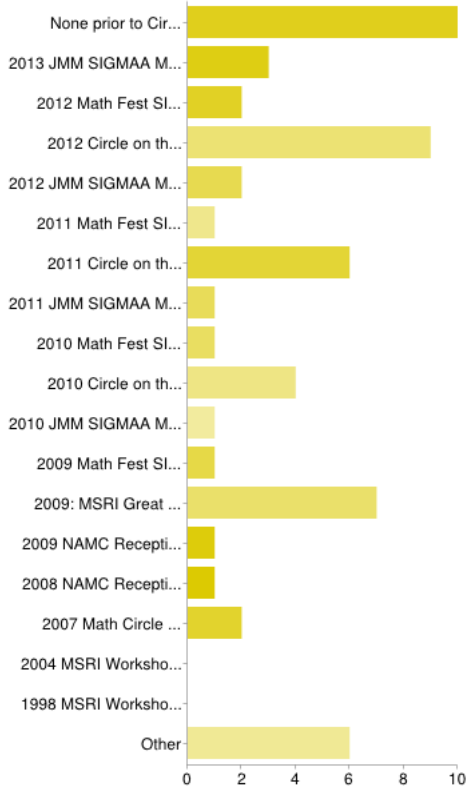
What is/ Will be your Math Circle role?



Math Circle Instructor	16	70%
Director	9	39%
Founding Director	11	48%
Grant Writer	5	22%
Parent	5	22%
None	3	9%
Other	1	4%

People may select more than one checkbox, so percentages may add up to more than 100%.

Have you attended previous Math Circle events?



None Prior to COR	10	43%
2013 JMM SIGMAA	3	13%
2012 MathFest	2	9%
2012 COR	9	39%
2012 JMM SIGMAA	2	9%
2011 MathFest	1	4%
2011 COR	6	26%
2011 JMM SIGMAA	1	4%
2010 MathFest	1	4%
2010 COR	4	17%
2010 JMM SIGMAA	1	4%
2009 MathFest	1	4%
2009 MSRI Great Circles	7	30%
2009 JMM	1	4%
2008 JMM	1	4%
2007 JMM	2	9%
2004 MSRI	0	0%
1998 MSRI	0	0%
Other	6	26%

People may select more than one checkbox, so percentages may add up to more than 100%.

Your Math Circle Experience

Please describe the Circle on the Road 2013 Workshop in 2 sentences.

It was awesome

It was motivational and stimulating. It exceeded my expectations and I feel more prepared to engage in circling work!

The Circle on the Road allowed me the opportunity to work closely with other Circle directors. These relationships will continue to develop and be a great resource in the future.

I enjoyed it thoroughly.

An incredibly diverse group teaching & learning together. An opportunity to truly broaden our horizons and get new perspectives.

Meeting, connecting with and working with other circle leaders is AWESOME. I came back home excited to use all the new ideas from the workshop.

Circle on the Road was a great meeting of bright, dedicated people. I got a lot of good ideas and inspiration for lessons.

I met a wide range of people interested in reaching out to young mathmaticians.
I connected with new math lovers and have a network of people with similar goals to reach out to.

A great experience in which people who doesn't like math at all can be included and have a new view of it. It was fun for the children as well as adults.

Awesome collaborative experience of living, breathing, doing, talking, thinking math with an inspiring and wonderfully diverse group of kindred spirits! It provided a much needed perspective that helped reinforce and fuel and improve my continuing local efforts.

It was refreshing to see both my students and son so enthusiastic in Math class.

A great opportunity to meet and get to know people with lots of experience running circles. I also really appreciated talking with people about other aspects of their careers, particularly math education.

Circle on the Road is a simple round link between a student, teacher, and a pronblem.

The CoR conferences provide an opportunity for teachers, mathematicians and professionals passionate about math and math education to share their ideals and practices with each other. While our motivations and ideals are very similar, there is great

diversity in how different individuals organize and run math circles, and this makes the math circle movement strong and robust.

This event was interested and amaizing. My students was very pleasent.
The workshop provided much needed opportunities to connect with more experienced math teachers' circles leaders. I feel like I am better prepared to start a math teachers' circle this summer.

This workshop filled my head with new ideas for my circle, and exposed me to new areas of math content knowledge. It also expanded my network of math circle leaders for support and collaboration.

Informative event, with enthusiastic math educators. It was very inspiring.

The Circle on the Road 2013 was a wonderful experience. I acquired a lot of information that will help improve my math circle.

It was a wonderful experience. I will love to do this with my students.

Inspiring gathering with interesting talks; Very valuable in terms of making connections, and get to know other people involved in Math Circles

Circle on the Road 2013 brought together students, teachers, and math educators from higher education in a tropical environment.

The place to exchange ideas about teaching: the place to teach and the place to learn.

Please describe 1 or 2 things that you gained by attending the workshop.
Great collaboration. A connection to Common Core Mathematics

Greater depth of understanding of tasks, temperament, and history of mathematics (teachers) circles.

It was very inspiring, an eye opener. I came back with a lot of new ideas for Math Circles, for working with teachers and for teaching my own classes.

I loved seeing presenters "in action" as they presented material/ideas that could be used in our own Circles. I left with great ideas!

Comraderie. Interest in the Common Core and its relationship to Math Circles.

Ideas for topics of future math circle sessions and an appreciation of different styles. Connections for resources

I came away with lots of ideas for future lessons and activities, and awareness of others' experieces.

I learned a lot about the different types and forums of math circles around the country. Such diversity! I discovered lots of new resources to use in my classroom and in math circle. I left with many new ideas and with a renewed enthusiasm.

Expand my vision of how important is to educate ourselves mathematically, since it helps us to see life in simpler ways. I really appreciate simplicity in this world full of complexities :)

Meeting and working with Gloria Brooks Brown was a fabulous and inspiring experience! She is truly glorious in her energy and enthusiasm and ideas!
So many wonderful phrases--I loved Gloria's concept of a ""math cave!"

The Navajo Nation work was incredibly uplifting and inspiring to hear about.

Chaim Goodman-Strauss's talk was an incredible high for me. I feel like I finally really *grok* non-Euclidean spaces now! And I have wonderful hands-on constructive ideas to share with my local community thanks to his workshop.

Since my Spanish is very limited, I *loved* the way that some of the English-fluent bilingual young students helped me learn the Spanish terms for the math concepts we were discussing. We were both learning from each other and I think it was very empowering for them to reexpress the ideas back in their own language.

I will be blogging about this.

Various activities to present in my classroom.
"Relationships with people who have been successful in running circles.
Good ideas about contributing more to the field of math education.

I discover how to gain the attention from the students with simple tasks.

I most benefited from the CCSS presentations, I feel this is going to be useful in my work with the local public schools. I also enjoy doing math, observing others teach and collecting good problems, and this conference is great for that.

I learned new assessment, and some mathemathica problems for my students.

The main thing I gained as expressed in the description above is that I was able to connect with others who are currently doing what I am beginning to do.
I saw connections between areas of math that earlier seemed unconnected to me.
ideas, enthusiasm, networking

1. Math circle activities
2. Math circles as a movement, as a community

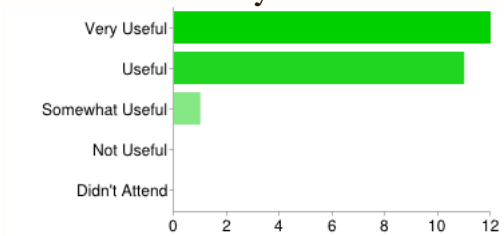
I gained knowledge about how important is to think and make students think.

Learned several new problems/ideas that I can directly use; Got to know several people who I can stay connected with

Tatiana Shubin's workshop was very interesting, and I enjoyed the artwork of Chaim Goodman-Strauss.

Several beautiful ideas about what can be taught in a math circle group

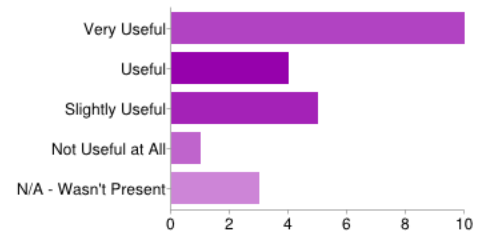
How useful did you find the Overall Circle on the Road Workshop?



Very Useful	12	50%
Useful	11	46%
Somewhat Useful	1	4%
Not Useful	0	0%
Didn't Attend	0	0%

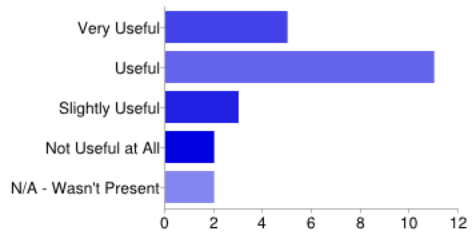
Follow-up Resources
Which topics were the most useful for you from the workshop Sessions?

What are Math Circles? Mark Saul



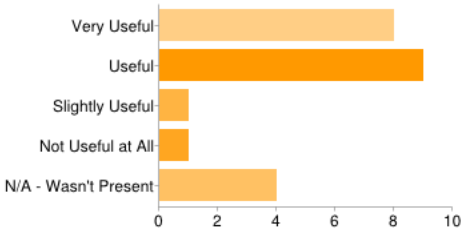
Very Useful	10	42%
Useful	4	17%
Slightly Useful	5	21%
Not Useful	1	4%
Didn't Attend	3	13%

What are Math Teachers' Circles? Diana White



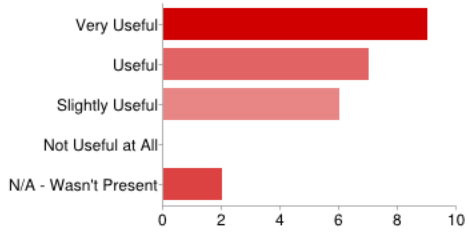
Very Useful	5	21%
Useful	11	46%
Slightly Useful	3	13%
Not Useful	2	8%
Didn't Attend	2	8%

Sample Math Circle: Turning Laughter into AH – a Trip with the Visually Impaired. Dave Auckly



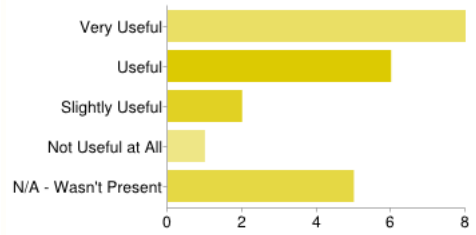
Very Useful	8	33%
Useful	9	38%
Slightly Useful	1	4%
Not Useful	1	4%
Didn't Attend	4	17%

Julia Robinson Math Festival Small Group Discussions: Math Circle Experiences and Plans



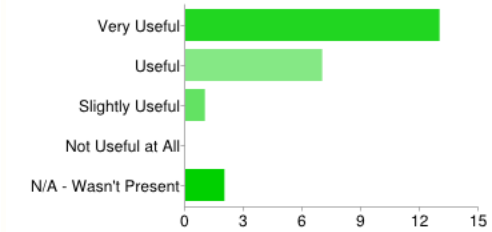
Very Useful	9	38%
Useful	7	29%
Slightly Useful	6	25%
Not Useful	0	0%
Didn't Attend	2	8%

The Navajo Nation Math Circle Project. Henry Fowler and Tatiana Shubin



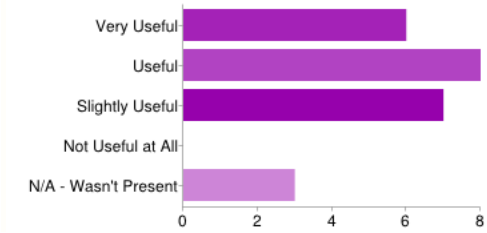
Very Useful	8	33%
Useful	6	25%
Slightly Useful	2	8%
Not Useful	1	4%
Didn't Attend	5	21%

Breakout Sessions: Great Ideas For Math Circle Leaders: Elementary, Secondary, Math Teachers' Circles



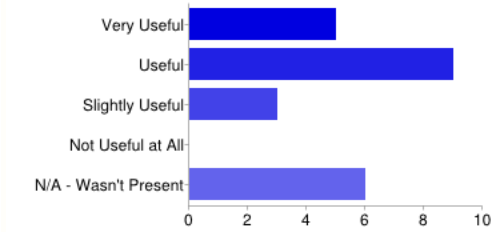
Very Useful	13	54%
Useful	7	29%
Slightly Useful	1	4%
Not Useful	0	0%
Didn't Attend	2	8%

Julia Robinson Teams Meet



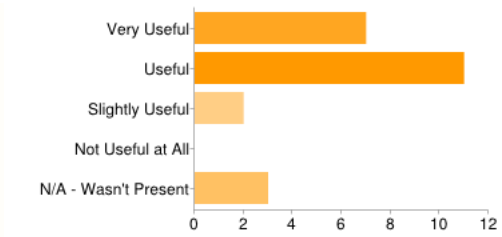
Very Useful	6	25%
Useful	8	33%
Slightly Useful	7	29%
Not Useful	0	0%
Didn't Attend	3	13%

Julia Robinson Teams Summaries



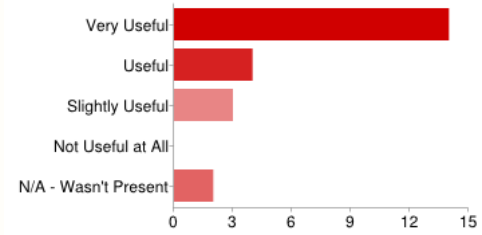
Very Useful	5	21%
Useful	9	38%
Slightly Useful	3	13%
Not Useful	0	0%
Didn't Attend	6	25%

Resources and Opportunities Available to Math Circle Leaders



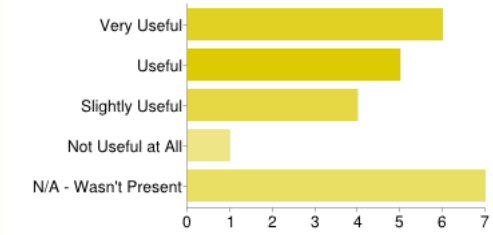
Very Useful	7	29%
Useful	11	46%
Slightly Useful	2	8%
Not Useful	0	0%
Didn't Attend	3	13%

Featured Recreational Mathematics Talk. Chaim GoodmanStrauss



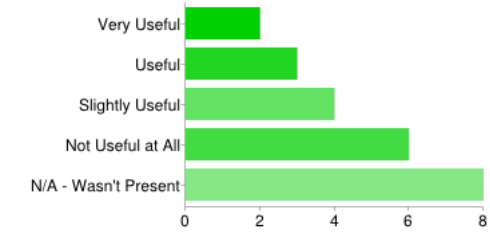
Very Useful	14	58%
Useful	4	17%
Slightly Useful	3	13%
Not Useful	0	0%
Didn't Attend	2	8%

What are the Common Core State Standards for Mathematics. Kristin Umland



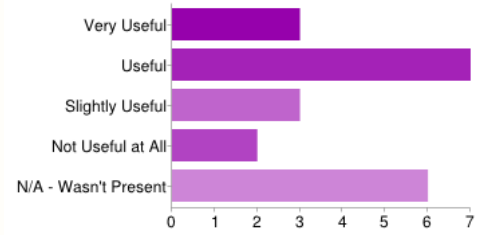
Very Useful	6	25%
Useful	5	21%
Slightly Useful	4	17%
Not Useful	1	4%
Didn't Attend	7	29%

Workshop: Analyzing Math Circle Lessons/Activities for Common Core State Standards for Mathematics Alignment



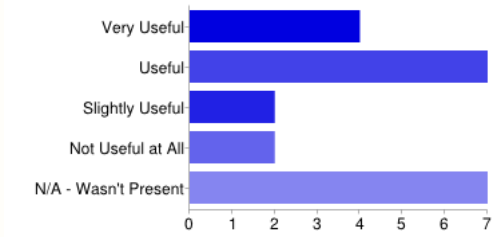
Very Useful	2	8%
Useful	3	13%
Slightly Useful	4	17%
Not Useful	6	25%
Didn't Attend	8	33%

Plans for Continued Work With Common Core State Standards. Amanda Serenevy



Very Useful	3	13%
Useful	7	29%
Slightly Useful	3	13%
Not Useful	2	8%
Didn't Attend	6	25%

Rotating round table discussions: Recruitment, reaching underserved populations, re training students, fundraising, bringing Math Circle ideas into classrooms, evaluation.



Very Useful	4	17%
Useful	7	29%
Slightly Useful	2	8%
Not Useful	2	8%
Didn't Attend	6	25%

Please share any comments related to your rankings above for the workshop Program

"What are Math Teachers' Circles?" was not useful because I am already experienced in the subject matter. It could be useful for others.

The things I love: fun mathematics, informal meetings with others running circles, hearing what others do, hearing about resources others have put together.

"I was very glad that the presenters of the Analyzing Math Circle Lessons for CCSS were in attendance, as I had very productive conversations with them, but I don't think that what they presented to the group was useful. I got the sense that they didn't have a very good understanding of what math circles are really all about, even though they thought that they did.

The ""Plans for Continued Work with CCSS"" session doesn't ring a bell. I didn't skip any activities but don't remember what was discussed.

The ""Round Table"" kind of got squeezed out due to time constraints. I was interested in this, but mostly asked questions of people during unstructured time. (I'm starting a teachers' circle.)"

I understand that you had good intentions creating some space for small group discussions and for getting to know each other. However, some guidelines need to be in place so that people don't dominate these discussions. Also, some of the technical difficulties were disruptive.

I find the Common Core discussions generally, not just at the Circle on the Road, to be tedious.

Julia Robinson Festival preparation negatives:
Compare to the past years, there was much less transparency in the festival preparation:
- there was no in-advance info about the lesson leaders and the topics of their lessons. (All the past years, the lists of topics and some of the lesson discussions were available way in advance on the wiki).
- there was no flexibility for apprentices in choosing a session: apprentices were assigned to their leaders. (All past years, people had a choice.)

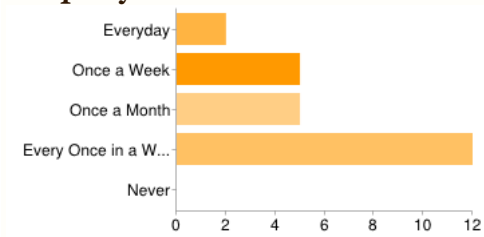
Workshop preparation negatives:
- there was no call for people to present on the workshop - all the presentations were planned by the organizational committee. Thus, compared to last years, there were fewer mathematically-interesting presentations.

Day 1
Negatives:
Too much time was allocated to team meetings. I am pretty sure that most of the teams did not need all this time. An interesting lecture would have been way more useful.
Positives:
Dave Auckly's lecture was a great demonstration of exciting math circle topic.

Day 2
Positive:
The Chaim Goodman lecture was brilliant. A person like him is a treasure of resources on new topics. If he agreed to come to a workshop, then he should be allocated a much bigger time slot for his presentations.
Negative:
The "" Common Core"" part was mostly not useful. The two ""common core"" guys who were running the ""Analyzing"" workshop were completely unprofessional. The impression was that they do not understand neither math-circle math, no regular math. ""Rotating round table discussions"" were too short to become useful as well.

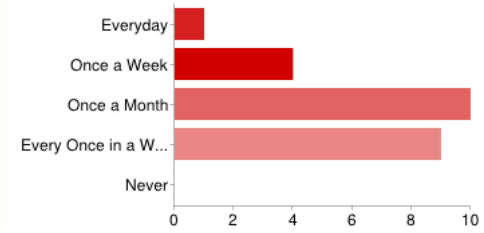
How often do you expect you will use the following resources:

People you met at Circle on the Road?



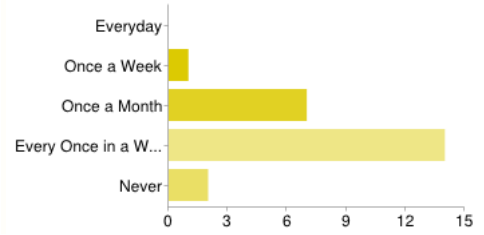
Everyday	2	8%
Once a Week	5	21%
Once a Month	5	21%
Every Once in a While	12	50%
Never	0	0%

Lesson plans for the sample circles (once posted)?



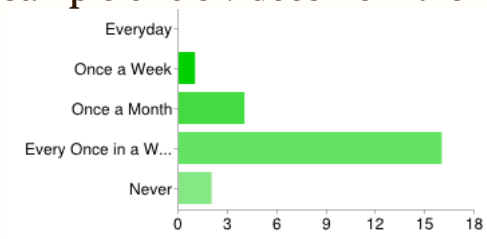
Everyday	1	4%
Once a Week	4	17%
Once a Month	10	42%
Every Once in a While	9	28%
Never	0	0%

Videos from workshop presentations (once posted)?



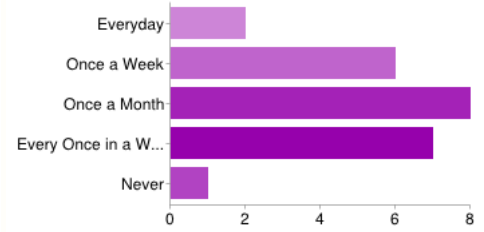
Everyday	0	0%
Once a Week	1	4%
Once a Month	7	29%
Every Once in a While	14	58%
Never	2	8%

Sample circle videos from the festival (once posted)?



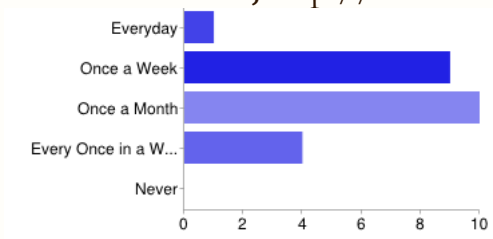
Everyday	0	0%
Once a Week	1	4%
Once a Month	4	17%
Every Once in a While	16	67%
Never	2	8%

MSRI Math Circle Library of Books?



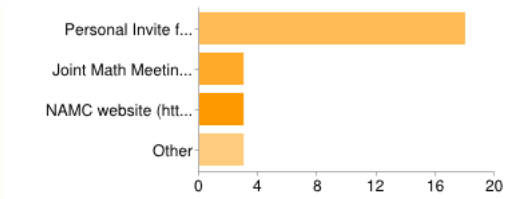
Everyday	2	8%
Once a Week	6	25%
Once a Month	8	33%
Every Once in a While	7	29%
Never	1	4%

NAMC Website, http://mathcircles.org?



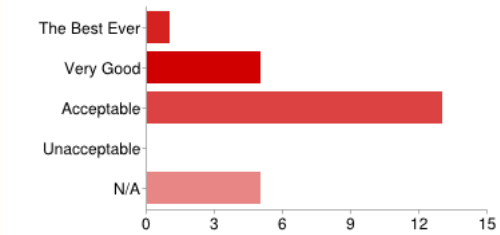
Everyday	1	4%
Once a Week	9	38%
Once a Month	10	42%
Every Once in a While	4	175
Never	0	0%

How did you hear about the Circle on the Road Workshop?



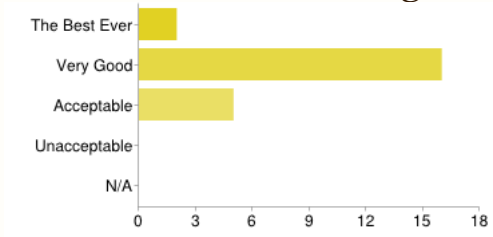
Personal Invite	18	78%
JMM	3	13%
NAMC Website	3	13%
Other	3	13%

Please Rank the Following Workshop Aspects: Pre Conference Publicity



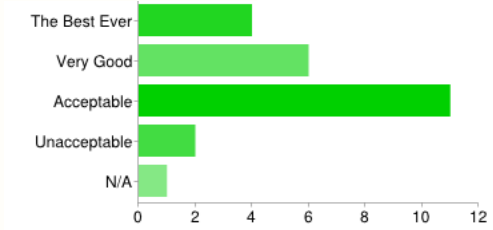
The Best Ever	1	4%
Very Good	5	21%
Acceptable	13	54%
Unacceptable	0	0%
N/A	5	21%

Please Rank the Following Workshop Aspects Conference Registration



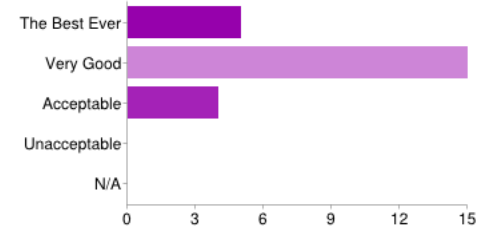
The Best Ever	2	8%
Very Good	16	67%
Acceptable	5	21%
Unacceptable	0	0%
N/A	0	0%

Please Rank the Following Workshop Aspects PreConference Communication



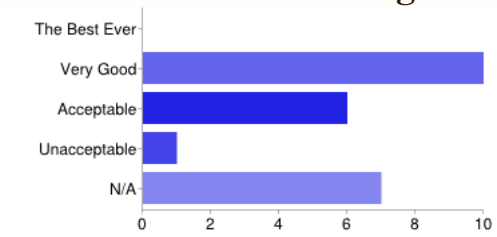
The Best Ever	4	17%
Very Good	6	25%
Acceptable	11	46%
Unacceptable	2	8%
N/A	1	4%

Please Rank the Following Workshop Aspects Math Festival (Saturday)



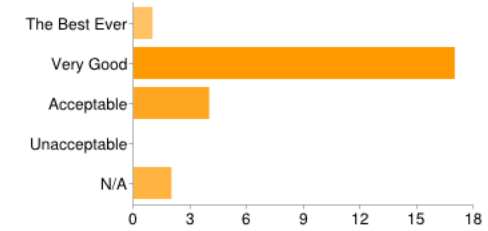
The Best Ever	5	21%
Very Good	15	63%
Acceptable	4	17%
Unacceptable	0	0%
N/A	0	0%

Please Rank the Following Workshop Aspects Math Circle Debrief



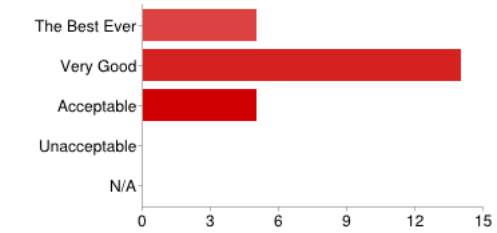
The Best Ever	0	0%
Very Good	10	42%
Acceptable	6	25%
Unacceptable	1	4%
N/A	7	29%

Please Rank the Following Workshop Aspects Math Circle Professional Presentations



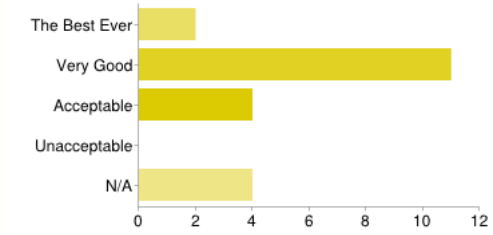
The Best Ever	1	4%
Very Good	17	71%
Acceptable	4	17%
Unacceptable	0	0%
N/A	2	8%

Please Rank the Following Workshop Aspects Banquet



The Best Ever	5	21%
Very Good	14	58%
Acceptable	5	21%
Unacceptable	0	0%
N/A	0	0%

Please Rank the Following Workshop Aspects PostConference Resources



The Best Ever	2	8%
Very Good	11	46%
Acceptable	4	17%
Unacceptable	0	0%
N/A	4	17%

Please share any comments related to your rankings above.

It was great!

It would assist the circle leaders and helpers in planning and preparing the sessions if you would keep a running list of talks with abstracts available on-line before the conference as you are getting the information.

Time could have been more efficiently managed.
Clear map/directions getting to building from hotel would have been great!
Better communication/efforts with schools to get kids at the Festival!

We need to find a closure method. The last workshop just drizzled away.

I would like to see a webpage, like juliarobinson.org or something. Its a bit difficult that its just a node under msri's webpage.

This was a very useful conference for me! The teachers' lessons on the festival day were great for me to see.

What was the Math Circle Debrief?

Logistics were problematic once we were at the university (not a problem beforehand). We didn't stick to the schedule very well and we had some problems such as lack of options for lunch on Sunday.

There also seemed to be a lack of focus, direction, and interest for the common core stuff on Sunday. Some people were interested in it, and some people thought it was useless nonsense. Personally, I saw value in the discussions, but it was clear that some people were going to derail the productive efforts with irrelevant comments. Kind of gave the conference a sour end.

I feel that the organization on Amanda and Brandy's part was very good, although there were some unexpected glitches after on site. I was very disappointed with the low attendance of the math festival by local students, especially in middle school and higher

grades. It was good that a teacher brought students from the military academy, but why couldn't more schools come?

I would have liked to have seen all the Math Festival lessons but did not because not enough students attended for the afternoon sessions to happen.

Send an email with the post-conference resources?

What was the "debrief"? I also don't know what the "professional presentations" were or what the "post-conference resources" are.

There was no pre-conference communication:
-the list of lessons topics and lesson leaders was not available in advance. (Compare to past years when lesson wikies were set up)
- there was not wiki space for lesson plans and discussions.
- there was no way for an apprentice to choose a lesson leaders
- there was no call for presenters for the conference - that is not right. The organizers should not rely on themselves to come up with a complete list of presentations.
Math circle professional presentations: While some were great, (like Goodman's), others were not too informative and some (like ""Lesson Analysis"") - a complete time waste.

Overall impression from the conference was that a lot of time was wasted for things that were not important.

Festival Activities
Please share any comments related to Saturday's Festival.

Not enough teachers and students attended!!

I wish there had been more kids there - there was so much for them to take advanatage of

Things were great! It is difficult to round up local kids and teachers, but we still need more. I do not know how I would do it, so I don't know how I would do better, but more kids need to be found.

I really enjoyed seen my children paying attention to what Amanda was telling them. Actually I think the Festival have boost their creativity and interest not only in math but physics. I like the idea that they inquire about everything. I think your resources where totally awesome!!!

Parents enjoyed a lot rotating on the centers that were displayed in the lobby of the building.

My students were very happy because they did something different. They could demonstrate their love to quest for knowledge.

See before. I think it was generally well organized (except food didn't seem to show up when it had to, but this didn't bother me), but I was disappointed with the very low turnout of local attendees. My own children attended a math festival like this for the first time, and my 3rd grader particularly enjoyed it. I feel lucky that she had a chance to attend workshops by some of the most experienced teachers. I was really impressed by the enthusiasm and friendliness of the local college student and other volunteer helpers. They were a very important part of the event.

It was a very useful.
I wish there would have been more teachers in the problem solving sessions.

No teachers came to the second session because they went to the first. So, it was kind of pointless to schedule it.
The Satyrday's Festival was well organized. Once the students started to arrive, it all went very well

The idea to contact teachers, and secure their commitment to bring their students was very effective for all parties concerned.
I liked the atmosphere with the kids interested in math activities. I helped with the puzzles and games section, although I didn't understand a lot of the puzzles myself.
"Saturday festival went well.

There were not too many kids. However, I believe that the organizer did everything they could to get students for the festival.

A2: Function Machine Garden (K3)

This session was very successful with a large group that we split into two. With the older kids (age 7-9, all English speakers), we discussed inverses, compounds, functions accepting geometric figures, and a variety of other function features. It was rather less successful with a second group of three younger kids, of whom only one spoke English.

Both my kids, 1st and 3rd graders, truly enjoyed this workshop, and continued making function machines during lunch break, over dinner, and over the next few days... definitely pitched at the right level.

I led this, and really enjoyed doing it with the kids. But, since the activity was story-based, I lost a lot of time having it translated into Spanish. In the future, with such an audience, I might want to prepare a less verbal lesson.

It was great fun to see the kids participating in this activity! Great ideas.

B2: Coloring, Handshakes, Maps, and More: Exploring Combinatorics. (K3)

Too guided to the sought-for answers - probably due to trying to cover too much in one session.
My Son enjoyed the activities a lot.

A3: This is Math? This is Math! (46)

My 3rd grader enjoyed this workshop very much, I think she did NIM, and explained me the poison cookie idea.

Observed and thought it was very good.

B3: Verbal Arithmetic. (46)

Presenter spent too much time at the board...seemed to be lecturing.

A4: The Cube Coloring Problem. (79)

Too pedantic - not enough open exploration.

This was my workshop. I had 8 students total in the two sessions combined. I think the problem was pitched at the right level, and several students got to a good point by the end of the session. I think I had more adult observers who came in to learn the problem than students....

Fun problem, kids were engaged and interested.

B4: Pascal's Triangle in Sidewalk Chalk. (79)

Love the idea of working outside!
Loved the visuals!
Way Cool
Guerrilla math circle sis a really neat idea!

Thanks to everyone who worked with me on this--to Gloria Brooks Brown who contributed awesome enthusiasm, energy, and ideas from the beginning, to Lauren Riva and Rain Garrison, who brought their enthusiasm and great ideas too, and to all the participants who stopped by and engaged with us, and especially to the wonderful students from Mayaguez who helped to construct this and take ownership of creating it.

I looked at this for a while and may do something like this with my students... I liked the kinds of questions Mary asked.

I like the use of outdoor space to do mathematics
Nice.

A6: The Cube Problem. (7-9)

I sat in on this workshop with my 3rd grader and truly enjoyed the problem. It was challenging for my daughter but she understood some points and I liked that Harold let the younger kids to progress at their own pace.

B6: Cryptography: Making and Breaking Codes. (7-9)

way cool. lots of interaction
Looked like it was really fun.
The middle school students really enjoyed the session.
Awesome

A5: The Spider and the Fly. (1012)

B5: Operation Cookie Jar.(1012)

The kids were very engaged - a really well-run math circle.

This was the best activity for them. They loved it because they offered different solutions to the problem.
I watched part of this workshop and Gabriella showed me the activity during a break. I really like it.

Observed and thought the activity was a good choice for high school students and could also be used with middle school students or middle school teachers.
Students were engaged , had great ideas.

A1: Parity Party (Teachers)

Great problems -- just needed more teachers in attendance.
Really liked this! Was glad to see how Tatiana facilitated.
A good session especially if more time would have available to work with the more "interesting" aspects of parity.
Needed more time
Really cool and interesting.

B1: The DBD Oil Spill. (Teachers)

Very interesting and challenging
This was a well-prepared lesson that I can see using myself. It gave me a different perspective on what teachers' circles can be, that they don't always have to be abstract problems.

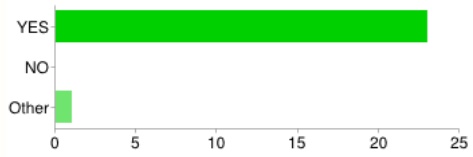
it is my opinion (which may not be a good opinion) that the activity is better suited for students than for teachers.
The teachers came late, so it got off to a start just by lecturing to the conference participants.
Needed more time
Nice application of math to a real-world problem.

Hands On Problem Solving: Origami, Ropes, So much more!

This was so engaging!
I had a ball!
Before the Festival I'd downloaded a few Origami and other Math applications to my tablet, but my children didn't pay too much attention to those. These past days they are always asking for them in their free time.
I didn't have a chance to play with these myself, but my family had a good time with the activities.
Fun activities!

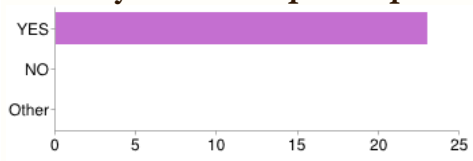
Future Circle on the Road Workshops

Should we repeat this event in the future?



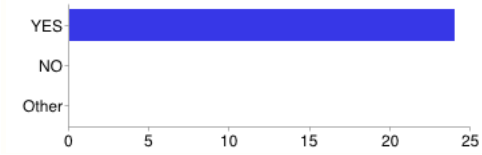
Yes	23	96%
No	0	0%
Other	1	4%

Would you like to participate in a future Circle on the Road Workshop?



Yes	23	100%
No	0	0%
Other	0	0%

Would you like to recommend to others that they participate in a future Circle on the Road Workshop?



Yes	24	100%
No	0	0%
Other	0	0%

Any comments about the future of this event?

I thoroughly enjoyed this event on a personal level. I feel the format should be reevaluated. The Saturday festival seemed like an exercise in futility. Is there a structure or format that would guarantee participants?
I want to be there for the next one :)
This is epic and awesome!

"A little better organization on the ground would be helpful, and a better sense of what issues will be the focus before we arrive. :)

Work with the local coordinator to adjust the schedule of the festival to local needs and practices, and try to give local schools some incentive to bring children in an organized way -- relying on the parents may not be enough.

Better organization of web information. More structured planning time for workshop groups. Very awesome overall!

There should be more presentations useful for circle leaders.

This is the space to add any last comments that weren't covered in other places in the survey.

The Common Core Standards talks were totally irrelevant and inappropriate for this conference, especially when given by people who do not have anything to do with the Math Circles. Talks about using math circle ideas in a classroom would be much more appropriate. I would love to learn from experienced teachers who are also Math Circle veterans. It is also appropriate for people who develop curriculum to ask for assistance with finding engaging tasks for learning the required school content. Whether this content is called "Common Core" or something else is irrelevant. Why not have a mini-workshop for participants: give us a content standard and a grade level and let us come up with great questions to ask.

We need to keep interest until the end, or put a really exciting speaker as closure.
Re the question a few pages ago that asked how often we'd use things - I just want to say that frequency isn't the right measure for me. I find these things to be extremely useful even if they're only actually used occasionally.

Thanks to all a of you who made this possible, to all who fed children with the light of knowledge and inquiry.

THANK YOU! This was very valuable for me.
I just want to thank Hector for invite our school and thank Weiger for help us during the accommodations.

Thank you to the organizers.

Hot Topics Workshop:
Surface subgroups and cube complexes

March 18 to March 22, 2013

MSRI, Berkeley, CA, USA

Organizers:

Ian Agol* (University of California, Berkeley)

Danny Calegari (University of Chicago)

Ursula Hamenstädt (University Bonn)

Vlad Markovic (California Institute of Technology)

REPORT ON THE MSRI WORKSHOP "SURFACE SUBGROUPS AND CUBE COMPLEXES" MARCH 18 TO MARCH 22, 2013

IAN AGOL, DANNY CALEGARI, URSULA HAMENSTÄDT, AND VLADIMIR MARKOVIC

1. Scientific description

Geometric group theory as a field has roots stretching back to the work of Klein and Poincaré in the 19th century, and Dehn in the early years of the 20th century, but in the recent era it emerged again in the work of Stallings, Thurston, Gromov and others. Both because of the interests of these practitioners, and the nature of the subject, geometric group theory has always been closely related to hyperbolic geometry, and the theory of 3-manifolds. Much work in the field has been concerned with "spinning off" ideas developed in the special context of manifolds and locally symmetric spaces for application in a broader context; but recently there have been some spectacular successes in 3-manifold topology that depend profoundly on work in "pure" geometric group theory.

In the last 12 months the work of Agol (building on work of many others, including Kahn-Markovic, Haglund-Wise, Wise, Agol-Groves-Manning) has led to a resolution of some of the most important outstanding questions in 3-manifold topology, including the virtual Haken conjecture of Waldhausen, the virtual fibration conjecture of Thurston, and several others. This resolution depended on an *a priori* unlikely interplay between two distinct kinds of geometric objects — surface subgroups, and cube complexes. These are connected in 3 dimensions by a result of Sageev: a 3-manifold group contains a surface subgroup if and only if it acts essentially on a CAT(0) cube complex. The idea we had for the workshop was that it should explicitly emphasize these two kinds of objects and their relationships, to gather people working on these objects from different points of view, and to enourage them to interact and to exchange techniques, insights, problems, and perspectives.

We consider this conference to be particularly timely, precisely because the theory of cube complexes, which developed in relative isolation for many years in the hands of a few practitioners (e.g. Sageev, Haglund, Wise), is unfamiliar to the majority of people working in the more "Gromov–Thurston" style of geometric topology and geometric group theory. The theory of cube complexes has its own peculiar flavor, background, examples etc., and having proved its value in so spectacular a manner, there is naturally great interest in these tools, especially among young mathematicians looking for new open vistas to explore. On the other hand, we believed that emphasizing the relationship of the theory of cube complexes to surface subgroups would make the conference more focussed and future-looking.

1.1. Description of some of the talks.

One very useful aspect of the conference was the extent to which several people gave (partially) expository or survey talks. This included Jason Manning, who talked about the theory of hyperbolic Dehn

filling, Daniel Groves, who talked about a new (more geometric) proof of Wise's Malnormal Special Quotient Theorem, whose (more combinatorial) proof by Wise is notoriously difficult to understand, and which is a crucial component of the recent breakthrough work alluded to earlier. Jeremy Kahn gave an expository talk on his work with Markovic on the surface subgroup problem in hyperbolic 3-manifolds (Marty Scharlemann remarked to an organizer that he appreciated this talk a lot and felt it gave a clear idea of the proof which he hadn't seen before). Yi Liu's talk explained an extension of the Kahn-Markovic techniques to the relative case constructing surfaces with specified boundary. Agol gave a survey talk on his proof of the virtual Haken conjecture, somehow managing to fit everything into a 50 minute presentation!

There was a significant number of talks as well which reached out into the future, discussing potential approaches to important open questions and the change in conception these questions have undergone by the recent developments.

Danny Calegari discussed progress obtained with Walker on Gromov's motivating question about the existence of surface subgroups in one-ended hyperbolic groups in the case of graphs of groups and random hyperbolic groups. It seems now likely that Gromov's problem could soon be solved for cubulated hyperbolic groups. Vladimir Markovic reduced Cannon's conjecture to the existence of sufficiently many nice surface subgroups of a hyperbolic group with boundary S^2.

Several people (Alden Walker, Sang-hyun Kim, David Futer, Anne Thomas) talked about ways to find surface subgroups in various classes of groups, all of which had some kind of connection to trees and their products (a venerable and important class of cube complexes). Other people (Mladen Bestvina, Ursula Hamenstädt, Piotr Przytycki) were more focussed on the properties of surface groups themselves, as revealed in the geometry of their outer automorphism groups (i.e. mapping class groups). Hamenstadt surprised some in the audience by announcing the resolution of an old conjecture that hyperbolic 4-manifolds cannot be surface bundles over a surface, by finding topological restrictions on geometrically finite surface subgroups of mapping class groups.

Alan Reid gave a more algebraic talk, about the "profinite" theory of the kinds of groups discussed at the conference; in particular his talk made a surprising connection of the surface subgroup problem for hyperbolic groups with the problem of distinguishing their profinite completions. Jack Button talked about explicit cube structures for certain classes of ascending HNN extensions, addressing some interesting special cases of the problem of whether hyperbolic ascending HNN extensions are cubulated.

Talia Fernos and Alessanda Iozzi connected the particular geometric structure of cube complexes to more "classical" structures used to understand automorphism groups, in particular to Poisson boundaries and bounded cohomology. As an main application, they obtain that certain lattices cannot act in an interesting way on CAT(0) cube complexes. Similar ideas and connections emerged in many of the talks, and it was very exciting to see speakers, ostensibly from different backgrounds and with quite different mathematical tastes and interests, all finding common ground in the subject matter of the workshop.

We would like to end with the following quote from one of us (DC) which captures some of his subjective sense of excitement during the proceedings:

(T)o those of us who are mid-career or older it was a bit shocking to see how quickly the landscape of low-dimensional geometry/topology and geometric group theory has been transformed by the recent breakthrough work of (Kahn-Markovic-Haglund-Wise-Groves-Manning-etc.-) Agol. Incidentally, when I first started as a graduate student, I had a vague sense that I had somehow "missed the boat"; all the exciting developments in geometry due to Thurston, Sullivan, Gromov, Freedman, Donaldson, Eliashberg etc. had taken place 10-20 years earlier, and the subject now seemed to be a matter of fleshing out the consequences of these big breakthroughs. 20 years and several revolutions later, I no longer feel this way.

Organizers

First Name	Last Name	Institution
Ian	Agol	UC Berkeley Math Faculty
Danny	Calegari	University of Chicago
Ursula	Hamenstaedt	Rheinische Friedrich-Wilhelms-Universität Bonn
Vladimir	Markovic	California Institute of Technology

Speakers

First Name	Last Name	Institution
Ian	Agol	UC Berkeley Math Faculty
Mladen	Bestvina	University of Utah
Jack	Button	Cambridge University
Danny	Calegari	University of Chicago
Talia	Fernos	University of North Carolina
David	Futer	Temple University
Daniel	Groves	University of Illinois
Ursula	Hamenstaedt	Rheinische Friedrich-Wilhelms-Universität Bonn
Alessandra	Iozzi	ETH Zürich
Jeremy	Kahn	Brown University
Sang-hyun	Kim	Korea Advanced Institute of Science and Technology (KAIST)
Yi	Liu	California Institute of Technology
Jason	Manning	University at Buffalo (SUNY)
Vladimir	Markovic	California Institute of Technology
Piotr	Przytycki	Institute of Mathematics of the Polish Academy of Sciences
Alan	Reid	University of Texas
Anne	Thomas	University of Sydney
Alden	Walker	University of Chicago

Mathematical Sciences Research Institute

Hot Topics: Surface subgroups and cube complexes

March 18 to March 22, 2013

Schedule

Monday, March 18, 2013			
9:15 AM - 9:30 AM	Simons Auditorium		Welcome
9:30 AM - 10:30 AM	Simons Auditorium	Jason Manning	Dehn filling of groups and spaces
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00	Simons Auditorium	Daniel Groves	Wise's Malnormal Special Quotient Theorem
12:00 - 2:00 PM	Atrium		Lunch
2:00 - 3:00 PM	Simons Auditorium	Ian Agol	The virtual Haken conjecture
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:30 PM	Simons Auditorium	Vlad Markovic	Criterion for Cannon's Conjecture

Tuesday, March 19, 2013			
9:30 AM - 10:30 AM	Simons Auditorium	Alden Walker	Surface subgroups from linear programming
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00	Simons Auditorium	Danny Calegari	Surface subgroups in random graphs of free groups
12:00 - 2:00 PM	Atrium		Lunch
2:00 - 3:00 PM	Simons Auditorium	Sang-Hyun Kim	Doubles of free groups and hyperbolic surface subgroups
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:30 PM	Simons Auditorium	Alan Reid	Recognizing free groups, surface groups and Kleinian groups by their finite quotients
4:30 PM - 6:20 PM	Atrium		Reception

Wednesday, March 20, 2013			
9:30 AM - 10:30 AM	Simons Auditorium	Piotr Przytycki	Slim unicorns
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00	Simons Auditorium	Mladen Bestvina	scl in mcg

Thursday, March 21, 2013			
9:30 AM - 10:30 AM	Simons Auditorium	Jeremy Kahn	Surface Subgroups of Isometries of Hyperbolic 3-Space
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00	Simons Auditorium	Yi Liu	Bounded quasi-Fuchsian subsurfaces in closed hyperbolic 3-manifolds
12:00 - 2:00 PM	Atrium		Lunch
2:00 - 3:00 PM	Simons Auditorium	David Futer	Surface quotients of hyperbolic buildings
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:30 PM	Simons Auditorium	Anne Thomas	Polyhedral complexes, lattices and surface subgroups

Friday, March 22, 2013			
9:30 AM - 10:30 AM	Simons Auditorium	Talia Fernos	Connecting the Roller Boundary and the Poisson-Furstenberg Boundary
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00	Simons Auditorium	Alexandra Iozzi	Rigidity of actions on CAT(0) cube complexes
12:00 - 2:00 PM	Atrium		Lunch
2:00 - 3:00 PM	Simons Auditorium	Ursula Hamenstadt	On surface subgroups of mapping class groups
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:30 PM	Simons Auditorium	Jack Button	Ascending HNN extensions of free groups

Participants

First Name	Last Name	Institution
Ian	Agol	UC Berkeley Math Faculty
shinpei	baba	California Institute of Technology
Hyungryul	Baik	Cornell University
Robert	Bell	Michigan State University
Mladen	Bestvina	University of Utah
Michael	Brandenbursky	Vanderbilt University
Corey	Bregman	Rice University
Jack	Button	Cambridge University
Danny	Calegari	University of Chicago
Corina	Ciobotaru	Université Catholique de Louvain
Saikat	Das	Rutgers University
Tushar	Das	Oregon State University
Yen	Duong	University of Illinois
Matthew	Durham	University of Illinois at Chicago
Robert	Edwards	UCLA
Talia	Fernos	University of North Carolina
Michael	Freedman	Microsoft Research
Lei	Fu	California Institute of Technology
David	Futer	Temple University
Giles	Gardam	University of Sydney
Pritam	Ghosh	Rutgers University
Daniel	Groves	University of Illinois
Ursula	Hamenstaedt	Rheinische Friedrich-Wilhelms-Universität Bonn
Kangjin	Han	KIAS
Shelly	Harvey	Rice University
Joel	Hass	University of California
Tim	Hsu	San Jose State University
Alessandra	Iozzi	ETH Zürich
Jeremy	Kahn	Brown University
Sang-hyun	Kim	Korea Advanced Institute of Science and Technology (KAIST)
Kenji	Kozai	Stanford University
Eon-Kyung	Lee	Sejong University
Sang-Jin	Lee	Konkuk University
Yi	Liu	California Institute of Technology
John	Lott	University of California
Joel	Louwsma	University of Oklahoma
Brian	Mann	University of Utah
Jason	Manning	University at Buffalo (SUNY)
Vladimir	Markovic	California Institute of Technology
George	Mossessian	University of California
Matthias	Nagel	Universität zu Köln
Walter	Neumann	Barnard College
Julien	Paupert	Arizona State University
Mark	Pedron	Universität Bonn
Piotr	Przytycki	Institute of Mathematics of the Polish Academy of Sciences
Ali	Rajaei	Tarbiat Modares
Alan	Reid	University of Texas
Eric	Samperton	University of California

Jenya	Sapir	Stanford University
Martin	Scharlemann	University of California
Suresh	Srinivasamurthy	Kansas State University
Emily	Stark	Tufts University
Timothy	Susse	CUNY, Graduate Center
Samuel	Taylor	University of Texas
Anne	Thomas	University of Sydney
Abigail	Thompson	University of California
Alden	Walker	University of Chicago
Genevieve	Walsh	Tufts University
Christopher	Westenberger	University of California
Graham	White	Stanford University
Yunhui	Wu	Rice University
Pengcheng	Xu	Oklahoma State University

Officially Registered Participant Information

Participants		62

Gender		62
Male	74.19%	46
Female	19.35%	12
Declined to state	6.45%	4

Ethnicity*		62
White	56.45%	35
Asian	27.42%	17
Hispanic	0.00%	0
Pacific Islander	0.00%	0
Black	0.00%	0
Native American	0.00%	0
Mixed	1.61%	1
Declined to state	14.52%	9

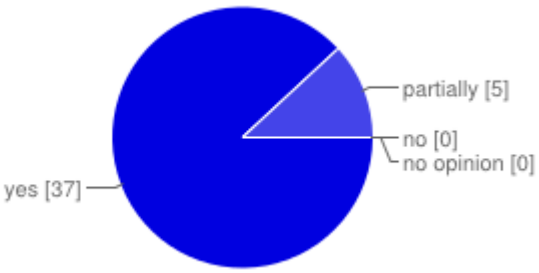
* ethnicity specifications are not exclusive

42 responses

Summary See complete responses

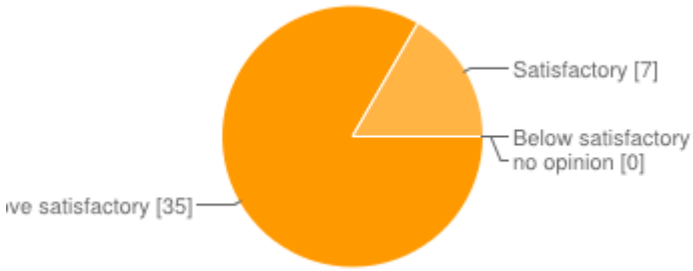
Topic presentation and organization

Did the various topics within the workshop integrate into a coherent picture?



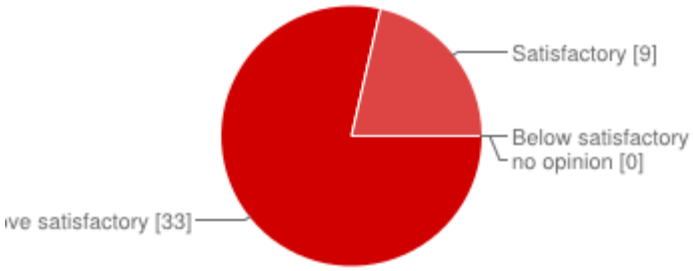
yes	**37**	88%
partially	**5**	12%
no	**0**	0%
no opinion	**0**	0%

Were the speakers generally clear and well organized in their presentation?



Above satisfactory	**35**	83%
Satisfactory	**7**	17%
Below satisfactory	**0**	0%
no opinion	**0**	0%

Was there adequate time between lectures for discussion?



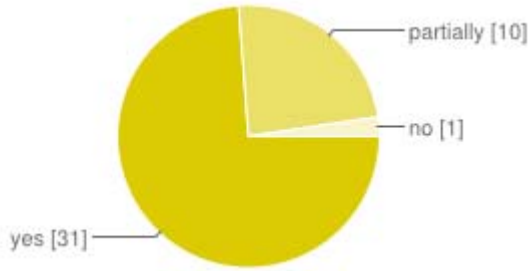
Above satisfactory	**33**	79%
Satisfactory	**9**	21%
Below satisfactory	**0**	0%
no opinion	**0**	0%

Additional comments on the topic presentation and organization

It was great! It is very good, I prefer a 3-days or 4-days workshop very well organized. The talks were related, and talks on the same day were related. I am a 1st year grad student. While coming for ...

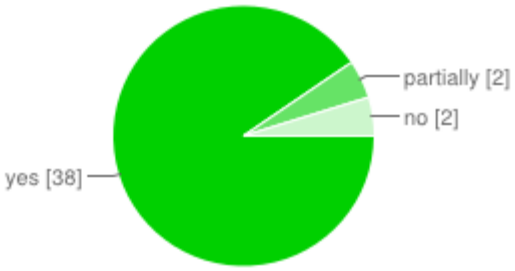
Personal assessment

Was your background adequate to access a reasonable portion of the material?



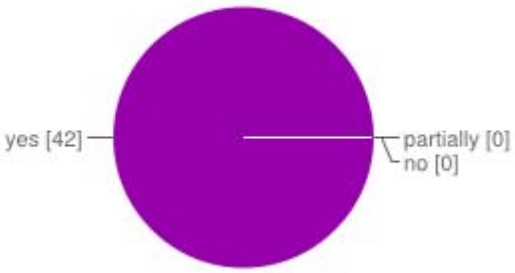
yes	**31**	74%
partially	**10**	24%
no	**1**	2%

Did the workshop increase your interest in the subject?



yes	**38**	90%
partially	**2**	5%
no	**2**	5%

Was the workshop worth your time and effort?



yes	**42**	100%
partially	**0**	0%
no	**0**	0%

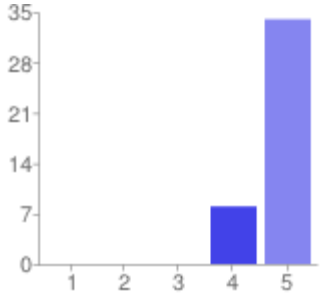
Additional comments on your personal assessment

I usually do not attend conferences where I am not speaking. However, I'm glad I attended this one.

My interest in the subject was already at a high level, so the workshop didn't really make me *mo ...

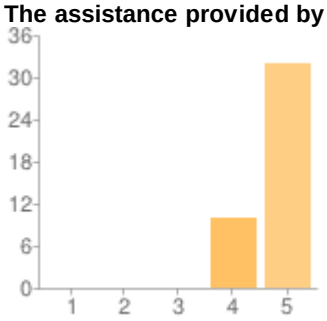
Venue

Your overall experience at MSRI



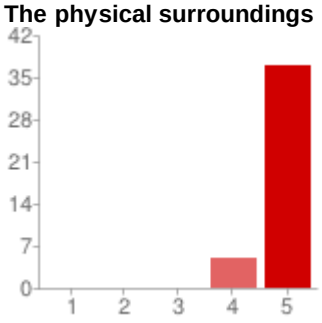
1 -Not satisfactory	**0**	0%
2	**0**	0%
3	**0**	0%
4	**8**	19%
5 -Above satisfactory	**34**	81%

The assistance provided by MSRI staff



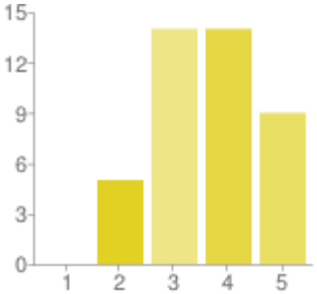
1 -Not satisfactory	**0**	0%
2	**0**	0%
3	**0**	0%
4	**10**	24%
5 -Above satisfactory	**32**	76%

The physical surroundings



1 -Not satisfactory	**0**	0%
2	**0**	0%
3	**0**	0%
4	**5**	12%
5 -Above satisfactory	**37**	88%

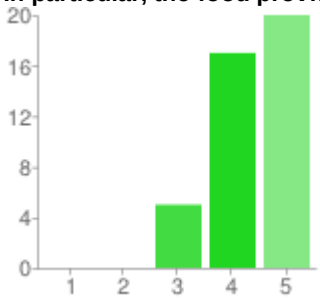
The food provided during the workshop



Not satisfactoryAbove satisfactory

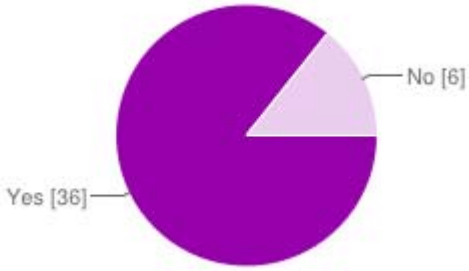
1 -Not satisfactory	**0**	0%
2	**5**	12%
3	**14**	33%
4	**14**	33%
5 -Above satisfactory	**9**	21%

In particular, the food provided during the reception



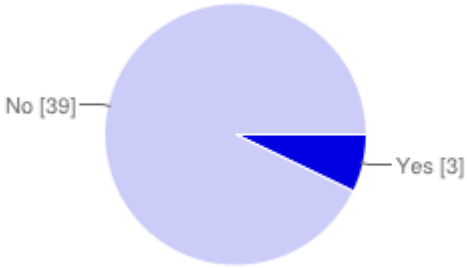
1 -Not satisfactory	**0**	0%
2	**0**	0%
3	**5**	12%
4	**17**	40%
5 -Above satisfactory	**20**	48%

Did you use MSRI's wireless network?



Yes	**36**	86%
No	**6**	14%

Did you experience any difficulties with the network?



Yes	**3**	7%
No	**39**	93%

If you did experience difficulties with the network, please explain:

intermittent connection/disconnections

Internet connection dropped out at one point

The only issue I had was attempting to use my iPhone as a wireless remote over the wifi network, which didn't work. ...

Additional comments on the venue

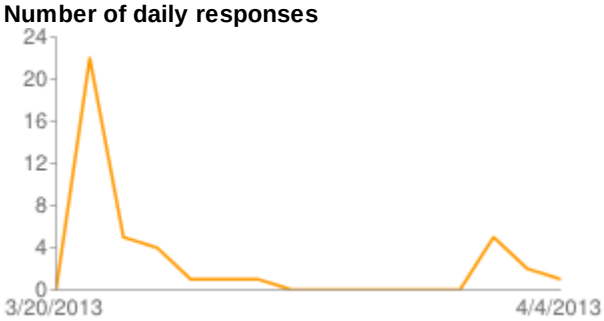
Not many lunch options (particularly vegetarian). However, the beauty makes up for it. It might be good to remind participants that there are not many vegetarian lunch options. However, the beaut ...

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 a grad student participant, I expected the workshop to have more opportunities for exploring ideas, either in separate groups or as a whole. This is not to say that there were no interesting que ...

Number of daily responses



Hot Topics Workshop
Surface subgroups and cube complexes
March 18 to March 22, 2013

Additional Survey Responses

Additional comments on the topic presentation and organization

- It was great!
- It is very good, I prefer a 3-days or 4-days workshop
- very well organized. The talks were related, and talks on the same day were related.
- I am a 1st year grad student. While coming for the workshop I didn't have much understanding as I had not much of background knowledge, but I understood some of the talks and have a vague understanding about many of the talks. Thanks to the speakers and the organisers.
- Wonderful
- Excellent all round.
- As an organizer, I asked the speakers to keep some part of their talk expository, and I think they generally did a good job with this.
- Excellent program and talks!
- 2 themes held together well

Additional comments on your personal assessment

- I usually do not attend conferences where I am not speaking. However, I'm glad I attended this one.
- My interest in the subject was already at a high level, so the workshop didn't really make me *more* interested.
- I had a great time, talked to many interesting people, heard many very interesting ideas and all round had a wonderful time mathematically.
- It was a super-great experience!
- Happy to have gone

Additional comments on the venue

- Not many lunch options (particularly vegetarian). However, the beauty makes up for it. It might be good to remind participants that there are not many vegetarian lunch options. However, the beauty of the math and the landscape makes up for it!
- The lunch food ran out some days. Might be better to just encourage us to order lunch online (which worked well).
- MSRI is wonderful.
- The auditorium can be a bit chilly in the morning. During my afternoon talk, it was hard to see the screen, especially the colors.
- Friendly staffs!
- Too far up to walk, but did walk down

We welcome any additional comments or suggestions you may have to improve the overall experience for future participants.

- As a grad student participant, I expected the workshop to have more opportunities for exploring ideas, either in separate groups or as a whole. This is not to say that there were no interesting questions raised, but for the benefit of the grad students, it is not always clear what particular questions the speakers and other professors are thinking about. I think that in the future it would be helpful for the senior participants to engage with the younger, in order that we be both led to think about the talks in a certain way, and to clarify the results explained in the talks. Often the

speakers did not talk to the grad students at all, but only kept to themselves, focusing on their own work.

- It was an awesome workshop. We should have more workshop in 3-manifold topology/geometric group theory.
- It was a great workshop! I had the opportunity to interact with the participants and speakers, which for me was the best part of the workshop. It would be very helpful if there was a way to arrange more time for interactions either before/during/after the talks.

Mathematical Sciences Research Institute

Summer Graduate School: Model Theory

July 23, 2012 to August 3, 2012

MSRI, Berkeley, CA, USA

Organizers:

David Marker* (University of Illinois, Chicago)

Thomas Scanlon (University of California, Berkeley)

Carol Wood (Wesleyan University)

Final Report
MSRI Graduate Summer Workshop
Model Theory
July 23–August 2, 2012

Organizers:
David Marker (University of Illinois at Chicago)
Thomas Scanlon (University of California, Berkeley)
Carol Wood (Wesleyan University)

,

To appreciate applications of model theory one usually needs a significant background both in the model theoretic methods and in the area of application. This creates a difficulty for graduate students who are not fluent in both areas. The primary goal of the workshop was to introduce o-minimality, a central area of research in modern model theory, and algebraic dynamics, an exciting new direction in number theory, and conclude with interesting recent examples showing how model theoretic methods can be applied.

The basic structure of the workshop included:

- Two ten lecture tutorials. The first tutorial taught by David Marker (University of Illinois at Chicago), Margaret Thomas (Konstanz University) and Alex Wilkie (Manchester University) focused on model theory and o-minimality. The second was taught by Drago Ghioca (University of British Columbia) and Thomas Tucker (University of Rochester) focused on algebraic dynamics. Although the tutorials started in very different directions, they both ended discussing applications of the Pila-Wilkie Theorem counting rational points on transcendental sets.

- Two capstone lectures by Thomas Scanlon (University of California, Berkeley) describing further applications of model theory to algebraic dynamics.

- Two hours per day of problem sessions lead by graduate assistant James Freitag (University of Illinois at Chicago) and postdoctoral assistants Alice Medvedev (University of California, Berkeley) and Margaret Thomas (Konstanz University) discussing problems posed in the courses.

- Breakout sessions lead by Freitag, Medvedev and Thomas filling in gaps in the model theoretic and algebraic backgrounds for some of the students.

Details on Tutorials and Capstone Lectures

Model Theory and o-minimality: The tutorial began with two introductory lectures by Marker. The first discussed the model theory of the real field and Tarski's quantifier elimination. The second introduced o-minimality and proved some of the foundational results including the monotonicity theorem and cell decomposition. Wilkie continued with five lectures on the real exponential field culminating with he celebrated result that $\mathbb{R}_{\exp}$ is model complete and o-minimal. Wilkie also speculated a bit on possible definability results for the more intractable $\mathbb{C}_{\exp}$. Thomas gave one lecture giving an overview of the proof of the Pila-Wilkie Theorem on asymptotics on heights of rational points in the transcendental part of sets definable in an o-minimal structure. In the final two lectures, Marker showed how the Pila-Wilkie Theorem can be used to obtain interesting diophantine results, in particular giving the Pila-Zannier proof of the Manin-Mumford Conjecture.

Algebraic Dynamics: The tutorial began with an introduction to Skolem's method for treating linear recurrence sequences via p-adic analytic parametrization. This involved defining the p-adic topology and developing the basic properties of p-adic power series. A generalization of Skolem's method was used to obtain p-adic analytic parametrizations of orbits of points for maps more general than those of multiplications maps. This lead to a discussion of the dynamical Mordell-Lang problem, which asks if the intersection of an orbit a point with a subvariety must have a very specific arithmetic structure.

Next, a set of Manin-Mumford type results and questions were introduced These ask that if a subvariety contains a Zariski dense set of preperiodic points, then the subvariety itself must be preperiodic. This turns out to be true in the context of multiplication-by-m maps (proved by Raynaud) but false even in for more general group variety endomorphisms Several other cases in which the result is true were explored. This led to a discussion of Julia sets and canonical measures. The tutorial concluded with the problem of "unlikely intersections" and the Pink-Zilber conjecture. This included the Masser-Zannier application of Pila-Wilkie to torsion anomalous points, and the dynamic analogs of Baker and DeMarco.

Capstone Lectures on Model Theory and Algebraic Dynamics: We closed the workshop with a pair of lectures tying together the two main strands of the Summer school through a discussion of model theoretic approaches to problems of Mordell-Lang type. In the first hour, the proof of the Masser-Zannier theorem on simultaneous torsion in the Legendre family of elliptic curves was sketched in detail with special attention paid to the role of definability in o-minimal structures and the Pila-Wilkie counting theorem. Tying the o-minimal methods to the more classical Mordell-Lang conjecture, it was shown how estimates on the intersection of varieties with finitely generated subgroups of abelian varieties may be deduced from Pila's strengthened counting theorem for points in finite dimensional vector spaces. Finally, it was shown how the p-adic Skolem-Chabauty method for proving the dynamical Mordell-Lang conjecture has a Euclidean, o-minimal counterpart which when combined with the Pila-Wilkie counting theorem yields quantitative results about higher rank algebraic dynamical systems.

Evaluation

The quality of the lectures was very high and the lecturers did an excellent job starting from near scratch and building up to discussions of current research. The capstone lectures were particularly successful in tying together the two themes of the program. Moreover, the graduate student and postdoctoral assistants worked very hard to make the problem sessions productive. This included a great deal of improvising to work with students with wildly different backgrounds.

The fact that we were trying to integrate both model theory and number theory created several challenges. It was only at the end of the workshop that the model theory and dynamics themes could truly be tied together. Although this was ultimately done very successfully, for the beginning of the program many students had the impression that the two tutorials were completely disconnected.

The dual nature of the program, also made it hard to gauge the audience. When planning the workshop we had hoped to get a mix of students planning to work in model theory and students planning to work in number theory. We expected most of the model theory students would have a good algebra background, including, in most cases, a first course in algebraic geometry, but we expected the number theory students to have little background in logic. For this reason we designed a program that focused much more on the applications than on the model theory. Unfortunately, we were not successful

in drawing as many number theory students as we had hoped. Instead, the audience was largely a mix of the model theory students we had hoped for, and students in other areas of logic who hoped to learn some model theory. For students in the first group the program seemed to work very well and their feedback has been very enthusiastic. It worked less well for the second group. Their algebra background was generally weaker and they struggled more with the dynamics tutorial. The graduate and postdoctoral assistants did a great job dealing with this. They organizing breakout sessions that focused more on the underlying algebra and model theory. In the end, we feel that even students in the second group got a lot out of the workshop. Perhaps, if we had more clearly marketed the workshop as "Model Theory and Number Theory" we would have attracted the balance of model theory and number theory which we sought.

Conclusion

Though our concept of tying together two very different themes presented speciai challenges, we feel the attempt was well worth while. As things turned out, we had to make mid-week adaptations, which were possible due to the hard work of the lecturers and assistants. In this way we were able to offer something to all the participants, and to allow members of different mathematical communities to get to know each other at an early stage in their careers.

Organizers* and Lecturers		
First Name	**Last Name**	**Institution**
Dragos	Ghioca	University of British Columbia
David	Marker*	University of Illinois
Alice	Medvedev	University of California, Berkeley
Thomas	Scanlon*	University of California, Berkeley
Margaret	Thomas	Universität Konstanz
Thomas	Tucker	University of Rochester
Alex	Wilkie	University of Manchester
Carol	Wood*	Wesleyan University

Teaching Assistant		
First Name	**Last Name**	**Institution**
James	Freitag	University of California

Summer Graduate School: Model Theory

July 23 - August 3, 2012

Schedule

WEEK ONE

	Monday 7/23	Tuesday 7/24	Wednesday 7/25	Thursday 7/26	Friday 7/27
9:15 AM	MSRI Welcome	o-minimality	o-minimality	o-minimality	o-minimality
9:30 AM	o-minimality				
9:45 AM					
10:00 AM					
10:15 AM					
10:30 AM		*Coffee Break*		*Coffee Break*	
10:45 AM	*Coffee Break*				
11:00 AM		Algebraic Dynamics	*Coffee Break*	Algebraic Dynamics	*Coffee Break*
11:15 AM					
11:30 AM	Algebraic Dynamics		***BBQ Lunch at nearby park***		Discussion I
11:45 AM					
12:00 PM					
12:15 PM		***Lunch***		***Lunch***	
12:30 PM	***Lunch***				***Lunch***
12:45 PM					
1:00 PM					
1:15 PM					
1:30 PM					
1:45 PM					
2:00 PM	Discussion I	Discussion I	Algebraic Dynamics	Discussion I	Algebraic Dynamics
2:15 PM					
2:30 PM					
2:45 PM					
3:00 PM	*Tea Break*	*Tea Break*		*Tea Break*	
3:15 PM					
3:30 PM			*Tea Break*		*Tea Break*
3:45 PM					
4:00 PM	Discussion II	Discussion II	Discussion	Discussion II	Discussion II
4:15 PM					
4:30 PM					
4:45 PM					
5:00 PM	*End of Day*	*End of Day*	*End of Day*	*End of Day*	*End of Day*

WEEK TWO

	Monday 7/30	Tuesday 7/31	Wednesday 8/1	Thursday 8/2	Friday 8/3
9:15 AM					
9:30 AM	o-minimality	o-minimality	o-minimality	o-minimality	o-minimality
9:45 AM					
10:00 AM					
10:15 AM					
10:30 AM		*Coffee Break*		*Coffee Break*	*Coffee Break*
10:45 AM					
11:00 AM	*Coffee Break*	Algebraic Dynamics	*Coffee Break*	Algebraic Dynamics	Algebraic Dynamics
11:15 AM					
11:30 AM	Discussion I		Discussion I		
11:45 AM					
12:00 PM					
12:15 PM					
12:30 PM	***Lunch***	***Lunch***	***Lunch***	***Lunch***	***Lunch***
12:45 PM					
1:00 PM					
1:15 PM					
1:30 PM					
1:45 PM					
2:00 PM	Algebraic Dynamics	Discussion I	Algebraic Dynamics	Discussion I	Further Directions I
2:15 PM					
2:30 PM					
2:45 PM					
3:00 PM		*Tea Break*		*Tea Break*	
3:15 PM					
3:30 PM	*Tea Break*		*Tea Break*		*Tea Break*
3:45 PM					
4:00 PM	Discussion II	Discussion II	Discussion II	Discussion II	Further Directions II
4:15 PM					
4:30 PM					
4:45 PM					
5:00 PM	*End of Day*	*End of Day*	*End of Day*	*End of Day*	*End of Day*

Attending Students		
First Name	**Last Name**	**Institution**
Samuel	Alexander	Ohio State University
Fabrizio	Barroero	Technische Universität Graz
Santiago	Camacho	University of Illinois at Urbana-Champaign
Yuchen	Chen	University of Missouri
Gabriel	Conant	University of Illinois at Chicago
Reid	Dale	University of Washington
Pedro	Diaz navarro	Central Michigan University
Andrew	Dudzik	University of California
Ellis	Fenske	Tulane University
Joanna	Furno	University of North Carolina
Dario	Garcia	Universidad de los Andes
Alejandro	Guillen	University of Hawaii at Manoa
Meng-Che	Ho	University of Wisconsin
Will	Johnson	University of California, Berkeley
Liudmyla	Kadets	University of Toronto
Mary	Karker	Wesleyan University
Edward	Krohne	University of North Texas
Alex	Kruckman	University of California
Omar	Leon Sanchez	University of Waterloo
Matthew	Luther	McMaster University
Edson	Makuluni	University of Wisconsin
Vincenzo	Mantova	University of Oxford
Alison	Mirin	Mills College
Matthew	Moore	University of Colorado
Joel	Nagloo	University of Leeds
Victoria	Noquez	University of Illinois
James	Ogaja	California State University
Trent	Ohl	Ohio State University
Jamie	Rahr	University of Rochester
Farbod	Shokrieh	Georgia Institute of Technology
Stefano	Silvestri	Boston University
Matthew	Smedberg	Vanderbilt University
Iian	Smythe	Cornell University
Caroline	Terry	University of Illinois at Chicago
Brett	Townsend	Wesleyan University
Minh	Tran	National University of Singapore
Somayeh	Vojdani	University of Notre Dame
Erik	Walsberg	University of California
Michael	Wan	University of California
Julian	Ziegler Hunts	High School Student

Student Statistics

Total Students		**40**

Gender		**40**
Male	72.50%	29
Female	22.50%	9
Declined to state	5.00%	2

Ethnicity*		**42**
White	59.52%	25
Asian	11.90%	5
Hispanic	11.90%	5
Pacific Islander	2.38%	1
Black	7.14%	3
Native American	0.00%	0
Declined to state	7.14%	3

* ethnicity specifications are not exclusive

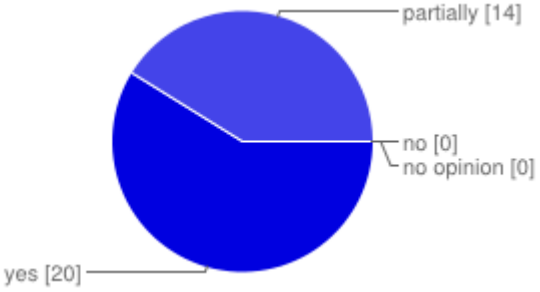
34 responses

Summary See complete responses

34 responses out of 40 participants: 85% of total participants.

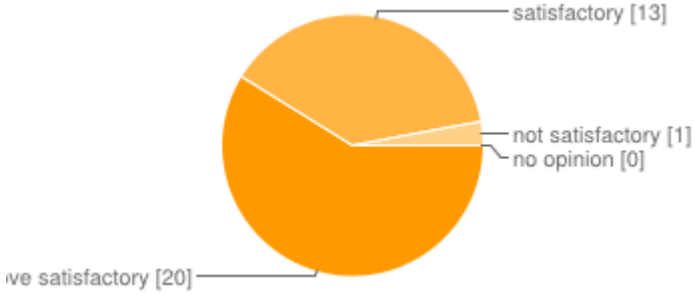
Topic presentation and organization

Did the various topics within the workshop integrate into a coherent picture?



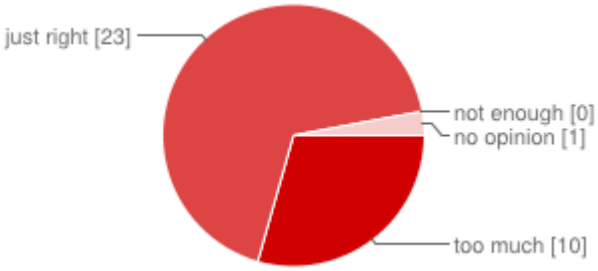
yes	**20**	59%
partially	**14**	41%
no	**0**	0%
no opinion	**0**	0%

Were the speakers generally clear and well organized in their presentation?



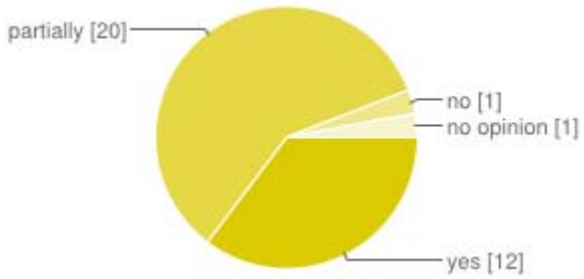
above satisfactory	**20**	59%
satisfactory	**13**	38%
not satisfactory	**1**	3%
no opinion	**0**	0%

Was there too much material presented; was the school too ambitious?



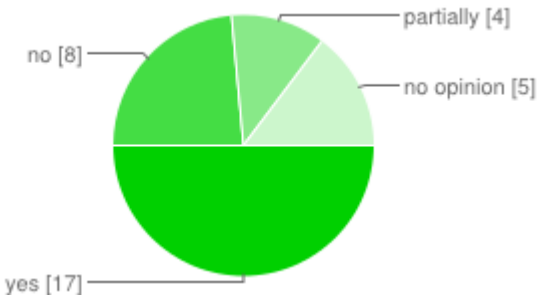
too much	**10**	29%
just right	**23**	68%
not enough	**0**	0%
no opinion	**1**	3%

Was the problem session helpful?



yes	**12**	35%
partially	**20**	59%
no	**1**	3%
no opinion	**1**	3%

Would you have liked there to be more organized social activities?



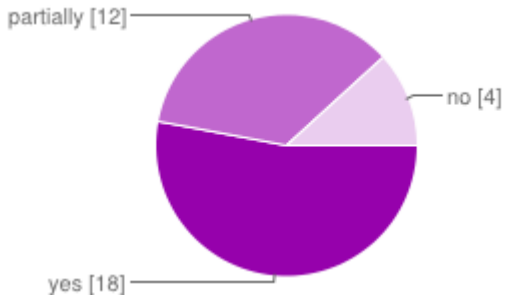
yes	**17**	50%
no	**8**	24%
partially	**4**	12%
no opinion	**5**	15%

Additional comment on the topic presentation and organization

excellent The algebraic dynamics problem sessions seemed to focus more on trick olympiad-style questions rather than material that would have been helpful for understanding the course. Dynamics sectio ...

Personal assessment

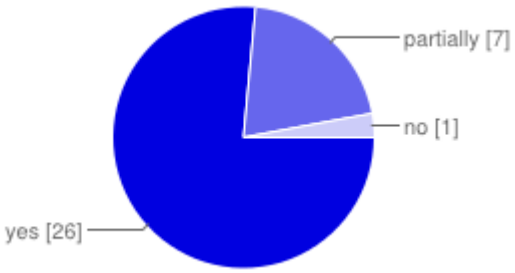
Was your background adequate to access a reasonable portion of the material?



yes	**18**	53%
partially	**12**	35%
no	**4**	12%

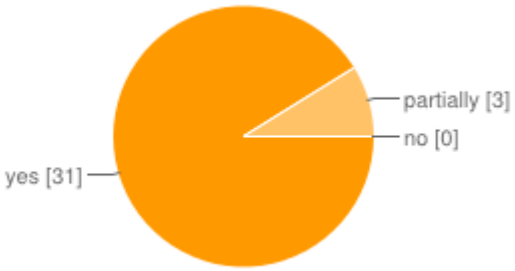
Summer Graduate School: Model Theory, July 23 to August 3, 2012 at MSRI, Berkeley, CA, USA

Did the workshop increase your interest in the subject?



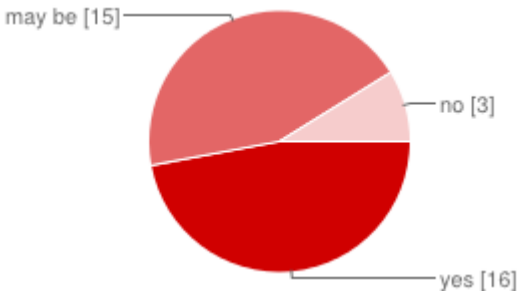
yes	**26**	76%
partially	**7**	21%
no	**1**	3%

Was the school worth your time and effort?



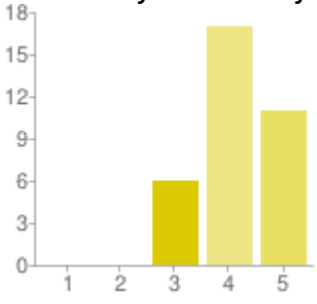
yes	**31**	91%
partially	**3**	9%
no	**0**	0%

Is it likely that you will work in the area of the workshop subject in the future?



yes	**16**	47%
may be	**15**	44%
no	**3**	9%

How would you evaluate your interaction with other participants?



1 -not satisfactory	**0**	0%
2	**0**	0%
3	**6**	18%
4	**17**	50%
5 -above satisfactory	**11**	32%

Additional comments on your personal assessment

MSRI Venue

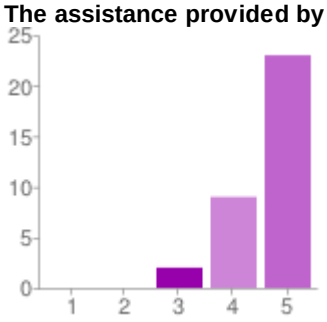
Please rate the different categories

Your overall experience

not satisfactoryabove satisfactory

1 -not satisfactory	**0**	0%
2	**0**	0%
3	**1**	3%
4	**18**	53%
5 -above satisfactory	**15**	44%

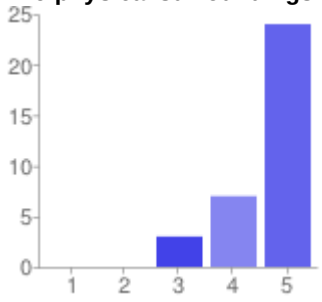
The assistance provided by staff



not satisfactoryabove satisfactory

1 -not satisfactory	**0**	0%
2	**0**	0%
3	**2**	6%
4	**9**	26%
5 -above satisfactory	**23**	68%

The physical surroundings



not satisfactoryabove satisfactory

1 -not satisfactory	**0**	0%
2	**0**	0%
3	**3**	9%
4	**7**	21%
5 -above satisfactory	**24**	71%

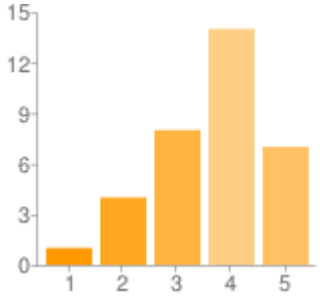
Additional comments on the MSRI venue

Transportation up the hill needs to be improved The lecture hall was way too cold when the air conditioning was on. I got sick half way through the program. The food and snacks provided were excell ...

Accommodation and Food

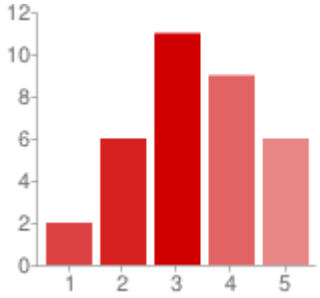
Please rate the different categories

The summer school accommodation



1 -not satisfactory	**1**	3%
2	**4**	12%
3	**8**	24%
4	**14**	41%
5 -above satisfactory	**7**	21%

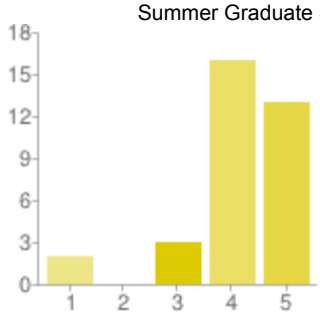
The food at the dormitories



1 -not satisfactory	**2**	6%
2	**6**	18%
3	**11**	32%
4	**9**	26%
5 -above satisfactory	**6**	18%

The food provided at MSRI

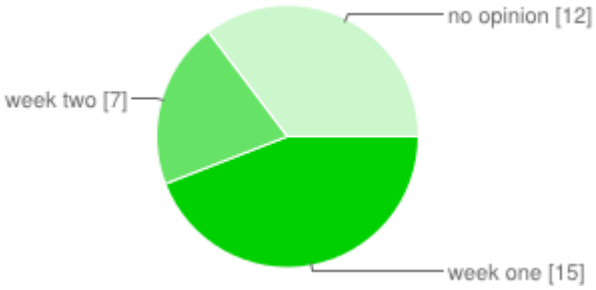
Summer Graduate School: Model Theory, July 23 to August 3, 2012 at MSRI, Berkeley, CA, USA



not satisfactoryabove satisfactory

1 -not satisfactory	**2**	6%
2	**0**	0%
3	**3**	9%
4	**16**	47%
5 -above satisfactory	**13**	38%

Did you prefer the lunch provided at MSRI in week one or week two



week one	**15**	44%
week two	**7**	21%
no opinion	**12**	35%

Additional comments on accommodation and food

the food was good both at MSRI and Dorm Disregard my answers about accomodation and dormitory food, since I didn't see either because I'm from Berkeley. Food at the dormitories was very greasy. I did n ...

Thank you for completing this survey

We welcome any additonal comments or suggestions you may have to improve the overall experience for future participants.

That was a good experience for me to meet with other participants and organizers to share our academic knowledge. A dinner with the lectures might be nice. Let the participants be provided with a Notebook, or a white sheet pad. Thanks for a great experience Exercise and problem selection made the difference between my great enjoyment of the model theory lectures and discussions, and my experience of the dynamics portion, which was much less engaged. I could not help feeling that the model theory problems were genuinely helping me understand the theory better, while I could not say the same for ...

Summer Graduate School: Model Theory, July 23 to August 3, 2012 at MSRI, Berkeley, CA, USA

Number of daily responses

Summer Graduate School: Model Theory
July 23 – August 4, 2012

Additional Survey Responses

Additional comments on the venue

- The lecture hall was way too cold when the air conditioning was on. I got sick half way through the program. The food and snacks provided were excellent though.
- Transportation up the hill needs to be improved

We welcome any additional comments or suggestions you may have to improve the overall experience for future participants

- That was a good experience for me to meet with other participants and organizers to share our academic knowledge.
- A dinner with the lectures might be nice. Let the participants be provided with a Notebook, or a white sheet pad.
- Thanks for a great experience
- Exercise and problem selection made the difference between my great enjoyment of the model theory lectures and discussions, and my experience of the dynamics portion, which was much less engaged. I could not help feeling that the model theory problems were genuinely helping me understand the theory better, while I could not say the same for the dynamics problems.
- It seemed that the knowledge expected by the speakers was a bit more than what was suggested in the materials sent out ahead of time. That is, it was recommended non-model theorists look at an introductory book, and no suggestions at all were given with regards to dynamics. However, it seemed the speakers in both courses were assuming a certain level of comfort and familiarity with the topics. That said, the lectures were very good, if a bit surprising.
- Find a way to allow more time for students to think about the problems (individually) before the discussions sessions.
- It would have been nice to know a little more about the dormitory accommodations ahead of time - like that there was a work out room available to the residents, who our roommates would be, if it would have been possible to request a single room, etc. The bus system up the hill seemed to have a lot of issues during the first week, but I guess they resolved it during the second week by sending more busses. Overall, I'm very glad that I attended this workshop. I learned a lot and appreciated the chance to work with other graduate students in my field.

Additional comments on accommodation and food

- the food was good both at MSRI and Dorm
- Food at the dormitories was very greasy.
- There was much more variety in the vegetarian lunch options week two.
- Some crucial information was only provided to the fully sponsored students, and not provided to those students who paid the $1500 themselves. For one example, the dorm wifi info was only sent to the former students and not the latter. Also, we were not told what dates would be suitable for arrival (the correct answer being "one day before lectures"), those who arrived early had to find their own accommodations during that time!
- Staying in the dormitories was awful. They were loud, dirty, and uncomfortable. The dining hall hours didn't match well with the workshop hours. The staff at the residence halls were unhelpful.

Additional comments on the topic presentation and organization

- Excellent
- The algebraic dynamics problem sessions seemed to focus more on trick olympiad-style questions rather than material that would have been helpful for understanding the course.

- Dynamics section was much more difficult to follow than model theory, came together at the end but very difficult to follow until then, moved very very quickly
- One of the strengths of the model theory, but not of the dynamics, was that a number of problems served as lemmas in the lectures, which made the overall presentation of the model theory much easier to follow.
- The BBQ and hike were really fun.

Mathematical Sciences Research Institute

Summer Graduate School: Noncommutative Algebraic Geometry

June 18, 2012 to June 29, 2012

MSRI, Berkeley, CA, USA

Organizers:

Dan Rogalski (University of California, San Diego)

Travis Schedler (Massachusetts Institute of Technology)

Michael Wemyss (The University of Edinburgh)

FINAL REPORT
MSRI SGW 'NONCOMMUTATIVE ALGEBRAIC GEOMETRY'
SUMMER 2012

DAN ROGALSKI, TRAVIS SCHEDLER, AND MICHAEL WEMYSS

The underlying goal of the workshop was to provide graduate students with a broad overview of many of the current ideas, research areas and themes in noncommutative algebraic geometry, in anticipation of the MSRI program on noncommutative algebraic geometry and representation theory to be held in Spring 2013.

The workshop was extremely popular, reaching its cap of 40 students on the first day of enrollment. A few days later, the number of nominations exceeded 70. Because of the exceptional demand, 52 students were accepted in total, making this one of the largest MSRI Summer Graduate Workshops.

The number and diversity of the students brought challenges, but our task was eased, and made more rewarding, by the students' exceptional levels of interest and motivation. We feel that this contributed to an extremely successful workshop.

The workshop consisted of:

(1) Four lecture series, each consisting of five 1.5 hour lectures. We chose these to cover a number of the major themes in noncommutative algebraic geometry, with certain concepts in common (such as Calabi-Yau algebras) discussed in all series in order to illustrate the connections between the four topics. We give more details about the material covered below.
(2) A pair of hour-long problem sessions each day. These allowed students to ask questions about the lectures, and try the many problems on the exercise sheets provided. We ran these informally, with students working in small groups or on their own as they preferred. The problem sessions were very well attended and the problems were enthusiastically tackled by all. We regard this as one of the great successes of this workshop. Some of the students were even motivated to work together in the dormitory after hours on these problems.
(3) Computer-based problems which allowed students to perform experimental calculations designed to help gain insight and intuition into the material.

These sessions were a mixed success, with students by and large preferring the theoretical problems to the computer-based ones.

(4) A fabulous cake, pictured above, illustrating an example of a resolution of singularities which appeared in three of the four lecture courses.

Before outlining the scientific content and outcomes below, we first summarize what we regard as the main successes of this program, together with suggestions to organizers of future Summer Graduate Workshops.

(1) We think all four lecturers worked hard to deliver well-pitched and carefully prepared lectures, and we received generally positive feedback from the students. The one-and-a-half hour long lectures seemed slightly long towards the end of the second week. On the other hand, the format allowed for a relaxed lecturing style and the inclusion of many examples, which would not have been possible with one-hour lectures. We feel that the positives of the one-and-a-half hour long lectures outweigh the negatives, and would recommend this format to future organizers in the case a workshop has two lecture courses a week.

(2) The problem sessions were extremely successful, with lots of questions and discussions both between lecturers and students, and between groups of students. Due to the large number of students and their diverse backgrounds, one of our strategies was to 'stagger' the problem sheets with problems suitable for different levels and backgrounds, so that everyone would be able to get at least something out of each session. We felt that this worked really well, with positive feedback across the whole spectrum of students.

(3) Computer calculations did not work as well as we hoped. This was at least partly due to lack of familiarity and interest on the students' part. At their best, the lecturers were able to provide code that the students could copy and paste into their computer, view the result, and tinker with the code a bit to discover related results. Overall, we believe that the computer component added value to the program, although at a greater time cost to the lecturers with respect to the value added than the other components of the minicourses. However, it is possible that different groups of students would react differently, so we would recommend further experimentation with a computer component, especially when it is a good fit for the topic of the workshop.

(4) We did not have teaching assistants for the problem sessions; instead the lecturers for the week also supervised both problem sessions. We made this choice primarily because, with four lecture courses on distinct subjects, finding a TA with the necessary broad level of expertise would have been difficult. Also, the budget would have been a bit tighter with a TA. Our choice seemed to work well, giving, as noted above, the students an opportunity to ask many questions of the actual lecturers. A minor downside was that it was tiring for the lecturers.

(5) All lecturers produced typewritten notes to go along with their course. These were enthusiastically received, especially since in some cases more details could be provided in the notes that were omitted from the lectures for time reasons. If anything, the students would probably have appreciated if these were provided in advance, rather than typed up bit by bit. We plan to collate the four sets of lecture notes and exercises into a book format in the future. We hope this might be a useful addition to the literature, since compared to some other subjects, noncommutative algebraic geometry seems short on expository sources.

We also would like to mention that the expertise and professionalism of the local staff at MSRI helped to make the logistical aspects of the workshop very easy for the organizers. The facility was also excellent, owing partly to its comfortable space for chatting and socializing at lunch and during breaks. Certainly, the opportunity for students to get acquainted with each other and the lecturers during the two weeks was one of the great benefits of the workshop. Apart from the formal program at MSRI, there were also a few informal social meetings at a local pub.

The dormitory (Foothill) was also conveniently located and comfortable, and it was useful that all students (except for a few with their own lodging) stayed in the same place, along with one of the lecturers. However, the common space in Foothill left something to be desired, with only a couple lounges in a central building and no common space near the rooms (except within a single suite of rooms), which were in other buildings. This had the effect of making it more difficult for students to work together after hours, although some still did. At least one suite's common door was sometimes left ajar so that other students could drop by to the common area of the suite and work on problems together.

In the remainder of this report, we outline the details of the material covered in each of the four lecture courses.

Michael Wemyss: Noncommutative resolutions.
Lecture one began by trying to motivate the study of Cohen-Macaulay modules in an extended example, since this leads naturally to Auslander algebras, which itself motivated (in lecture two) the main definition of a noncommutative crepant resolution. We then covered uniqueness issues in dimension two and three, followed by (in lecture three) a brief introduction to quiver geometric invariant theory, with many examples. We covered derived categories in lecture four, which provided the necessary language to discuss the more advanced topics (in lecture five) of Calabi-Yau categories, Auslander-Reiten duality and the McKay correspondence. Throughout the lectures and the example sheets, we covered many common examples as well as common counterexamples.

Daniel Rogalski: Noncommutative Projective Geometry.
This subject arose in the late 1980's, with one of its signature early results being the complete classification of noncommutative $\mathbb{P}^2$'s, which correspond to Artin-Schelter regular algebras of dimension three. We thus took Artin-Schelter regular algebras as our motivating theme. We began in lecture one with a review of noncommutative Gröbner bases for graded algebras, and a review of some homological algebra. In lecture two we defined Artin-Schelter regular algebras, and classified the Artin-Schelter regular algebras of dimension two. We discussed the general methodology behind the classification in dimension three. In lecture three we defined point modules for algebras, showed how the scheme parametrizing them can be calculated in some cases, and explained how these point schemes are connected with the classification of Artin-Schelter regular algebras of dimension three. In lecture four, we discussed the categorical noncommutative Proj construction, and also defined Calabi-Yau algebras and connected them with Artin-Schelter regular algebras. In lecture five, after a brief introduction to twisted homogeneous coordinate rings, we discussed the classification of noncommutative curves, and gave a survey of some more recent results in the subject.

Travis Schedler: Deformation Theory.
The first lecture discussed motivating examples of deformations of associative algebras, including Weyl algebras, enveloping algebras of Lie algebras, and symplectic reflection algebras. In the second lecture, we defined and discussed formal deformations of algebras, leading to a statement of Kontsevich's formality theorem

regarding quantization of smooth Poisson algebras. The third lecture introduced Hochschild cohomology, which controls deformations of algebras quite concretely. In the fourth lecture, we introduced the more sophisticated Maurer-Cartan formalism, which gives a description of the space of all formal deformations up to equivalence, and we discussed the full statement of Kontsevich's theorem. The fifth lecture turned to the case of Calabi-Yau algebras, their deformations, and their application to the quantization of singular Poisson varieties, by embedding them into smooth ambient Calabi-Yau varieties. This culminated in a discussion of Etingof and Ginzburg's approach to quantization of del Pezzo surfaces (or, of quasihomogeneous hypersurfaces in three-dimensional space with an isolated singularity at the origin).

Gwyn Bellamy: Symplectic reflection algebras.[1]
The purpose of this course was to give the reader a flavor of, and basic grounding in, the theory of symplectic reflection algebras, which are related to several other areas of mathematics such as combinatorics, integrable systems, resolutions of symplectic singularities and representation theory. In the first lecture, we gave motivation for the definition of symplectic reflection algebras by considering deformations of symplectic quotient singularities. We also introduced a special class of symplectic reflection algebras, called rational Cherednik algebras. In the second lecture, we considered symplectic reflection algebras at $t = 1$. We focused mainly on ratioinal Cherednik algebras and, in particular, on category $\mathcal{O}$ for these algebras. We showed that it is a highest weight category with finitely many simple objects. Our understanding of category $\mathcal{O}$ is most complete when the corresponding complex reflection group is the symmetric group, and in the third lecture we studied this case in greater detail. The fourth lecture dealt with the Knizhnik-Zamolodchikov functor, which illustrates the connection between rational Cherednik algebras and D-modules, braid groups and cyclotomic Hecke algebras. The final lecture dealt with symplectic reflection algebras at $t = 0$. For these parameters, the algebras are finite modules over their centers. We explained how the geometry of the center is related to the representation theory of the algebras.

[1]This outline was provided by G. Bellamy, the lecturer for this minicourse; we are grateful to him for providing it.

Organizers		
First Name	**Last Name**	**Institution**
Daniel	Rogalski	University of California, San Diego
Travis	Schedler	Massachusetts Institute of Technology
Michael	Wemyss	University of Edinburgh

Speakers		
First Name	**Last Name**	**Institution**
Gwyn	Bellamy	University of Manchester

Summer Graduate School: Nomcommutative Algebraic Geometry

June 18 - 29, 2012

Schedule

WEEK ONE

	Monday 6/18	Tuesday 6/19	Wednesday 6/20	Thursday 6/21	Friday 6/22
9:15 AM	Introduction to MSRI				
9:30 AM 10:00 AM 10:30 AM	*Lecture:* Michael Wemyss	*Lecture:* Michael Wemyss	*Lecture:* Michael Wemyss	*Lecture:* Michael Wemyss	*Lecture:* Michael Wemyss
11:00 AM	*Coffee Break*	*Coffee Break*	*Coffee Break*	*Coffee Break*	*Coffee Break*
11:30 AM 12:00 PM	Exercises	Exercises	***BBQ Lunch at nearby park***	Exercises	Exercises
12:30 PM 1:00 PM 1:30 PM	***Lunch***	***Lunch***		***Lunch***	***Lunch***
2:00 PM 2:30 PM 3:00 PM	*Lecture:* Dan Rogalski	*Lecture:* Dan Rogalski	*Lecture:* Dan Rogalski	*Lecture:* Dan Rogalski	*Lecture:* Dan Rogalski
3:30 PM	*Tea Break*	*Tea Break*	*Tea Break*	*Tea Break*	*Tea Break*
4:00 PM 4:30 PM	Exercises	Exercises	Exercises	Exercises	Exercises
5:00 PM	*End of Day*	*End of Day*	*End of Day*	*End of Day*	*End of Day*

WEEK TWO

	Monday 6/25	Tuesday 6/26	Wednesday 6/27	Thursday 6/28	Friday 6/29
9:30 AM 10:00 AM 10:30 AM	*Lecture:* Travis Schedler	*Lecture:* Travis Schedler	*Lecture:* Travis Schedler	*Lecture:* Travis Schedler	*Lecture:* Travis Schedler
11:00 AM	*Coffee Break*	*Coffee Break*	*Coffee Break*	*Coffee Break*	*Coffee Break*
11:30 AM 12:00 PM	Exercises	Exercises	Exercises	Exercises	Exercises
12:30 PM 1:00 PM 1:30 PM	***Lunch***	***Lunch***	***Lunch***	***Lunch***	***Lunch***
2:00 PM 2:30 PM 3:00 PM	*Lecture:* Gwyn Bellamy	*Lecture:* Gwyn Bellamy	*Lecture:* Gwyn Bellamy	*Lecture:* Gwyn Bellamy	*Lecture:* Gwyn Bellamy
3:30 PM	*Tea Break*	*Tea Break*	*Tea Break*	*Tea Break*	*Tea Break*
4:00 PM 4:30 PM	Exercises	Exercises	Exercises	Exercises	Exercises
5:00 PM	*End of Day*	*End of Day*	*End of Day*	*End of Day*	*End of Day*

Attending Graduate Students		
First Name	**Last Name**	**Institution**
Donald	Adams	Arizona State University
Seth	Baldwin	Temple University
Bryan	Bischof	Kansas State University
Merrick	Brown	University of North Carolina
Branimir	Cacic	California Institute of Technology
Kei Yuen	Chan	University of Utah
Harrison	Chen	UC Berkeley Math Faculty
Hui	Chen	Kansas State University
Bryce	Chriestenson	University of Colorado
Kosmas	Diveris	Syracuse University
Eduard	Einstein	University of California
Gabriel	Feinberg	University of Connecticut
Jason	Gaddis	University of Wisconsin
Marton	Hablicsek	University of Wisconsin
Jessica	Hamm	Temple University
Johanna	Hennig	University of California, San Diego
Cody	Holdaway	University of Washington
Leonard	Huang	University of Kansas
Junho	Hwang	University of British Columbia
Andrew	Jaramillo	University of California
Giovanny	Jaramillo-Puentes	Universidad de los Andes
Xin	Jin	Northwestern University
Jaiung	Jun	Johns Hopkins University
Atsushi	Kanazawa	University of British Columbia
Yun-Hwan	Kim	Seoul National University
Jordan	Kostiuk	University of Alberta
Kyoung Seog	Lee	Seoul National University
Binglin	Li	University of California
Yunchang	Li	University of Hong Kong
Andras	Lorincz	Northeastern University
Jacob	Matherne	Louisiana State University
Kalina	Mincheva	Johns Hopkins University
Cris	Negron	University of Washington
Emily	Norton	University of Chicago
Hendrik	Orem	University of Texas
Brian	Paljug	Temple University
David	Platt	University of Oregon
Christopher	Policastro	University of Chicago
Brent	Pym	University of Toronto
Nathan	Saritzky	University of California
Jaeho	Shin	University of Georgia
Ross	Sweet	Boston University
Junyi	Tu	University of South Florida
Bolor	Turmunkh	University of Illinois at Urbana-Champaign
Dmitry	Vaintrob	Massachusetts Institute of Technology
Zhaoting	Wei	University of Pennsylvania
Tobias	Wilson	University of Massachusetts, Amherst
Zhengyao	Wu	Emory University
Philsang	Yoo	Northwestern University
Xuan	Yu	University of Nebraska
Lucy Liuxuan	Zhang	University of Toronto
Naizhen	Zhang	University of California
Qiao	Zhou	Northwestern University

Graduate Student Statistics

Participants		**53**

Gender		**53**
Male	79.25%	42
Female	16.98%	9
Declined to state	3.77%	2

Ethnicity*		**53**
White	47.17%	25
Asian	41.51%	22
Hispanic	1.89%	1
Pacific Islander	0.00%	0
Black	1.89%	1
Native American	0.00%	0
Mixed	1.89%	1
Declined to state	5.66%	3

* ethnicity specifications are not exclusive

40 responses

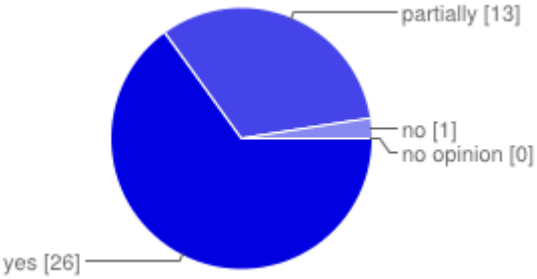
Summary

See complete responses

40 responses out of 57 participants: 70% of total participants.

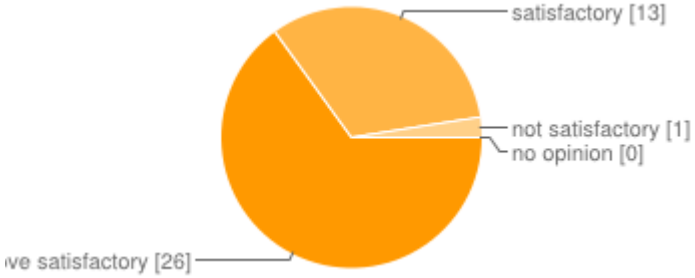
Topic presentation and organization

Did the various topics within the workshop integrate into a coherent picture?



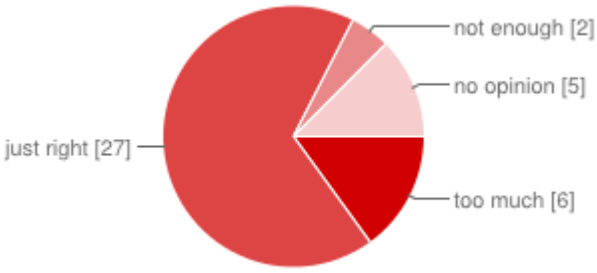
yes	**26**	65%
partially	**13**	33%
no	**1**	3%
no opinion	**0**	0%

Were the speakers generally clear and well organized in their presentation?



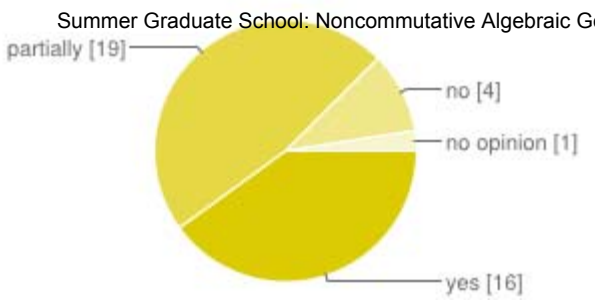
above satisfactory	**26**	65%
satisfactory	**13**	33%
not satisfactory	**1**	3%
no opinion	**0**	0%

Was there too much material presented; was the school too ambitious?



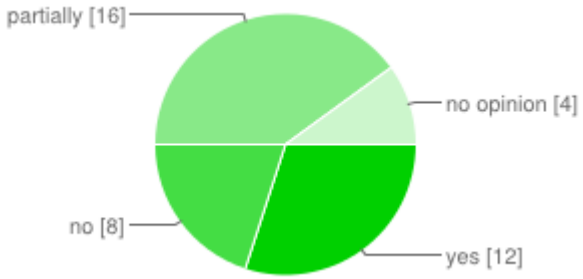
too much	**6**	15%
just right	**27**	68%
not enough	**2**	5%
no opinion	**5**	13%

Was the problem session helpful?



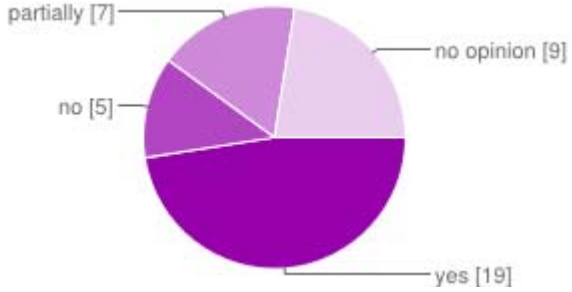
yes	**16**	40%
partially	**19**	48%
no	**4**	10%
no opinion	**1**	3%

Did you think the computer exercises were helpful?



yes	**12**	30%
no	**8**	20%
partially	**16**	40%
no opinion	**4**	10%

Would you have liked there to be more organized social activities?



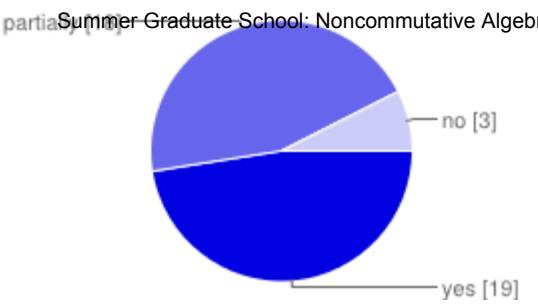
yes	**19**	48%
no	**5**	13%
partially	**7**	18%
no opinion	**9**	23%

Additional comment on the topic presentation and organization

Organizers should try to intergrate exercises with lectures. Rather than assign problems that explore related topics, organizers should omit proofs from lectures to be assigned as exercises. This wi ...

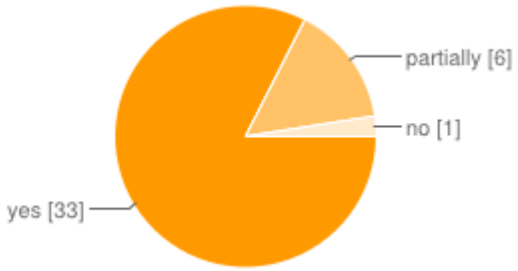
Personal assessment

Was your background adequate to access a reasonable portion of the material?



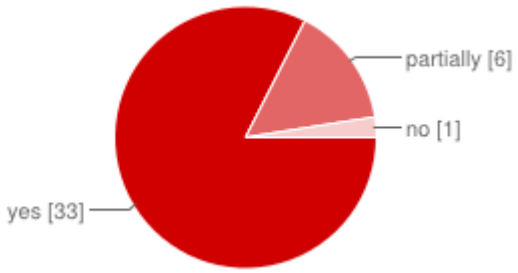
yes	**19**	48%
partially	**18**	45%
no	**3**	8%

Did the workshop increase your interest in the subject?



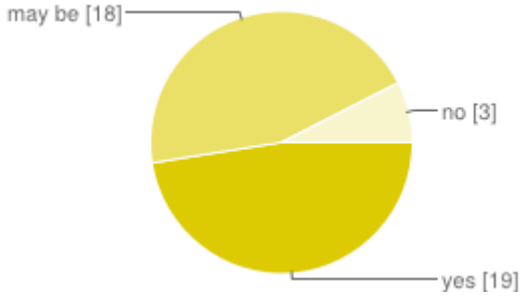
yes	**33**	83%
partially	**6**	15%
no	**1**	3%

Was the school worth your time and effort?



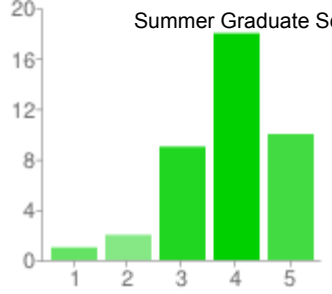
yes	**33**	83%
partially	**6**	15%
no	**1**	3%

Is it likely that you will work in the area of the workshop subject in the future?



yes	**19**	48%
may be	**18**	45%
no	**3**	8%

How would you evaluate your interaction with other participants?



not satisfactoryabove satisfactory

1 -	not satisfactory	**1**	3%
2		**2**	5%
3		**9**	23%
4		**18**	45%
5 -	above satisfactory	**10**	25%

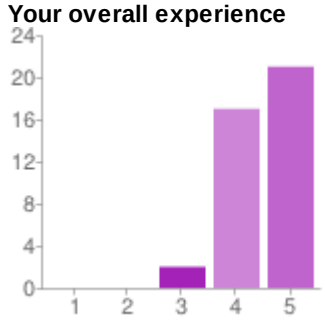
Additional comments on your personal assessment

Do not allot funds for social activities. Interaction should be through math! Most of the participants were wonderful--some were annoying or didn't bother to speak to me More organized social activity ...

MSRI Venue

Please rate the different categories

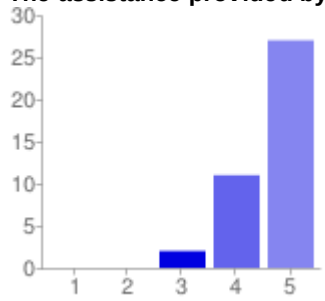
Your overall experience



not satisfactoryabove satisfactory

1 -	not satisfactory	**0**	0%
2		**0**	0%
3		**2**	5%
4		**17**	43%
5 -	above satisfactory	**21**	53%

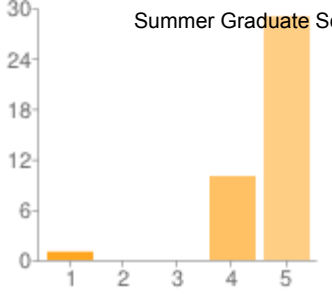
The assistance provided by staff



not satisfactoryabove satisfactory

1 -	not satisfactory	**0**	0%
2		**0**	0%
3		**2**	5%
4		**11**	28%
5 -	above satisfactory	**27**	68%

The physical surroundings



not satisfactoryabove satisfactory

1 -	not satisfactory	**1**	3%
2		**0**	0%
3		**0**	0%
4		**10**	25%
5 -	above satisfactory	**29**	73%

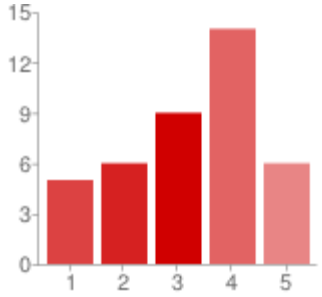
Additional comments on the MSRI venue

Staff provide nice maps for the fire road. However this route is time consuming. A more direct route to campus exists through Berkeley hills. Maps with this route would be helpful for those of us wi ...

Accommodation and Food

Please rate the different categories

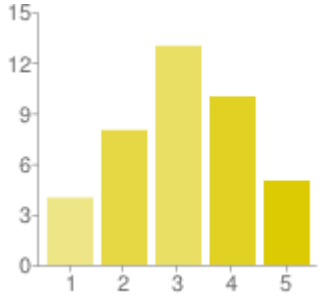
The summer school accommodation



not satisfactoryabove satisfactory

1 -	not satisfactory	**5**	13%
2		**6**	15%
3		**9**	23%
4		**14**	35%
5 -	above satisfactory	**6**	15%

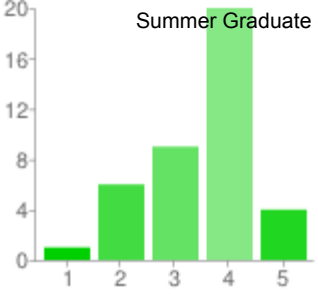
The food at the dormitories



not satisfactoryabove satisfactory

1 -	not satisfactory	**4**	10%
2		**8**	20%
3		**13**	33%
4		**10**	25%
5 -	above satisfactory	**5**	13%

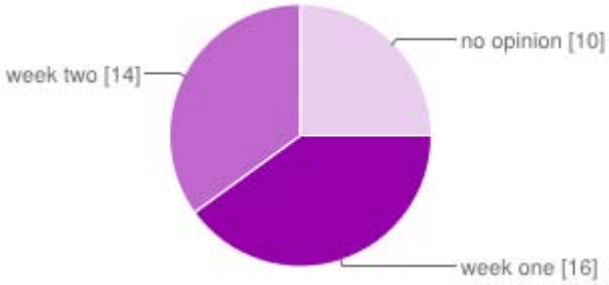
The food provided at MSRI



not satisfactoryabove satisfactory

1 -not satisfactory	**1**	3%
2	**6**	15%
3	**9**	23%
4	**20**	50%
5 -above satisfactory	**4**	10%

Did you prefer the lunch provided at MSRI in week one or week two



week one	**16**	40%
week two	**14**	35%
no opinion	**10**	25%

Additional comments on accommodation and food

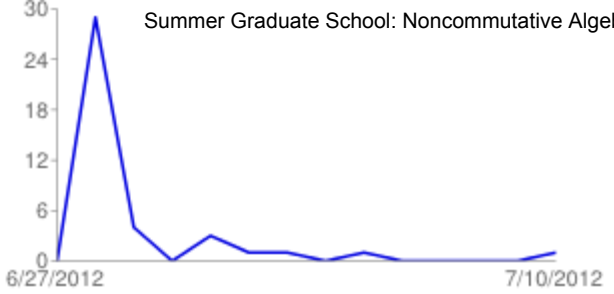
saulty The dorms were a bit primitive, the showers didn't quite work, but overall it was fine Both caterers had mostly good meals with one or two excellent meals, and I am thus unable to choose. Both c ...

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 would like to thank the administration for its amazing work. Everything was perfect. Now I can say that the the MSRI is a propitious place to work and develop high quality mathematics. The library is very good, and the supplies in general are excellent. Thank you for your work. The buses heading down the hill at the end of each day were often very crowded and uncomfortable. On an unrelated note: you should sell MSRI mugs! I felt bad about the number of paper cups I used each day, and would have loved a souvenir. The charter buses provided in the morning of the first week were very nice-- ...

Number of daily responses


30
24
18
12
6
0
6/27/2012
7/10/2012

Summer Graduate School: Noncommutative Algebraic Geometry June 18 – 29, 2012

Additional Survey Responses

Additional comments on your personal assessment

- Do not allot funds for social activities. Interaction should be through math!
- Most of the participants were wonderful--some were annoying or didn't bother to speak to me
- More organized social activity would have been welcome.
- I learned from participants more than from lecturers. It would be more helpful if there were working groups.
- Only the lectures by Dr Schedler are relevant to my area of research. Dr Wemyss has done a good job in cultivating my interest in a field that I am totally unfamiliar with. I might undertake the study of crepant resolutions in the future.

Additional comments on the venue

- Staff provide nice maps for the fire road. However this route is time consuming. A more direct route to campus exists through Berkeley hills. Maps with this route would be helpful for those of us without fancy phones.
- The staff here are wonderful! I wish I went to grad school here!
- MSRI provided a focused but relaxing workplace.
- The air conditioning in the lecture hall made the room freezing in the afternoon.
- I think US driver's license with valid date + student id card should work for receiving the reimbursement for international students if we are invited and supposed to be supported.
- Great view of the bay area. Excellent library.

We welcome any additional comments or suggestions you may have to improve the overall experience for future participants

- I would like to thank the administration for its amazing work. Everything was perfect. Now I can say that the the MSRI is a propitious place to work and develop high quality mathematics. The library is very good, and the supplies in general are excellent. Thank you for your work.
- The buses heading down the hill at the end of each day were often very crowded and uncomfortable. On an unrelated note: you should sell MSRI mugs! I felt bad about the number of paper cups I used each day, and would have loved a souvenir.
- The charter buses provided in the morning of the first week were very nice--in general, transportation was a bit of a hassle using the Hill Line because the normal buses were out of service. But overall the program was quite wonderful--the staff were great, and I learned a lot! Thank you!
- I was very impressed with the way that the four topics came together - they overlapped in a very appealing way.
- The buses were overcrowded during the morning and evening commutes. Every time the buses got filled with people standing leaving no space left and I was stuck in my seat I couldn't help but imagine the bus losing control and falling off the edge of the cliff along the road to MSRI sending 60+ people to their deaths. Honestly it was really scary. Are you sure it is safe to drive along that road in overcrowded buses?
- Lectures were good and I could be motivated by them. It would be much nicer, however, if the lecturers would have been more organized and prepared. Especially the second week lectures, I think, were not well prepared enough, so many participants even didn't come or left earlier. Nevertheless, there were given really good experiences which surely will help the future research.

Additional comments on accommodation and food

- Saulty
- The dorms were a bit primitive, the showers didn't quite work, but overall it was fine
- Both caterers had mostly good meals with one or two excellent meals, and I am thus unable to choose.
- buses were overcrowded
- Lodging was terrible. Should be quiet at least at night. Hardly fell asleep because of the noise made by cars. Horrible experience for two weeks.
- The dorms were beside the main road, so sleeping was made difficult by the sound of fire engine sirens and car engines. Each student should be given his/her own room. If two share a room, when one person decides to sleep, the other has to turn off the lights, which makes late-night studying extremely difficult.

Additional comments on the topic presentation and organization

- Organizers should try to intergrate exercises with lectures. Rather than assign problems that explore related topics, organizers should omit proofs from lectures to be assigned as exercises. This will allow for more greater connection between lecture and problem sessions. Moreover this will allow lecture topics to be discussed conceptually.
- The first two presenters (Dan Rogalski, Michael Wemyss) were excellent; their topics were unified, and presentations well-organizes and well-presented.
- 3 of the presenters were excellent--one was lacking in motivation and clarity
- The speakers were excellent, the school paced well, and the exercise well-chosen.
- The 1st talk of the 1st week was well organized
- The notes that lecturers intend to use for their lectures should be made available to students way in advance. Some notes assumed that the reader had the necessary background to comprehend the contents, which does not work out well in my case.
- The lectures are too difficult or technical. The exercise session should be more interactive.

Mathematical Sciences Research Institute

Summer Graduate Workshop: Seminaire de Mathematiques Superieures 2012:

Probabilistic Combinatorics

June 25, 2012 to July 06, 2012

University of Montreal, Canada

Organizers:

Louigi Addario-Berry* (McGill University)

Luc Devroye (McGill University)

Bruce Reed (McGill University)

Université de Montréal

Faculté des arts et des sciences
Département de mathématiques
et de statistique

SMS 2012: Director's report.

The scientific and educational value of 2012 *Séminaire de Mathématiques Supérieures* was superb. The meeting took place in Montréal in the period June 25- July 6, 2012. The quality of the talks was very high as was the preparation and level of the students. Exceptional for this year, an introductory series of lectures was offered in the two weeks preceding the SMS. The number of participants - 79 - was remarkably high. Simultaneously the organizers managed to negotiate lower housing costs compared to the usual rates.

The organizers, **Louigi Addario-Berri, Luc Devroye and Bruce Reed** have done a great job not only in what concerns the scientific program but also in operating a rigourous selection of the student participants as well as in managing the day-to-day organizational issues. 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 last year, 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 **Universities of Montreal**, support from the **Canadian Mathematical Society** as well as with support of the Montréal **CARP** research group. I thank all these insitutions for their contributions and I also thank the board of directors of the SMS for their work and support.

In the following you will find a detailed scientific, organizational and budgetary report. I thank again the organizers for taking the time to prepare such a thorough document.

Sincerely Yours,

Octav Cornea
Director, Séminaire de Mathématiques Supérieures
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September 3, 2012

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2012 Séminaire de Mathématiques Supérieures Scientific Report.

Overview

The 2012 Séminaire de Mathématiques Supérieures introduced nearly eighty young researchers from eastern and western Canada, the USA, Australia, Belgium, Brazil, the Czech Republic, England, France, Germany, Hungary, India, the Netherlands, and Sweden, to some of the most exciting subjects of active research in the area of probabilistic combinatorics. The subjects addressed at the summer school can be roughly arranged into two overlapping themes: (i) properties of discrete Markov chains; and (ii) new techniques for understanding structural properties of deterministic and random graphs.

The majority of the eleven invited speakers stayed for at least one full week of the SMS, and four of the speakers (Hatami, McDiarmid, Scott, Winkler) stayed for both weeks. This gave the students plenty of opportunity to interact with the speakers outside of the lecture hall, which contributed substantially to the scientific quality of the meeting. (For example, one speaker, Prasad Tetali, ended up giving a supplementary "mini-course" to a subset of the students who were interested in hearing more detail about some of the research Tetali touched on in his lectures.)

Theme 1: discrete Markov chains

The flagship lectures on this theme were by Peter Winkler, who gave a sequence of five ninety-minute talks on random walks on graphs. This (by now) classical subject has lots of beautiful theorems and scores of applications in mathematics and computer science. Nonetheless, new and remarkable results keep coming in. Winkler started by reviewing the classical results in the area, including the connection between random walks and electrical networks and its extensions. He then moved to some exciting new research, including recent results and open problems on covering the vertices and edges of a graph, the use of potential functions to prove universal bounds for cover times, and cat-and-mouse (or cop-and-robber) games on graphs.

James Lee' s talks dovetailed beautifully with Winkler's, while consisting of more classically probabilistic content. Lee presented his recent *tour de force* with Ding and Peres, relating the cover time of reversible Markov chains to the extremes of an associated Gaussian process. This research has now appeared in the Annals of Mathematics. Lee provided a brief background on Gaussian processes and beautifully presented Talagrand's majoring measures theorem. He then explained how he, Ding, and Peres used the majorizing measures theory to exhibit a close connection between the cover time of a graph and the expected square of its Gaussian free field.

The main tool allowing results for the Gaussian free field to be transferred to the setting of Markov chains is the the Dynkin isomorphism theory for Markov processes. While this connection is extremely useful and has already resulting in solutions to some open questions on cover times, it is also rather mysterious even in extremely simple examples. Lee discussed some natural starting points for possible research into the deeper structure behind the Dynkin theory.

Prasad Tetali's talks, on geometric and functional analysis on graphs, were conceptually linked to those of James Lee via the connection between isoperimetric inequalities and extremes of Gaussian processes. Tetali began with a review of some classical isoperimetric and functional inequalities in discrete spaces, with applications to concentration of measure and convergence to equilibrium of finite Markov chains. He then presented recent results on generalizations of Cheeger-type inequalities and refinements of Brunn-Minkowski inequalities, which suggest new directions for interesting research in geometric and functional analysis on graphs.

Perla Sousi presented her recent result, joint with Yuval Peres (and independently proved by Roberto Oliveira) on the equivalence of a broad family of notions of mixing time. Most notable among these is the fact that for reversible Markov chains, the mixing time is equivalent to the hitting time of large sets. This easily-stated fact provides a robust equivalent of the mixing time which can be used both to simplify many existing proofs and to derive new results. Sousi highlighted one such result, related to a geometric characterization of the mixing time for random walks on trees.

Yuval Peres's lectures were on the subject of random walks on *infinite graphs*, which despite being more classical is still rife with open problems and areas where our understanding is incomplete. At the outset, Peres motivated his lectures with the following question: which of the following random walks on $\mathbb{Z}^2$ are transient and which are recurrent?

1. In $\mathbb{Z}^2$, at times $t \in [4^k, 2 \cdot 4^k)$ we go up or down with equal probability. At times $t \in [2 \cdot 4^k, 4^{k+1})$, we go left or right with equal probability.

2. In $\mathbb{Z}^2$, if the current node has been visited before, then move left or right with equal probability; otherwise go up or down with equal probability.

3. In $\mathbb{Z}^2$, if $|x| \geq |y|$ then we go up or down each with probability 0.3, and left or right each with probability 0.2. This is reversed if $|y| > |x|$.

4. In $\mathbb{Z}^3$, fix two mean-zero measures μ_1, μ_2 that are truly 3D (that is, doesn't assign probability 1 to any hyperplane) with bounded support. If X_t has been visited before, then $X_{t+1} - X_t \sim \mu_2$, else $X_{t+1} - X_t \sim \mu_1$.

(It turns out that 1, 3, and 4 are transient, and it is an open problem to determine transience or recurrence for number 2.) Peres then presented a wide range of questions and results

on transience, recurrence, and speed of random walks on various models of infinite graphs, with a particular focus on highlighting basic gaps in our conceptual understanding and current techniques.

Finally, Eric Vigoda's talks formed a bridge between the first and second themes, presenting results related to Markov Chain Monte Carlo algorithms for generating random colourings of graphs of bounded degree. Vigoda explained the basic coupling technique, and its refinement – known as path coupling – due to Bubley and Dyer. He then explained the well-known result of Mark Jerrum on rapid mixing of the Glauber dynamics for colouring when the number of colours exceeds twice the maximum degree Δ. Vigoda followed this up with various improvements, beginning with his own famous result showing rapid mixing for the Glauber dynamics with $11\Delta/6$ colours, via the analysis of a more complicated chain that flips 2-color components. He also showed how a multi-step coupling can be used to get improved results assuming lower bounds on the girth and on the maximum degree, Δ. Finally, he explained a beautiful use of spectral graph theory to obtain improved results for planar graphs or graphs embeddable on a fixed surface.

THEME 2: COLOURINGS, CLIQUES, AND CONNECTIVITY

Many questions in combinatorics concern the relationship between the local and global structure of a graph or set system. For instance, what can we say about the subgraphs of a graph with large chromatic number? What about graphs without large cliques or independent sets? How uniformly is it possible to distribute edges in a graph? In 7.5 hours of lectures, Alex Scott presented a wide range of results and conjectures of this flavour, touching on the Erdos-Hajnal Conjecture, the Gyarfas-Sumner Conjecture, discrepancy for graphs and hypergraphs, and recently developed VC-dimension techniques.

Nikhil Bansal gave another extended mini-course of 7.5 hours, which brought the participants to the edge of existing knowledge in discrepancy theory. Discrepancy theory deals with the following type of question. Given a set-system, find a red-blue coloring of the elements such that each set is colored as evenly as possible. Perhaps surprisingly, this notion has a wide variety of applications both in computer science and mathematics, and several techniques (many of them non-constructive) have been developed to understand the discrepancy of various set-systems.

Recently, there have been several new developments in discrepancy based on connections to semidefinite programming. This connection is useful is various ways. It gives efficient polynomial time algorithms for several problems for which only non-constructive results were previously known. It also leads to several new structural results, such as tightness of the so-called determinant lower bound, and bounds on the discrepancy of union of set systems. Bansal presented these results in detail and touched on several related concepts such as correlated Brownian motions, the non-constructive entropy method, Gaussian

rounding, and SDP duality.

Penny Haxell's lectures had the intriguing title "a topology-free topological method." Over the last dozen years or so, certain topological methods have been developed and used to prove a family of results related to the following general problem. Let G be a graph whose vertex set is partitioned into nonempty sets $V_1, ..., V_r$. What conditions will guarantee that G contains an independent set $\{v_1, ..., v_r\}$ such that $v_i \in V_i$ for each i? This family of results includes theorems on matchings in hypergraphs, list colouring, strong colouring, and Aharoni's proof of Ryser's longstanding conjecture on packing and covering in tripartite hypergraphs. The topological arguments used are based on the notion of topological connectivity of simplicial complexes. Haxell has recently developed a method for establishing this entire theory using only elementary combinatorial arguments, and this approach was the subject of her SMS lectures.

Colin McDiarmid presented some recent breakthroughs on a classic question in probabilistic graph theory: what is the typical behaviour of the chromatic number $\chi(G)$ of a graph G? If R_n denotes some sort of random graph on n vertices, can we determine a function $f(n)$ such that $\chi(R_n)/f(n) \to 1$ in probability as $n \to \infty$? If so, what is $f(n)$? Can we bound the typical spread of the values $\chi(R_n)$? Is $\chi(R_n)$ usually close to $\omega(R_n)$, the maximum size of a complete subgraph?

McDiarmid presented a variety of his recent results; his lectures focussed primarily on the classical Erds-Rnyi or Bernouilli random graph $G(n, p)$ (both in the dense case when p is a constant and in the sparse case when np is constant), and on random geometric graphs. He also touched on other graph invariants such as edge chromatic number (chromatic index), list chromatic number, total chromatic number, achromatic number, improper chromatic number, and span. Perhaps most notably, he presented a recent technique that yields improved estimates for $\chi(G(n, p))$ in the dense case; and a surprising 'phase change' that occurs when colouring random geometric graphs.

The subject of influences is key to the understanding of phase transitions and sharp thresholds for various properties of discrete systems, including colouring of graphs, satisfiability of random formulas, and connectivity of random networks. Hatami presented the basic notion of the influence of a variable on a Boolean function, then sketched the proof of the Friedgut's theorem which says that if $f : \{0, 1\}^n \to \{0, 1\}$ has small total influence then it essentially depends on few coordinates. This theorem does not hold when the uniform distribution on $\{0, 1\}^n$ is replaced with the p-biased distribution for a small value of p. He discussed the relevance of this case to the study of the threshold phenomenon, and then sketch the proof of his own recent result, which characterizes the structure of Boolean functions with small total influences on general product probability spaces. The latter result has garnered substantial attention and has recently appeared in the Annals of Mathematics.

ORGANIZATION AND ADMINISTRATION

We received 135 applications from which we selected to fund 58 participants other than speakers. Approximately 20 other participants attended without our support, five of whom were funded by their home institutions and/or research supervisors, and the remainder of whom were mostly local graduate students and postdocs. Of the funded participants, eight are based at Fields institute member universities (University of Toronto x3, University of Waterloo x3, Carleton University x2), and six are based at PIMS member or affiliated universities (University of Washington x2, UBC, SFU, University of Victoria, University of Portland). We also had eighteen participants based at CRM member universities (McGill x16, Université de Montréal x2).

About 90% of the funding for participants went to graduate students, of which we tried to select those who were already advanced in their studies and working in areas closely related to the topic of the school. The remaining funding was directed primarily to three recent PhDs (who received their doctorates in 2009, 2010 and 2012). There were a few exceptions such as the graduate students selected by MSRI based on other criteria, and a very advanced undergraduate student from Carleton who was about to enter graduate school. In the selection process, we gave priority to the applicants for whom the school could have a significant impact on their research activities and development. In this regard, a letter from the advisor explaining the relevance of the school for the students program of studies was often a decisive factor. About 27% of the total number of participants, with or without funding, were female.

With the exception of the two CMS scholarships, and the 19 graduate students funded through MSRIs contribution (covering both local and travel expenses), the majority received a somewhat basic local support: 2 weeks in the student residences of the Université de Montréal and a contribution for travel expenses. The accommodation costs were somewhat reduced, compared with previous years, as we were able to negotiate a lower rate for the rental of student residences. To make up for the lack of support for local expenses, we provided a breakfast every day of the school, as well as coffee breaks. The CRMs administrative assistant was essential in the planning and the organization of the latter.

The CMS scholarships were awarded to two exceptionally qualified students enrolled in Canadian PhD programs. Both recipients actively engaged in all the SMS activities and made valuable contributions (both questions and comments) during the lectures. The MSRI-funded students were also an excellent fit for the summer school. They also participated actively in the lectures and in discussions with the other summer school participants.

OUTLINE OF THE EXPENDITURES

SPEAKERS: housing at the Terrace Royale 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 (CDN$ 380, non-refundable), plus support for travel expenses ranging from $250 CDN to $750 CDN depending on the distance to Montréal from the participant's location of study.

CMS SCHOLARSHIPS: 2 AT CDN $1000 EACH.

MSRI FUNDED PARTICIPANTS: 18 participants. MSRI support covered housing, meals and travel expenses.

SOCIAL ACTIVITIES:

- Daily breakfast and coffee breaks.
- One wine-and-cheese reception for the students and speakers (covered by the CDN $20 fee charged to each participant).
- Two dinners for the speakers at local restaurants (one per week due to some speakers not staying for the whole two weeks).

Acknowledgements

The organizers wish to acknowledge the generous support of the sponsors of the SMS 2012: the CRM, Fields Institute, PIMS, MSRI, ISM, Unversité de Montréal and the CMS. We also recognize and appreciate the hard work of the SMS Director, Octav Cornea. Finally, particular thanks are due to Sakina Benhima, the SMS administrator at the CRM, for her assistance at all stages of the organization and execution of the SMS.

SPEAKERS

Nikhil Bansal (Eindhoven University, Institute of Technology).
Title: *Low discrepancy colorings and semidefinite programming.*

Hamed Hatami (McGill University).
Title: *Influences and sharp thresholds.*

Penny Haxell (University of Waterloo).
Title: *A topology-free topological method.*

James Lee (University of Washington).
Title: *Cover times and Gaussian measures.*

Colin McDiarmid (University of Oxford).
Title: *Colouring random graphs.*

Yuval Peres (Microsoft Research)
Title: *Markov chain mixing times and related topics.*

Alex Scott (University of Oxford)
Title: *Cliques, colourings and discrepancy.*

Perla Sousi (University of Cambridge)
Title: *Markov chain mixing times: bounds and asymptotics.*

Prasad Tetali (Georgia Institute of Technology)
Title: *Geometric and Functional Analysis on Discrete Spaces.*

Eric Vigoda (Georgia Institute of Technology)
Title: *Markov chains for graph colouring.*

Peter Winkler (Dartmouth)
Title: *Random walk on a graph.*

PARTICIPANTS

1. Ambrus, Gergely (University of British Columbia)
2. Albenque, Marie (École Polytechnique)
3. Annamalai, Senguttuvan (Sree Vidyanikethan Engineering College)
4. Barba Flores, Luis Felipe (Carleton University)
5. Barta, Winfried (University of Chicago)
6. Bastos, Antonio (Universidade federal do Ceara)
7. Bhat, Vindya (Emory University)
8. Bhupatiraju, Sandeep (Indiana University)
9. Bissacot, Rodrigo (University of São Paolo)
10. Choi, Ilkyoo (University of Illinois)

11. Chuangpishit, Hoda (Dalhousie University)
12. Cream, Megan (Emory University)
13. Das, Shagnik (UCLA)
14. Delcourt, Michelle (University of Illinois)
15. Dos Santos, Vinicius (Universidade federal do Ceara)
16. Drellich, Elizabeth (University of Massachusetts)
17. Edwards, Kathryn (Princeton)
18. Eslava, Laura (McGill University)
19. Farczadi, Linda (University of Waterloo)
20. Fawzi, Omar (McGill University)
21. Fraiman, Nicolas (McGill University)
22. Freij, Ragnar (Chalmers University)
23. Gagnon, Jean-Franǫis (Université de Montréal)
24. Gopaladesikan, Mohan (Purdue)
25. Haddadan, Sharzad (Dartmouth College)
26. Hamaker, Zachary (Dartmouth College)
27. Hatami, Pooya (University of Chicago)
28. Hirscher, Timo (McGill University)
29. Hoda, Nima (Carleton University)
30. Hu, Ping (University of Illinois)
31. Hulshof, Tim (TU-Eindhoven)
32. Infeld, Ewa (Dartmouth College)
33. Jacob, Emmanuel (Universit Paris 6)
34. Johannson, Karen (University of Memphis)

35. Johnson, Katherine (University of Nebraska-Lincoln)
36. Khalil, Omar (McGill University)
37. Kang, Ross (Centrum voor Wiskunde en Informatica)
38. Komarov, Natasha (Dartmouth College)
39. Lavrov, Mikhail (Carnegie Mellon University)
40. Lei, Tao (McGill University)
41. Liu, Hong (University of Illinois)
42. Li, Lisha (University of California, Berkeley)
43. Li, Weiqiang (University of Delaware)
44. Loewenstein, Christian (Universität Ulm)
45. Mahoney, James (Portland State University)
46. Maia de Oliveira, Ana Karolinna (INRIA)
47. Medabalimi, Venkatesh (University of Toronto)
48. Mehrabian, Abbas (University of Waterloo)
49. Melczer, Stephen (Simon Fraser University)
50. Moura, Phablo (University of São Paolo)
51. Noël, Jonathan (McGill University)
52. Norouzian, Atta (McGill University)
53. Paquette, Elliot (University of Washington)
54. Pryby, Chris (Georgia Institute of Technology)
55. Rahman, Mustazee (University of Toronto)
56. Roberts, Matt (McGill University)
57. Salles, Marina (University of São Paolo)
58. Santos, Marcio (Universidade federal do Ceara)

59. Sato, Cristiane (University of Waterloo)
60. Sivaraman, Vaidy (Ohio State University)
61. Slivken, Erik (University of Washington)
62. Soo, Terry (University of Victoria)
63. Sulzbach, Henning (McGill University)
64. Tomar, Vikrant Singh (McGill University)
65. Turcotte, Jean-Sbastien Université de Montréal)
66. Ushijima-Mwesigwa, Hayato (Clemson University)
67. Volec, Jan (Charles University/Rutgers)
68. Vu, Dominic (University of Memphis)
69. Wang, Ruidong (Georgia Institute of Technology)
70. Wang, Xuan (University of North Carolina)
71. Weiner, Leah (McGill University)
72. Weller, Kerstin (University of Oxford)
73. Wen, Yuting (McGill University)
74. Wong, Tony (California Institute of Technology)
75. Wu, Hehui (McGill University)
76. Yepremyan, Liana (McGill University)
77. Yuditsky, Lena (McGill University)
78. Yung, Chun Kong (University of Toronto)
79. Zhou, Sanming (University of Melbourne)

THE SPRING SCHOOL IN GRAPH THEORY

In 2010, CARP member Bruce Reed organized the "First Montréal Spring School in Graph Theory". The 2010 school was supported by the CRM, Fields, PIMS, the ISM, and our CARP research group, and was a resounding success. This school was modelled on the PIMS summer schools in probability, which have taken place in 2004,2005,2008,2009, and 2010, and have played a large role in the development of an exceptionally strong community of young probabilists in North America and Europe.

The *Second* Montréal Spring School in Graph Theory (SSGT) took place in 2012. The first half of the second SSGT consisted of two courses, each consisting of ten 90-minute lectures over the course of two weeks. Bruce Reed gave a sequence of ten lectures on graph colouring and the probabilistic method; Louigi Addario-Berry gave a sequence of ten lectures on the use of Markov chain mixing, meeting, and covering times, and on random walks on random graphs. These two weeks provided an introduction to some of the probabilistic tools and techniques used in the research presented at the SMS. Approximately 40 of the 75 SMS participants also attended the two preliminary weeks of SSGT lectures.

Centre de recherches mathématiques
Université de Montréal

École d'été SMS 2012 "Combinatoire probabiliste"
Du 25 juin au 6 juillet 2012

SMS 2012 Summer School "Probabilistic Combinatorics"
June 25 - July 6, 2012

HORAIRE / *PROGRAM*

Le lundi 25 juin 2012 / *Monday, June 25, 2012*

08:30 - 09:00 Inscription et café croissants (1221) / *Registration and Coffee & Croissants (1221)*

09:00 - 10:30 **Alex Scott** (University of Oxford)
"Cliques, colourings and discrepancy - I"

10:30 - 11:00 Pause-café / *Coffee break*

11:00 - 12:00 **Prasad Tetali** (Georgia Institute of Technology)
"Geometric and Functional Analysis on Discrete Spaces - I"

12:00 - 13:30 Pause-déjeuner / *Lunch break*

13:30 - 15:00 **Peter Winkler** (Dartmouth College)
"Random walk and electrical networks"

15:00 - 15:30 Pause-café / *Coffee break*

15:30 - 16:30 **Perla Sousi** (University of Cambridge)
"Markov chain mixing times: bounds and asymptotics - I"

Le mardi 26 juin 2012 / *Tuesday, June 26, 2012*

09:00 - 10:30 **Peter Winkler** (Dartmouth College)
"Cover time for vertices and for edges"

10:30 - 11:00 Pause-café / *Coffee break*

11:00 - 12:00 **Perla Sousi** (University of Cambridge)
"Markov chain mixing times: bounds and asymptotics - II"

12:00 - 13:30 Pause-déjeuner / *Lunch break*

13:30 - 15:00 **Alex Scott** (University of Oxford)
"Cliques, colourings and discrepancy - II"

15:00 - 15:30 Pause-café / *Coffee break*

15:30 - 16:30 **Prasad Tetali** (Georgia Institute of Technology)
"Geometric and Functional Analysis on Discrete Spaces - II"

16:30 Cocktail de bienvenue (6245) / *Welcoming reception (6245)*

Le mercredi 27 juin 2012 / *Wednesday, June 27, 2012*

09:00 - 10:30 **Alex Scott** (University of Oxford)
"Cliques, colourings and discrepancy - III"

10:30 - 11:00 Pause-café / *Coffee break*

11:00 - 12:00 **Prasad Tetali** (Georgia Institute of Technology)
"Geometric and Functional Analysis on Discrete Spaces - III"

12:00 - 13:30 Pause-déjeuner / *Lunch break*

13:30 - 15:00 **Peter Winkler** (Dartmouth College)
"Collision and avoidance"

15:00 - 15:30 Pause-café / *Coffee break*

15:30 - 16:30 **Colin McDiarmid** (University of Oxford)
"Colouring random graphs - I"

Le jeudi 28 juin 2012 / *Thursday, June 28, 2012*

09:00 - 10:30 **Yuval Peres** (Microsoft Research)
"Markov chain mixing times and related topics - I"

10:30 - 11:00 Pause-café / *Coffee break*

11:00 - 12:00 **Colin McDiarmid** (University of Oxford)
"Colouring random graphs - II"

12:00 - 13:30 Pause-déjeuner / *Lunch break*

13:30 - 15:00 **Alex Scott** (University of Oxford)
"Cliques, colourings and discrepancy - IV"

15:00 - 15:30 Pause-café / *Coffee break*

15:30 - 16:30 **Perla Sousi** (University of Cambridge)
"Markov chain mixing times: bounds and asymptotics - III"

Le vendredi 29 juin 2012 / *Friday, June 29, 2012*

09:00 - 10:30 **Alex Scott** (University of Oxford)
"Cliques, colourings and discrepancy - V"

10:30 - 11:00 Pause-café / *Coffee break*

11:00 - 12:00 **Colin McDiarmid** (University of Oxford)
"Colouring random graphs - III"

12:00 - 13:30 Pause-déjeuner / *Lunch break*

13:30 - 15:00 **Peter Winkler** (Dartmouth College)
"Pursuit and evasion"

15:00 - 15:30 Pause-café / *Coffee break*

15:30 - 17:00 **Yuval Peres** (Microsoft Research)
"Markov chain mixing times and related topics - II"

Le lundi 2 juillet 2012 / *Monday, July 2, 2012*

09:00 - 10:30 **Nikhil Bansal** (Eindhoven University)
"Low discrepancy colorings and semidefinite programming - I"

10:30 - 11:00 Pause-café / *Coffee break*

11:00 - 12:00 **Eric Vigoda** (Georgia Institute of Technology)
"Markov chains for graph colourings - I"

12:00 - 13:30 Pause-déjeuner / *Lunch break*

13:30 - 15:00 **James R. Lee** (University of Washington)
"Cover times, Gaussian process and majorizing measures - I"

15:00 - 15:30 Pause-café / *Coffee break*

15:30 - 17:00 **Peter Winkler** (Dartmouth College)
"Branching random walk"

Le mardi 3 juillet 2012 / *Tuesday, July 3, 2012*

09:00 - 10:30 **James R. Lee** (University of Washington)
"Cover times, Gaussian process and majorizing measures - II"

10:30 - 11:00 Pause-café / *Coffee break*

11:00 - 12:00 **Eric Vigoda** (Georgia Institute of Technology)
"Markov chains for graph colourings - II"

12:00 - 13:30 Pause-déjeuner / *Lunch break*

13:30 - 15:00 **Nikhil Bansal** (Eindhoven University)
"Low discrepancy colorings and semidefinite programming - II"

15:00 - 15:30 Pause-café / *Coffee break*

15:30 - 16:30 **Hamed Hatami** (McGill University)
"Influences and sharp thresholds - I"

Le mercredi 4 juillet 2012 / *Wednesday, July 4, 2012*

09:00 - 10:00 **Eric Vigoda** (Georgia Institute of Technology)
"Markov chains for graph colourings - III"

10:00 - 11:00 **Penny Haxell** (University of Waterloo)
"A topology-free topological method - I"

11:00 - 11:30 Pause-café / *Coffee break*

11:30 - 13:00 **Nikhil Bansal** (Eindhoven University)
"Low discrepancy colorings and semidefinite programming - III"

13:00 Pause-déjeuner et après-midi libre / *Lunch Break and Free Afternoon*

Le jeudi 5 juillet 2012 / *Thursday, July 5, 2012*

09:00 - 10:30 **Nikhil Bansal** (Eindhoven University)
"Low discrepancy colorings and semidefinite programming - IV"

10:30 - 11:00 Pause-café / *Coffee break*

11:00 - 12:00 **Penny Haxell** (University of Waterloo)
"A topology-free topological method - II"

12:00 - 13:00 **Hamed Hatami** (McGill University)
"Influences and sharp thresholds - II"

Le vendredi 6 juillet 2012 / *Friday, July 6, 2012*

09:00 - 10:00 **Hamed Hatami** (McGill University)
"Influences and sharp thresholds - III"

10:00 - 11:00 **Penny Haxell** (University of Waterloo)
"A topology-free topological method - III"

11:00 - 11:30 Pause-café / *Coffee break*

11:30 - 13:00 **Nikhil Bansal** (Eindhoven University)
"Low discrepancy colorings and semidefinite programming - V"

Attending Graduate Students

First Name	Last Name	Current Institution
Vindya	Bhat	Emory University
Megan	Cream	Emory University
Megan	Cream	Emory University
Shagnik	Das	University of California
Elizabeth	Drellich	University of Massachusetts, Amherst
Pooya	Hatami	University of Chicago
Ping	Hu	University of Illinois at Urbana-Champaign
Ewa	Infeld	Dartmouth College
Katherine	Johnson	University of Nebraska
Lisha	li	UC Berkeley Math Faculty
weiqiang	Li	University of Delaware
James	Mahoney	Portland State University
Elliot	Paquette	University of Washington
Christopher	Pryby	Georgia Institute of Technology
Vaidy	Sivaraman	Ohio State University
Hayato	Ushijima-Mwesigwa	Clemson University
Dominik	Vu	University of Memphis
Ruidong	Wang	Georgia Institute of Technology
Wing Hong Tony	Wong	California Institute of Technology

Graduate Student Statistics

Participants		19

Gender		19
Male	63.16%	12
Female	36.84%	7
Declined to state	0.00%	0

Ethnicity*		19
White	47.37%	9
Asian	47.37%	9
Hispanic	0.00%	0
Pacific Islander	0.00%	0
Black	0.00%	0
Native American	0.00%	0
Mixed	5.26%	1
Declined to state	0.00%	0

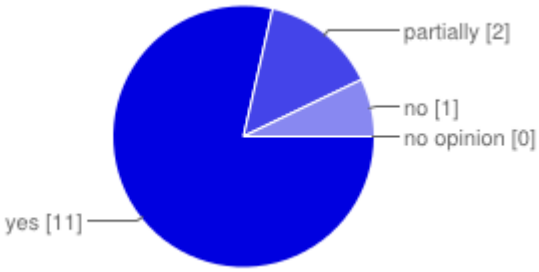
* ethnicity specifications are not exclusive

14 responses

Summary See complete responses

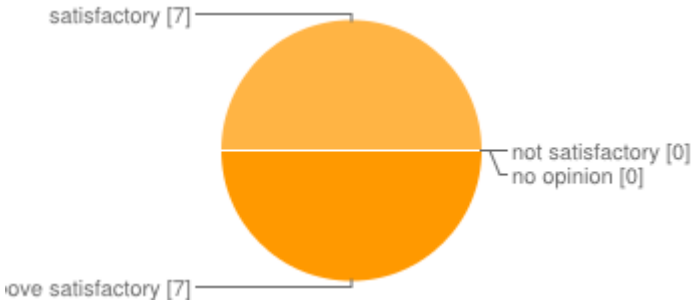
Topic presentation and organization

Did the various topics within the workshop integrate into a coherent picture?



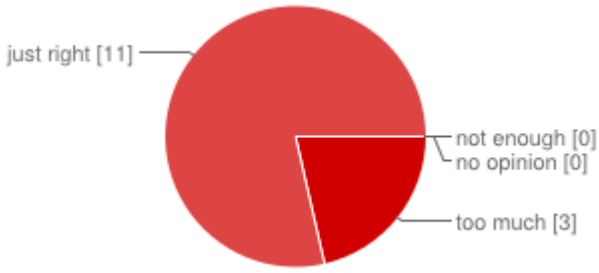
yes	**11**	79%
partially	**2**	14%
no	**1**	7%
no opinion	**0**	0%

Were the speakers generally clear and well organized in their presentation?



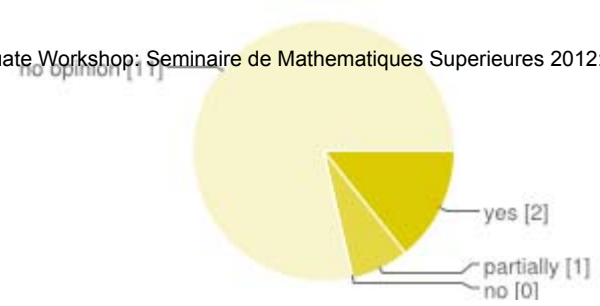
above satisfactory	**7**	50%
satisfactory	**7**	50%
not satisfactory	**0**	0%
no opinion	**0**	0%

Was there too much material presented; was the school too ambitious?



too much	**3**	21%
just right	**11**	79%
not enough	**0**	0%
no opinion	**0**	0%

Was the problem session helpful?



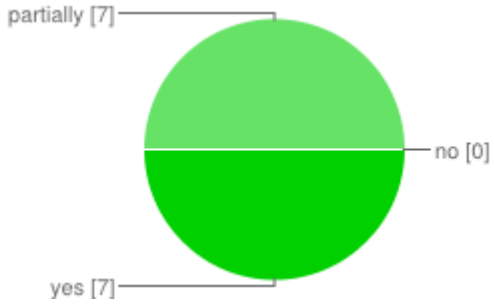
yes	**2**	14%
partially	**1**	7%
no	**0**	0%
no opinion	**11**	79%

Additional comment on the topic presentation and organization

There wasn't a problem session. all speakers were well prepared, some had better lecturing skills than others I felt like there was too much emphasis on Markov chain mixing times; I would like to have ...

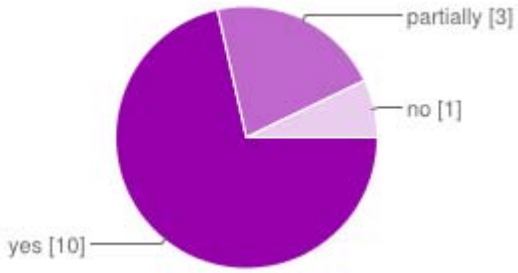
Personal assessment

Was your background adequate to access a reasonable portion of the material?



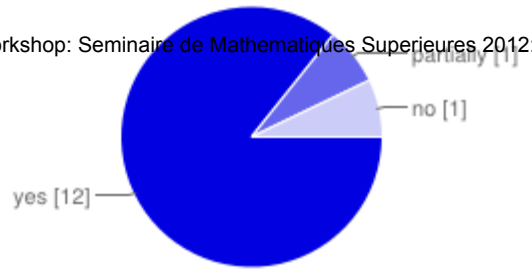
yes	**7**	50%
partially	**7**	50%
no	**0**	0%

Did the workshop increase your interest in the subject?



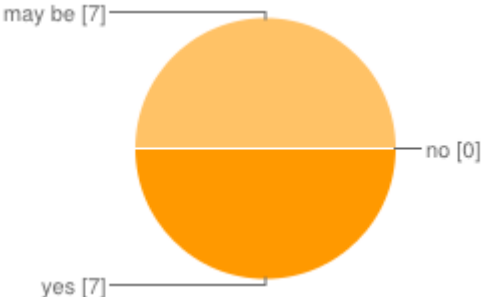
yes	**10**	71%
partially	**3**	21%
no	**1**	7%

Was the school worth your time and effort?



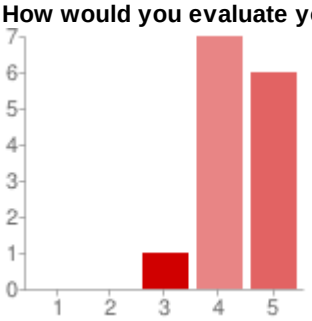
yes	**12**	86%
partially	**1**	7%
no	**1**	7%

Is it likely that you will work in the area of the workshop subject in the future?



yes	**7**	50%
may be	**7**	50%
no	**0**	0%

How would you evaluate your interaction with other participants?



1 -	not satisfactory	**0**	0%
2		**0**	0%
3		**1**	7%
4		**7**	50%
5 -	above satisfactory	**6**	43%

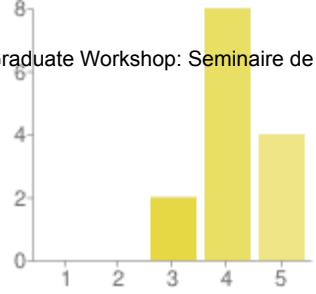
Additional comments on your personal assessment

Great!!!! some topics were new to me and i'm looking forward to looking further at them I think my expectation of the summer school was that it would be a more intense review of the basics of probabil ...

Venue

Please rate the different categories

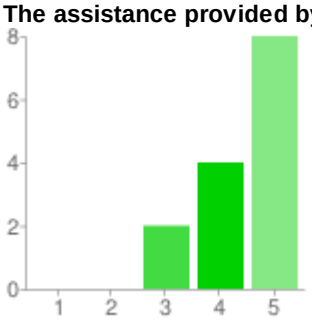
Your overall experience



not satisfactoryabove satisfactory

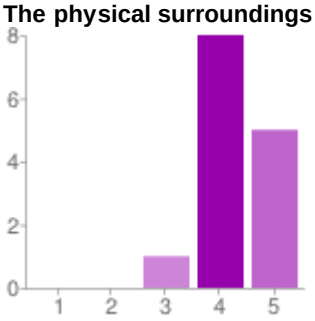
1 -	not satisfactory	**0**	0%
2		**0**	0%
3		**2**	14%
4		**8**	57%
5 -	above satisfactory	**4**	29%

The assistance provided by staff



1 -not satisfactory	**0**	0%
2	**0**	0%
3	**2**	14%
4	**4**	29%
5 -above satisfactory	**8**	57%

The physical surroundings



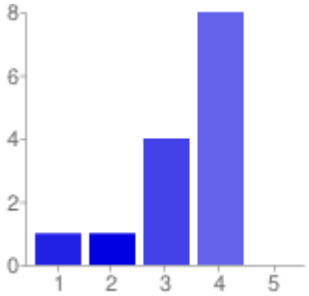
1 -not satisfactory	**0**	0%
2	**0**	0%
3	**1**	7%
4	**8**	57%
5 -above satisfactory	**5**	36%

Additional comments on the school venue

Accommodation and Food

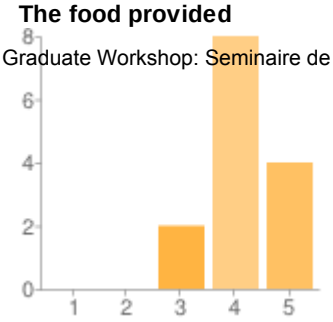
Please rate the different categories

The summer school accommodation



1 -not satisfactory	**1**	7%
2	**1**	7%
3	**4**	29%
4	**8**	57%
5 -above satisfactory	**0**	0%

The food provided



not satisfactoryabove satisfactory

1 -not satisfactory	**0**	0%
2	**0**	0%
3	**2**	14%
4	**8**	57%
5 -above satisfactory	**4**	29%

Additional comments on accommodation and food

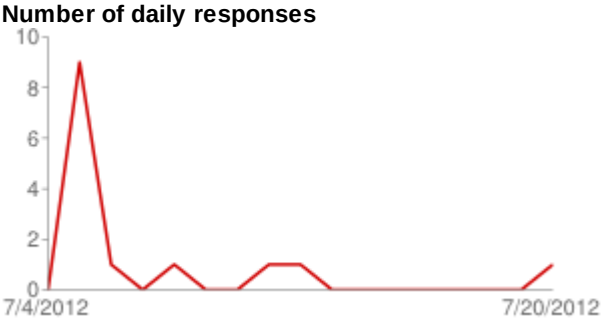
It will be better if there is welcoming lunch/dinner. would have been nice if wifi/internet provided in dorm rooms; no pots/pans/utensils in kitchen It was quite warm while I was there, and there was ...

Thank you for completing this survey

We welcome any additonal comments or suggestions you may have to improve the overall experience for future participants.

-plan more social/cultural events around city to promote grad student interaction -let participants know what to bring with them to prevent unnecessary purchases (shampoo, flip-flops, bowls, plates, pots/pans, etc) Be clear about what the $20 was used for. Social events? I don't think so... It would be nice if more events (in addition to the coffee breaks) were organized to get everyone together and talking about math. I enjoyed Peter Winkler's and Alex Scott's talks the most. Invite speakers with significant teaching experience who are capable of *teaching* a course rather than giving a lec ...

Number of daily responses



Summer Graduate School:
Seminaire de Mathematiques Superieures 2012: Probabilistic Combinatorics
June 25 – July 6, 2012

Additional Survey Responses

Additional comments on your personal assessment

- Great!!!!
- some topics were new to me and i'm looking forward to looking further at them
- I think my expectation of the summer school was that it would be a more intense review of the basics of probabilistic combinatorics combined with problem sessions to get the participants to interact with each other and learn the material. It felt instead more like a conference, or perhaps I just didn't have the right background to appreciate the material.

We welcome any additional comments or suggestions you may have to improve the overall experience for future participants

- -plan more social/cultural events around city to promote grad student interaction -let participants know what to bring with them to prevent unnecessary purchases (shampoo, flip-flops, bowls, plates, pots/pans, etc)
- Be clear about what the $20 was used for. Social events? I don't think so...
- It would be nice if more events (in addition to the coffee breaks) were organized to get everyone together and talking about math. I enjoyed Peter Winkler's and Alex Scott's talks the most.
- Invite speakers with significant teaching experience who are capable of *teaching* a course rather than giving a lecture.
- Better accommodation, closer to rest of the city to enable the possibility to have better social interaction amongst participants. Social events organized by the summer school

Additional comments on accommodation and food

- It will be better if there is welcoming lunch/dinner.
- would have been nice if wifi/internet provided in dorm rooms; no pots/pans/utensils in kitchen
- It was quite warm while I was there, and there was no air conditioning in the room.
- The accommodation was extremely subpar, charging extra horrendously for internet access in a student dorm. In addition to this, my room was not cleaned, nor the linens changed during the two weeks, contrary to what was promised. The building I lived in was under renovation, thus generating a lot of noise and irritating odors (paint).

Additional comments on the topic presentation and organization

- There wasn't a problem session.
- all speakers were well prepared, some had better lecturing skills than others
- I felt like there was too much emphasis on Markov chain mixing times; I would like to have seen more varied topics. Prasad Tetali's "side lecture" on the relation between spectral gaps and isoperimetric inequalities was a nice addition to the mix of topics. Also, I wish there had been "homework problems" or problem sessions to give the participants some focus on what to take away from the lectures.
- There was no problem session, one speaker was significantly weaker and less qualified than the others consequently delivering the least suitable session

Mathematical Sciences Research Institute

Summer Graduate Workshop:
IAS/PCMI Summer 2012:
Geometric Group Theory

July 1, 2012 to July 21, 2012

Park City, Utah USA

Organizers:

Mladen Bestvina (University of Utah)

Michah Sageev (Technion – Israel Institute of Technology)

Karen Vogtmann (Cornell 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 2012

The 22nd annual Summer Session was held July 1-21, 2012, in Park City, Utah, and attracted some 400 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
Secondary School Teachers Program
Service, Teaching and Research (STaR) Program (one week)
Undergraduate Faculty Program
Undergraduate Summer School

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 2012 the topic was *Geometric Group Theory*. The topic *Making Mathematical Connections* provided the focus for the three-week Secondary 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 Mladen Bestvina, University of Utah; Michah Sageev, Technion – Israel Institute of Technology; and Karen Vogtmann, Cornell University. *Geometric Group Theory* is a very broad area of mathematics whose objective is to study groups using diverse tools from topology, geometry, algebra, analysis, and dynamics; and the Graduate Summer School lecture series reflected this diversity. The Research Program's centerpiece was a series of lectures on the recent breakthrough by Agol and Wise on the geometry of hyperbolic cube complexes that solved the last major 3-manifold conjectures.

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 2012 Graduate Summer School had nine lecture series (with a total of 36 lectures), each on a particular aspect of Geometric Group Theory. Each lecture series consisted of 4 lectures and 3 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 2012

Mladen Bestvina: *Topology and Geometry of Outer space*
Emmanuel Breuillard: *Property T, expanders and approximate groups*
Pierre-Emmanuel Caprace: *Structure of CAT(0) spaces and their isometry groups*
Tsachik Gelander: *Arithmetic Groups, Locally Symmetric Manifolds and some Asymptotic Invariants*
Vincent Guirardel: *Rotating families, Dehn fillings and small cancellation*
Michael Kapovich: *Quasi-isometric rigidity*
Dave Morris: *Some arithmetic groups that do not act on the circle*
Michah Sageev: *CAT(0) cube complexes*
Amie Wilkinson: *Geometric rigidity and the geodesic flow in negative curvature*

The Research Program

A broad spectrum of highly active researchers in *Geometric Group Theory* 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 are likely to develop into new collaborations.

The highlight of this year's program consisted of the exposition of the recent breakthrough in the theory of special cube complexes by Ian Agol and Dani Wise. Agol gave two formal talks and a third informal lecture after dinner. Agol's collaborator Jason Manning, as well as Wise's collaborator Piotr Przytycki, gave one formal and two informal talks each. One of the graduate lectures, by Michah Sageev, covered the background material on cube complexes.

The speakers in the research seminar and their titles were:

Ian Agol: *The virtual Haken conjecture, Part I and Part 2*
Martin Bridson: *Recognition problems, profinite completions of groups, and cube complexes*
Ken Bromberg: *Bounded cohomology with coefficients and groups acting on quasi-trees*
Kai-Uwe Bux: *Finiteness Properties of the Braided Thompson Group V_{br}.*
Ruth Charney: *Outer Space for Right-Angled Artin Groups*
Tom Church: *A stability conjecture for the unstable cohomology of mapping class groups, SL_n(Z), and Aut(F_n)*
Jim Conant: *Hairy graphs and the homology of out(F_n)*
Benson Farb: *Permutations and polynomiality in algebra and topology*
Mark Feighn: *Subsurface projection in the Out(F_n)-setting*
Alessandra Iozzi: *Rigidity of actions on CAT(0) cube complexes*
Sebastian Hensel: *Realisation and Dismantlability*
Thomas Koberda: *Canonical quasi-trees for right-angled Artin groups*
Chris Leininger: *Mapping class groups, Kleinian groups, and convex cocompactness*
Lars Louder: *Relative hyperbolicity and hierarchies for finitely presented groups*
Jason Manning: *Relatively hyperbolic Dehn filling*
Lee Mosher: *Hyperbolicity of the free splitting complex of F_n (joint work with M. Handel)*
Shahar Mozes: *Invariant measures and divisibility Piotr Przytycki: Mixed 3-manifolds are virtually special*
John Pardon: *Totally disconnected groups (not) acting on three-manifolds*
Alexandra Pettet: *On fully irreducible elements of the outer automorphism group of a free group*
Doron Puder: *Measure preserving words are primitive*
Iddo Samet: *(title unpublished)*
Bill Thurston: *(title unpublished)*
Kevin Wortman: *Cohomology of arithmetic groups*

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 2012 Clay Scholars at PCMI were Alex Lubotzky from Hebrew University, and William Thurston from Cornell University. Due to Thurston's ill health, Martin Bridson from Oxford University was awarded the status of Senior Scholar in Residence and gave the public all-institute lecture. Since the Summer Session ended, Thurston passed away on August 21, 2012; PCMI was honored to have him in residence for two weeks and to be a part of his final work. Thanks go to Thurston's son, Dylan, for accompanying his father to PCMI and assisting with Thurston's talk, and to Martin Bridson for his willingness to assume the responsibilities of the Clay Scholar.

SECONDARY SCHOOL TEACHERS PROGRAM

The Secondary School Teachers Program (SSTP) of 2012 attracted 64 teachers from all levels. The participants followed an intense daily schedule that included learning mathematics, reflecting on the practice of teaching mathematics in today's classrooms, and working together in groups to create products to be shared with their colleagues.

Participants took part daily in a two-hour, mathematics problem-solving course; this year's course was entitled *Moving Things Around: Card Shuffles, Repeating Decimals and Geometric Transformations*. By focusing on symmetry and group theory, the course provided a connection with PCMI's Research Program topic of *Geometric Group Theory*. Beginning with the problem of why eight repeated perfect shuffles of a deck of cards return the cards to their original positions, participants pursued this problem for decks of various size, investigating specific examples using modular arithmetic (especially the group of units in Zn) and repeating decimals (and repeating binary expansions), making surprising connections to remainders in the long division algorithm on the way. The course connected these ideas to symmetry groups of regular polygons, and polyhedra and arrived at the construction and application of several Cayley graphs, an important concept for the *Geometric Group Theory* topic. On the last day, the course ended with a brief, elegant proof that there exist only five regular polyhedra.

The materials for the mathematics problem-solving courses are created by a team led by Al Cuoco and Bowen Kerins from the Educational Development Center (EDC); instructors for the course were Darryl Yong from Harvey Mudd College and Kerins, a mathematics educator from EDC and a former math teacher.

In the daily *Reflecting on Practice* session participants considered research related to teaching and learning mathematics with a particular focus on questioning and how it impacts instruction. The discussion was grounded in the research literature as participants worked collaboratively to better understand why questions are an important component of instruction and how they can use questioning in their own classrooms to promote student understanding. A staff of six teacher leaders designed and led the sessions under the guidance and supervision of the SSTP leadership team. Videos of classrooms from the US and other countries, transcripts, research findings, articles, assessment results and student work were used to prompt an analysis of effective questioning and how it can be enacted in classrooms.

Each afternoon the participants took part in one of seven Working Groups in the following topics: data analysis, functions, geometry, discrete mathematics, lesson study, preparing for the implementation of the Common Core State Standards (c-TaP), and a group that took part in PCMI's Undergraduate (College) Faculty Program's mathematics course. In this last working group, participants not only learned about the research topic of *Geometric Group Theory,* but also wrote reflections on how the mathematics of the UFP course related to their own teaching at the high school level. (These and abstracts of the other working group reports can be found at http://mathforum.org/pcmi/hstp/sum2012/abstracts.html). The working group on functions focused on preparing a matrix of examples to enable their colleagues to understand the role of functions in the Common Core State Standards in Mathematics. The other working groups explored technology, developed lessons and classroom activities and created drafts of potential articles on interesting and useful mathematics that will be tested in classrooms when appropriate, reviewed during the coming year, revised as necessary, and posted on the PCMI website. The SSTP publications editor, Bob Stein, met with the working groups, with individual teachers, and with working group leaders who have projects nearing completion. The lesson study report and the work of the function group were immediately processed for review and potential publication.

The c-TaP Project

New this year is the Committee on Teachers as Professionals (c-TaP) project, which is composed of representatives of 11 organizations associated with mathematics education in the United States. The c-TaP project supports the concept that it is mathematics teachers who should have a leadership role in implementing the Common Core State Standards in Mathematics (CCSSM) from the beginning, and that this role should expand as the CCSSM are implemented across the nation. To promote this concept, three c-TaP working groups in the SSTP drafted professional development activities and a facilitator's guide for workshops on implementing the CCSSM at the elementary, middle, and high school levels. These workshops were piloted in July and August by some of the developers who were participants at PCMI.

Other Connected Programs

The Service, Teaching and Research (STaR) project for new faculty in mathematics education, organized by Robert and Barbara Reys from the University of Missouri, met during the third week of PCMI. The structured conversation at lunch among the SSTP participants and the STaR participants from similar geographic areas was a productive and informative opportunity for the two communities to interact.

A high school student Math Camp was a pilot feature at PCMI in 2012. Organized by Troy Jones, a teacher from Westlake High School in Alpine, Utah, with funding from IM Flash Technologies, the program enabled 12 select high school students to attend PCMI for the second week. The students, chaperoned by a subset of parents, worked in their own classroom on the same mathematical problem sets as the SSTP participants in the morning and had a series of afternoon speakers from nearby universities, industries or from other PCMI programs. They also attended and took part in the cross program activities (e.g., Clay Mathematics Institute lectures, pizza and problem solving session) and attended the SSTP sessions held in late afternoon or evening (e.g., origami building). In addition to their own class work and homework, the students functioned as the laboratory for the first teaching done by the SSTP's Lesson Study Working Group. They also managed to complete two weeks of the mathematics course during their morning sessions and were actually able to join the SSTP participants in the mathematics course on their last day at PCMI.

Distance learning

In addition to the SSTP taking place in Park City, 11 teachers from Las Cruces, New Mexico, funded through a National Science Foundation grant, took part each day in real time via electronic "e-tables:" i.e. distance learning with real time screen images and interaction between the two sites. The New Mexico e-tables were organized by Susana Salamanca, a mathematician at New Mexico State University, and facilitated by Rina Martinez, a past SSTP participant, with Soledad Gonzales and Robyn Perkins, all three middle school teachers.

UNDERGRADUATE FACULTY PROGRAM

For faculty members whose main focus is teaching undergraduate students, the Undergraduate Faculty Program (UFP) at PCMI offers the opportunity to renew excitement about mathematics, talk with peers about new teaching approaches, address some challenging research questions, and interact with the broader mathematical community. The UFP is unique in that it bridges the educational and research objectives of PCMI.

This year's UFP instructor/coordinator was Moon Duchin, Tufts University. Duchin approached the UFP program in a new, experimental way, with an emphasis on fostering research ties between the participants and on developing an excellent source of potential research problems in *geometric group theory* for undergraduate students.

Unlike previous years, all of the 16 participants had experience in geometric group theory, or at least in areas close by. In the first week, each UFP participant gave a roughly thirty minute talk on their research. This set up a common language for all the people in the UFP. The second and third weeks had two components. First, the participants came up with a list of topics in geometric group theory that they wanted to know more about, and various people in the Research Program were asked to give introductory talks on these topics, explicitly modeled on the "What is …" articles in the Notices of the American Mathematical Society. Second, and more importantly, there were sessions at least twice a day with all the participants brainstorming research problems, both for themselves and for students. The problems they generated have been collected and organized. A number of the participants are planning on having students start on some of these problems this fall.

Duchin is writing a grant for a follow-up conference in a year and a half for the participants and their students, with the hope that the conference proceedings would be published by the AMS. More importantly, the UFP participants want to document how they are creating their own research community.

UNDERGRADUATE SUMMER SCHOOL

Some forty undergraduate students took part in PCMI's 2012 Undergraduate Summer School. PCMI offers two distinct courses for undergraduates, one Introductory and one Advanced, with students self-selecting into either or both.

The introductory course, by Jennifer Taback, of Bowdoin College, drew on the text by John Meier on *Groups, Graphs and Trees: An Introduction to the Geometry of Infinite Groups.* Although the text contains more than one can typically cover in a full semester, Professor Taback managed to motivate, explore and establish key results in each of the chapters. She developed ideas briskly, at the board, with, as the class progressed, significant collaboration with and among her students. Her course also attracted a few graduate students, a few participants in the Undergraduate Faculty Program and ten or so thoroughly engaged High School Teachers.

Kevin Wortman, of the University of Utah, offered the Advanced Course on *Arithmetic Groups*. This subject and course draws on a broad array of insights and theories, resulting in an integrated series of mini-courses on matrix groups, Lie groups, hyperbolic geometry and analysis. His course attracted several graduate students and several participants from the Undergraduate Faculty Program.

WORKSHOP FOR MENTORS OF UNDERGRADUATE MATHEMATICS RESEARCH BY MINORITY STUDENTS (WFM)

New to PCMI this year was a workshop funded by the National Science Foundation through a targeted supplement to PCMI's larger grant. The first Workshop for Mentors of Undergraduate Mathematics Research by Minority Students (WfM) was held at PCMI July 9-13, 2012. Organized and conducted by Steven Cox, Rice University, and Dennis Davenport, Howard University, the workshop attracted some 22 applicants from a variety of institutions, some specifically minority-serving. Ten participants were selected to take part in the workshop, whose focus was to enable more mentors to successfully engage their minority undergraduate students in mathematical research. The stated goals of the workshop were:
(1) construct or select exciting undergraduate-tractable research problems,
(2) transform their mentees into confident speakers and writers of mathematics,

(3) acquire group building skills and so create communities of scholars,
(4) design and/or augment curricula for academic and/or summer research,
(5) construct competitive proposals to fund and sustain activities (1-4).

The program met for three-four hours each day, and was joined by the Undergraduate Faculty Program on three occasions for a joint session. The content sessions served to inform the younger participants and to anchor the daily discussion periods. These discussions brought up concrete challenges and approaches to

1) preparing and mentoring underrepresented groups, and
2) supporting faculty and fostering research at Minority Serving Institutions,

and worked to identify suitable funding mechanisms and ways to better integrate with and/or grow related PCMI activities. In particular, the 10 participants and two instructors constituted four working groups, with some members contributing to more than one group. Each group generated and presented an outline for a program for addressing points 1 and 2 above.

Group one reviewed the BYU/CURM REU model and proposed to establish something of its ilk at Howard University.

Group two proposed an Undergraduate Faculty Student Partnership Program that would pair mentors and students at Minority Serving Institutions (MSI) and provide (i) faculty incentives to offer a spring time background course in the upcoming PCMI theme and (ii) seats in the undergrad program for some fraction of those students.

A third group proposed a variant on the NSF RTG model that would bring multiple mentors and their students to PCMI, with the lead mentor coming from an MSI.

The fourth group proposed a Proposal Writing Workshop with significant stress on hands-on components and expert follow-up, with the intent to not merely prepare the faculty member but to actually see that each member submits a complete, competitive proposal.

Discussion of theses four ideas is on-going, both among the 12 workshop members, and the PCMI Steering Committee.

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 planned by the organizers:

The Opening Socials
Clay Mathematics Institute Lecture – Alex Lubotsky, Hebrew University
Presentation on the Common Core State Standards in Mathematics
The PCMI Opening Dinner
The Annual Park City 4th of July Parade Entry by PCMI
PCMI World Cup Soccer Match
Robert J. Lang: *The Modern Science of Origami*
Film: *The Derivative vs. the the Integral: the Final Smackdown*
Discussion forum: *Conversations between Undergraduate Faculty and Secondary Teachers*
Origami construction sessions.
David Bressoud: *Characteristics of Successful Program in College Calculus*

Pizza and Problem Solving Session
Zome Tool Extravaganza with Paul Hildebrandt, Zometools, Inc.
Ice Cream Social
Clay Mathematics Institute Lecture – Martin Bridson, Oxford University
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 18 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 disseminates its teacher-created materials and other resources via a special website created by the Math Forum at Drexel University.

The proceedings and briefs of the International Seminar on Mathematics Education are also published on the website at the Math Forum.

Funding

The IAS/Park City Mathematics Institute was made possible by the generosity of the following funders:

The National Science Foundation, grants DMS-0940733 and EHR-0554309
Math for America
The Morrell Foundation
The National Security Agency
Mrs. Rosanna Jaffin
The Wolfensohn Family Foundation
The Clay Mathematics Institute
The Mathematical Sciences Research Institute

Appreciation is extended for the in-kind contributions of the Department of Mathematics at the University of Utah.

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 2012:
Director: Richard Hain, Duke University
Aaron Bertram, University of Utah
Mladen Bestvina, University of Utah
Gail Burrill, Michigan State University
Steve Cox, Rice University
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 Mississippi
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John Polking, Rice University
Michah Sageev, Technion – Israel Institute of Technology
Ronald Stern, University of California-Irvine
Karen Vogtmann, Cornell University

PCMI Diversity Sub-Committee:
Chair: 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

Attending Graduate Students

First Name	Last Name	Current Institution
Patricia	Cahn	Dartmouth College
Christopher	Cappadocia	McMaster University
David	Cohen	Rice University
Aliska	Gibbins	Ohio State University
Ryan	Greene	Ohio State University
funda	gultepe	University of Oklahoma
Michael	Hull	Vanderbilt University
Ashley	Johnson	University of Nebraska
Curtis	Kent	Vanderbilt University
Maria	Mendoza	Centro de Investigacion y de Estudios Avanzados del IPN
Thang	Nguyen	Indiana University
Andrei	Pavelescu	University of Southern California
Jenya	Sapir	Stanford University
Emily	Stark	Tufts University
Balazs	Strenner	University of Wisconsin
Shuyun	Wu	Princeton University
Ning	Yang	Indiana University

Graduate Student Statistics

Participants		17

Gender		17
Male	52.94%	9
Female	41.18%	7
Declined to state	5.88%	1

Ethnicity*		17
White	76.47%	13
Asian	11.76%	2
Hispanic	5.88%	1
Pacific Islander	0.00%	0
Black	0.00%	0
Native American	0.00%	0
Mixed	0.00%	0
Declined to state	5.88%	1

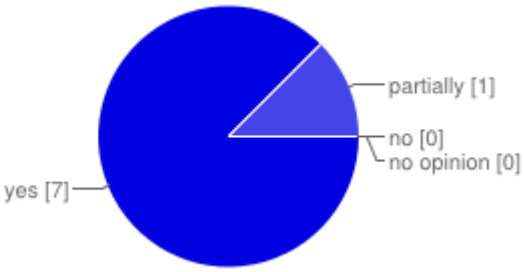
* ethnicity specifications are not exclusive

Summary

See complete responses

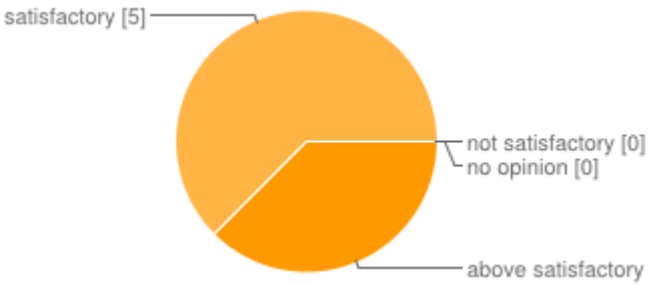
Topic presentation and organization

Did the various topics within the workshop integrate into a coherent picture?



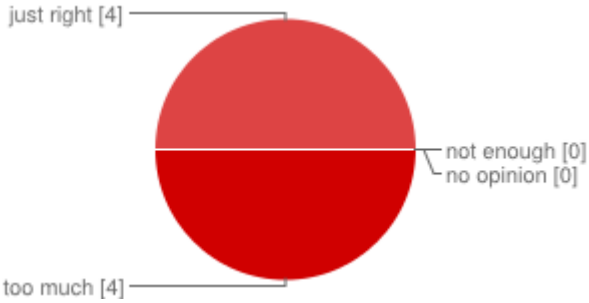
yes	**7**	88%
partially	**1**	13%
no	**0**	0%
no opinion	**0**	0%

Were the speakers generally clear and well organized in their presentation?



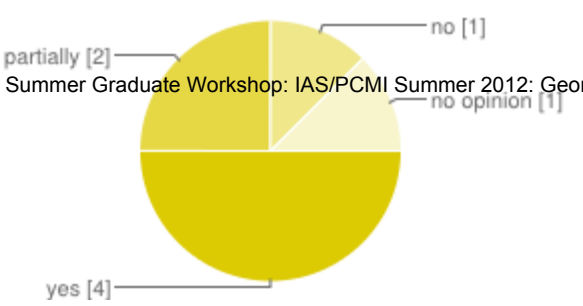
above satisfactory	**3**	38%
satisfactory	**5**	63%
not satisfactory	**0**	0%
no opinion	**0**	0%

Was there too much material presented; was the school too ambitious?



too much	**4**	50%
just right	**4**	50%
not enough	**0**	0%
no opinion	**0**	0%

Was the problem session helpful?



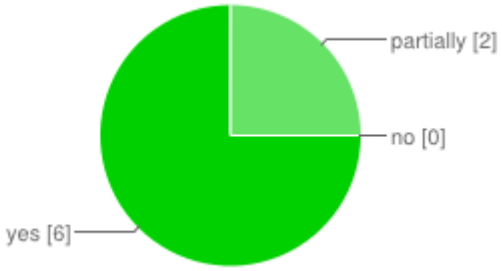
yes	**4**	50%
partially	**2**	25%
no	**1**	13%
no opinion	**1**	13%

Additional comment on the topic presentation and organization

I would have liked one less mini course per week - three is a little overwhelming.

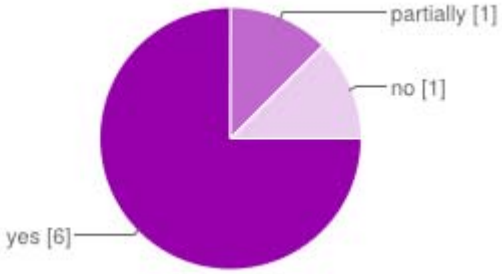
Personal assessment

Was your background adequate to access a reasonable portion of the material?



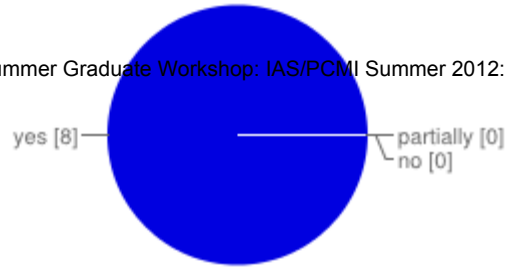
yes	**6**	75%
partially	**2**	25%
no	**0**	0%

Did the workshop increase your interest in the subject?



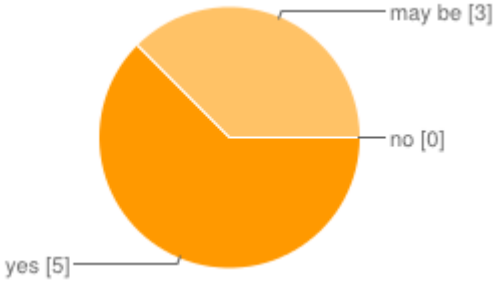
yes	**6**	75%
partially	**1**	13%
no	**1**	13%

Was the school worth your time and effort?



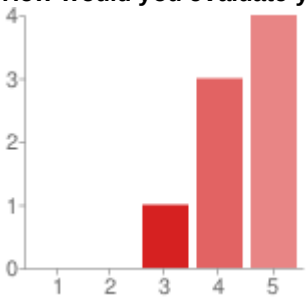
yes	**8**	100%
partially	**0**	0%
no	**0**	0%

Is it likely that you will work in the area of the workshop subject in the future?



yes	**5**	63%
may be	**3**	38%
no	**0**	0%

How would you evaluate your interaction with other participants?



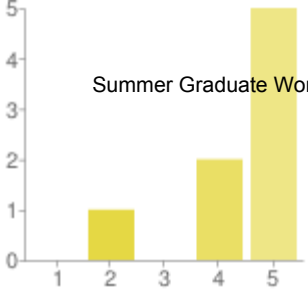
1 -	not satisfactory	**0**	0%
2		**0**	0%
3		**1**	13%
4		**3**	38%
5 -	above satisfactory	**4**	50%

Additional comments on your personal assessment

Venue

Please rate the different categories

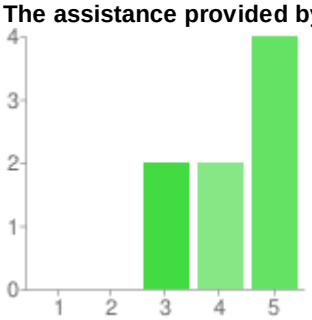
Your overall experience



not satisfactoryabove satisfactory

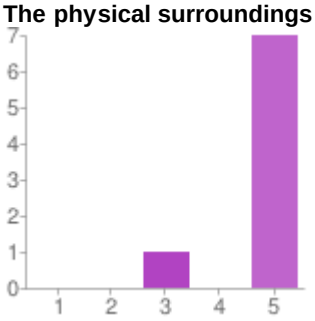
1 -	not satisfactory	**0**	0%
2		**1**	13%
3		**0**	0%
4		**2**	25%
5 -	above satisfactory	**5**	63%

The assistance provided by staff



1 -not satisfactory	**0**	0%
2	**0**	0%
3	**2**	25%
4	**2**	25%
5 -above satisfactory	**4**	50%

The physical surroundings



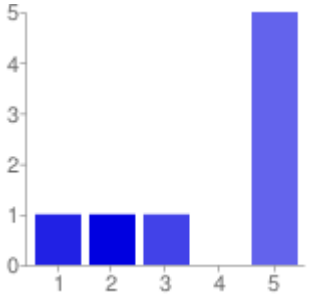
1 -not satisfactory	**0**	0%
2	**0**	0%
3	**1**	13%
4	**0**	0%
5 -above satisfactory	**7**	88%

Additional comments on the school venue

Accommodation and Food

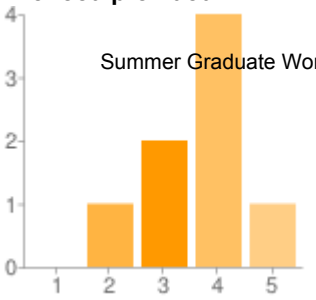
Please rate the different categories

The summer school accommodation



1 -not satisfactory	**1**	13%
2	**1**	13%
3	**1**	13%
4	**0**	0%
5 -above satisfactory	**5**	63%

The food provided



not satisfactoryabove satisfactory

1 -not satisfactory	**0**	0%
2	**1**	13%
3	**2**	25%
4	**4**	50%
5 -above satisfactory	**1**	13%

Additional comments on accommodation and food

Breakfast was really repetitive. I would have preferred healthier food options. The hotel personnel is reluctant to do anything, even in changing sheets. they treat us as if we are staying for free. I ...

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 everything was excellent.

Number of daily responses

Summer Graduate School:
IAS/PCMI: Geometric Group Theory
July 1 – July 21, 2012

Additional Survey Responses

We welcome any additional comments or suggestions you may have to improve the overall experience for future participants

- I think everything was excellent.

Additional comments on accommodation and food

- Breakfast was really repetitive.
- I would have preferred healthier food options.
- The hotel personnel is reluctant to do anything, even in changing sheets. they treat us as if we are staying for free. Its very very noisy, they cannot make people abide by the rulesn they have no control over partying people. Food is also mediocre, they keep serving the same sandwiches over and over. Bread is always unfresh and breakfas is not cooked well.

Additional comments on the topic presentation and organization

- I would have liked one less mini course per week - three is a little overwhelming.

Summer Graduate School: Mathematical General Relativity

July 9, 2012 to July 20, 2012

MSRI, Berkeley, CA, USA

Organizers:

Justin Corvino* (Lafayette College)

Pengzi Miao (University of Miami)

Final Report
MSRI Summer Graduate Workshop
Mathematical General Relativity
July 9-20, 2012

Organizers:
Justin Corvino (Lafayette College)
Pengzi Miao (University of Miami)

Overview. This workshop was a precursor to the semester-long program on Mathematical General Relativity at MSRI in Fall 2013. The goal of the workshop was to introduce to a diverse group of graduate students 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 the first week, the organizers each gave background lectures, followed by mini-courses developing a topic. Justin Corvino introduced Special Relativity and Minkowski space-time, and then discussed the Einstein constraint equations, culminating in a proof of the Positive Energy Theorem. Pengzi Miao gave several lectures on the formulation of the Einstein equation and examples of solutions, followed by a mini-course on the foundations of causality theory, culminating in proofs of the celebrated Singularity Theorems of Hawking and Penrose.

In the second week, Lan-Hsuan Huang (Columbia University) gave a four-lecture mini-course on constant mean curvature foliations of asymptotically flat geometries with applications to mass and center of mass, followed by a topics lecture on scalar curvature and a special case of the Positive Mass Theorem and the Penrose Inequality. This tied in with the mini-course by Fernando Schwartz (University of Tennessee), who gave five lectures on aspects of the Penrose Inequality. The organizers each gave two topic lectures in the second week: Corvino discussed scalar curvature deformation, as well as a gluing method for producing solutions to the constraint equations with prescribed asymptotics. Miao's first lecture discussed the Cauchy problem and Cosmic Censorship, while his second topics lecture discussed applications of the Positive Mass Theorem to compact manifolds with boundary.

2. **TA Sessions**. The TA sessions were led by Alan Parry (Duke University) and Xin Zhou (Stanford University), and they occurred in the afternoon, after tea time. During the first week, students worked on their own or in groups on problem sets that were distributed. They were also encouraged to ask questions about background material, as well as material from the lectures. The TAs, and often the organizers, circulated around the room 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 second week, two of the sessions were organized around topics presented by the TAs. Xin Zhou presented the conformal method to solve the Einstein constraint equations. He focused on the constant mean curvature case, in the spirit of Isenberg's work on the super and sub-solution method. Alan Parry presented the work of Bray on the foundations

of general relativity with applications to astrophysics, which ties into his Ph.D. dissertation. In particular he derived the Einstein equation from the Einstein-Hilbert action and discussed a generalization of this action.

In the first week, there was a hike and BBQ, and in the second week we organized a trip to an A's-Yankees game, preceded by a TA session led by Corvino and Parry on the rules of baseball.

Description of Mini-Courses and Lectures.

Justin Corvino: Corvino's nine lectures were organized as follows:

I. Introduction to Special Relativity and Minkowski space-time (2 lectures). These lectures provided an introduction to the Minkowski metric, and the Lorentzian notions of the light-cone and the causal type of vectors. Lorentz transformations were discussed and used to present some classical "'paradoxes" in special relativity. The conformal compactification of Minkowski space-time was derived and discussed.

II. Analysis on Asymptotically Flat Manifolds and the Positive Energy Theorem (5 lectures). The first lecture highlighted important facts about harmonic functions, including the behavior near isolated singularities and the Kelvin transform. The Einstein constraint equations were derived in the second lecture. Some analysis on asymptotically flat metrics was presented in the third lecture, including the definition of mass and linear momentum. The Schwarzschild solution was a motivating example. The analysis was used in the following lecture, to normalize the asymptotics for the proof of the Positive Energy Theorem. The final lecture in this mini-course discussed the Schoen-Yau obstruction to positive scalar curvature and its application to the proof of the Positive Energy Theorem.

III. Scalar Curvature Deformation and a Gluing Construction for the Einstein Constraint Equations (2 lectures). In these two topics lectures, 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.

Pengzi Miao: Miao's ten lectures were organized as follows:

I. Introduction to General Relativity (3 lectures). The first lecture provided a self-contained, non-variational derivation of the Einstein equation, based on a comparison with the classical Newtonian gravitation theory. In the second and the third lectures, examples of space-time solutions to the Einstein Equation were analyzed in detail, including the Robertson-Walker space-time, the Schwarzschild space-time, and the Kruskal space-time. The physical features of the big bang singularity in the Robertson-Walker model and the black hole region in the Kruskal extension of the Schwarzschild space-time were emphasized.

II. Introduction to Causality with a goal towards space-time singularity theorems and the initial value formulation of GR (6 lectures). The first five lectures comprised a mini-course on causality and singularity theorems. Three lectures were devoted to introducing students to basic concepts, ideas and results on causality. Two lectures were used to provide a geometric derivation of the Riccati and Raychaudhuri Equations, and to prove the Penrose singularity theorem concerning the null geodesic incompleteness of space-times as modeled by the Kruskal space-time, as well as the Hawking singularity theorem on the space-like geodesic incompleteness as modeled by the Robertson-Walker space-time.

With Cauchy hypersurfaces being understood as a causal concept, in a related topic lecture, space-like hypersurfaces were linked to Cauchy hypersurfaces to motivate the initial value formulation of general relativity. A brief discussion of the maximum Cauchy development of smooth vacuum initial data sets and the Cosmic Censorship Conjecture was provided.

III. Application of the positive mass theorem to the study of compact manifolds with boundary (1 lecture). In this special topic lecture, the Positive Mass Theorem on manifolds with corners was introduced. Direct application was given, including the scalar curvature rigidity of Euclidean disks with prescribed intrinsic boundary metric and mean curvature. The proof of the Shi-Tam's theorem on the boundary behavior of compact manifolds with boundary using the Positive Mass Theorem was explained.

Lan-Hsuan Huang: Huang's five lectures can be organized as follows:

I. On the center of mass and foliations of constant mean curvature surfaces in asymptotically flat manifolds. The 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 three lectures discussed recent progress on the stable constant mean curvature surfaces in asymptotically flat manifolds, geometric center of mass, and related classical results in differential geometry. The fourth 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.

II. Positive Mass Theorem and Penrose Inequality for Asymptotically Flat Graphs. The fifth lecture was a topics lecture with ties to the mini-course given by Fernando Schwartz, in which the lecturer presented the up-to-date results on the Positive Mass Theorem and the Penrose inequality for asymptotically flat graphs in Euclidean space.

Fernando Schwartz: Schwartz's five lectures comprised a mini-course
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 reduced to the important special case of time-symmetric space-times. The remainder of lecture one along with lecture two were devoted to Lam's proof of the inequality for the graphical case. Lectures three and four covered 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.

On Student Backgrounds and Survey Responses. The biggest challenge by far was coming to terms with the wide range of student backgrounds. We anticipated this, and we gave out a survey to measure the backgrounds in geometry, analysis and partial differential equations before the workshop. The students ranged from those who had just finished their first years (at least one of whom was quite advanced, while others were not), to those who had just finished their Ph.D. Upwards of about 25% of students did not meet the clearly advertised pre-requisite of a one-semester course in Riemannian geometry. In order to address this, the organizers sent to the students early in the summer a problem set of geometry basics, including some suggested reading from John M. Lee's textbook. Furthermore, time was devoted in the TA sessions to helping some students with the basic geometric structures necessary to understand the lectures.

With this in mind, we decided to try to cover fewer topics in more depth. It was a challenge to find the right level and depth of presentation. For example with regard to PDE, Corvino presented one lecture on the Laplacian on Euclidean space, and another lecture on basic results on the Laplacian on weighted spaces; still some more elliptic theory made it into a lecture on scalar curvature deformation. More of the PDE structure could have been presented at the expense of geometry, but the feeling was that this was the best way to get some of the flavor across. Miao's coverage of causality involved a completely different set of techniques. Rather than be too sketchy, Miao presented much (though not all) detail to give students a better idea of the ingredients of the proof of the singularity theorems.

The talks were delivered in a combination of chalk talks and Beamer talks. Several students indicated that the Beamer overhead talks could be harder to follow, but we do note that PDF files of all Beamer talks were readily made available on the MSRI page, as were problem sets and related notes. This includes the lectures by Miao, notes by Corvino on General Relativity and Constraint Equation basics, and some lecture notes of Huang.

The student responses, both in person and via the survey, were by-and-large quite positive. Based on the in-person comments, we learned that students from first years to those who were the most advanced appreciated the workshop, which was very gratifying.

One of the most thoughtful student responses addresses directly the divergence of student backgrounds, and its impact on the structure of the workshop. Indeed much of the constructive criticism and feedback broached there deal with issues we struggled with. In presenting some background and some topics in reasonable depth, there were topics we had to skip. In retrospect, we would liked to have had one more lecturer to develop the conformal method. As far as the divergent backgrounds, we had broached some possible ways to address the issue. Early on, we considered having evening sessions on background geometry and PDE—this was not an option once we learned that MSRI is closed around 5 PM. Note that one student commented that evening sessions would have been beneficial. We don't know if Evans Hall would be available for such sessions in a future workshop. We also considered segregating the TA sessions, but decided against it—we wanted to keep everyone together.

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.

Organizers* and Lecturers		
First Name	**Last Name**	**Institution**
Justin	Corvino*	Lafayette College
Lan-Hsuan	Huang	Columbia University
Pengzi	Miao*	University of Miami
Fernando	Schwartz	University of Tennessee

Teaching Assistant		
First Name	**Last Name**	**Institution**
Alan	Parry	Duke University

MSRI Mathematical Sciences Research Institute

Summer Graduate School: Mathematical General Relativity

July 9 - 20, 2012

Schedule

** subject to change*

WEEK ONE

	Monday 7/9	Tuesday 7/10	Wednesday 7/11	Thursday 7/12	Friday 7/13
9:15 AM	Welcome to MSRI				
9:30 AM 9:45 AM 10:00 AM	*Lecture:* Justin Corvino	*Lecture:* Pengzi Miao	*Lecture:* Pengzi Miao	*Lecture:* Pengzi Miao	*Lecture:* Justin Corvino
10:15 AM			*Coffee Break*		
10:30 AM 10:45 AM 11:00 AM	*Coffee Break*	*Coffee Break*	*Lecture:* Justin Corvino	*Coffee Break*	*Coffee Break*
11:15 AM 11:30 AM 11:45 AM 12:00 PM	*Lecture:* Pengzi Miao	*Lecture:* Justin Corvino		*Lecture:* Justin Corvino	*Lecture:* Pengzi Miao
12:15 PM 12:30 PM 12:45 PM 1:00 PM 1:15 PM 1:30 PM 1:45 PM	***Lunch***	***Lunch***	***BBQ Lunch at nearby park***	***Lunch***	***Lunch***
2:00 PM 2:15 PM 2:30 PM 2:45 PM 3:00 PM	*Lecture:* Justin Corvino	*Lecture:* Pengzi Miao	**Lecture:* Justin Corvino/Pengzi Miao	*Lecture:* Pengzi Miao	*Lecture:* Justin Corvino
3:15 PM 3:30 PM	*Tea Break*	*Tea Break*	*Tea Break*	*Tea Break*	*Tea Break*
3:45 PM 4:00 PM 4:15 PM 4:30 PM 4:45 PM	TA Session	TA Session	*TA Session	TA Session	*TA Session
5:00 PM	*End of Day*	*End of Day*	*End of Day*	*End of Day*	*End of Day*

WEEK TWO

	Monday 7/16	Tuesday 7/17	Wednesday 7/18	Thursday 7/19	Friday 7/20
9:30 AM 9:45 AM 10:00 AM 10:15 AM 10:30 AM	*Lecture:* Fernando Schwartz	*Lecture:* Fernando Schwartz	*Lecture:* Fernando Schwartz	*Lecture:* Fernando Schwartz	*Lecture:* Fernando Schwartz
10:45 AM 11:00 AM	*Coffee Break*	*Coffee Break*	*Coffee Break*	*Coffee Break*	*Coffee Break*
11:15 AM 11:30 AM 11:45 AM 12:00 PM	*Lecture:* Lan-Hsuan Huang	*Lecture:* Lan-Hsuan Huang	*Lecture:* Lan-Hsuan Huang	*Lecture:* Lan-Hsuan Huang	*Lecture:* Lan-Hsuan Huang
12:15 PM 12:30 PM 12:45 PM 1:00 PM 1:15 PM 1:30 PM 1:45 PM	***Lunch***	***Lunch***	***Lunch***	***Lunch***	***Lunch***
2:00 PM 2:15 PM 2:30 PM 2:45 PM 3:00 PM	*Lecture:* Justin Corvino	*Lecture:* Pengzi Miao	*Lecture:* Justin Corvino	*Lecture:* Pengzi Miao	*Lecture:* TBA
3:15 PM 3:30 PM	*Tea Break*	*Tea Break*	*Tea Break*	*Tea Break*	*Tea Break*
3:45 PM 4:00 PM 4:15 PM 4:30 PM 4:45 PM	TA Session	TA Session	TA Session	TA Session	*Wrap-Up:* Justin Corvino/Pengzi Miao
5:00 PM	*End of Day*	*End of Day*	*End of Day*	*End of Day*	*End of Day*
↯					
7:05 PM ↯ ↯ 10:00 PM				Oakland A's Baseball Game	

Attending Graduate Students		
First Name	**Last Name**	**Institution**
Brian	Allen	University of Tennessee
Xinliang	An	Princeton University
Timaeus	Bouma	Portland State University
Alessandro	Carlotto	Stanford University
Ye Sle	Cha	SUNY
Otis	Chodosh	Stanford University
Isaac	DeFrain	Kent State University
James	Dilts	University of Oregon
MARCELO	DISCONZI	SUNY
Jonathan	Epstein	Dartmouth College
MAYUKH	GANGOPADHYAY	University of Notre Dame
Renato	Ghini Bettiol	University of Notre Dame
Andrew	Goetz	Duke University
Yaron	Hadad	University of Arizona
Matthew	Harris	University of North Carolina
Fei	He	University of California
Younghun	Hong	Brown University
Mihaela	Ifrim	Univeristy of California at Davis
Rohit	Jain	University of Texas
Moulik	Kalluplam Balasubramanian	Rutgers University
Shoshana	Kamholtz	North Carolina State University
Shelvean	Kapita	University of Delaware
Eugenia	Kim	University of California
Kenneth	Knox	SUNY
Christopher	LeBailly	University of California
Lu	Li	University of California
Caleb	Meier	University of California
Jesus	Oliver	University of California, San Diego
Aaron	Palmer	Cornell University
Woongdae	Park	Korea Advanced Institute of Science and Technology (KAIST)
francis	seuffert	Rutgers University
Peter	Smillie	Harvard University
Brian	Streit	Baylor University
Hongtan	Sun	Johns Hopkins University
Kyle	Thompson	University of Toronto
Christopher	Toni	University of California
Carlos	Vega	University of Miami
Lihan	Wang	University of California
Ye-Kai	Wang	Columbia University
Klaus	Widmayer	New York University, Courant Institute
Shawn	Witte	Central Michigan University
Mathew	Wolak	Tufts University
Hangjun	Xu	Duke University
Yunyun	Yang	Louisiana State University
Xin	Zhou	Stanford University

Graduate Student Statistics

Participants		45

Gender		45
Male	82.22%	37
Female	17.78%	8
Declined to state	0.00%	0

Ethnicity*		45
White	51.11%	23
Asian	35.56%	16
Hispanic	6.67%	3
Pacific Islander	0.00%	0
Black	0.00%	0
Native American	0.00%	0
Mixed	4.44%	2
Declined to state	2.22%	1

* ethnicity specifications are not exclusive

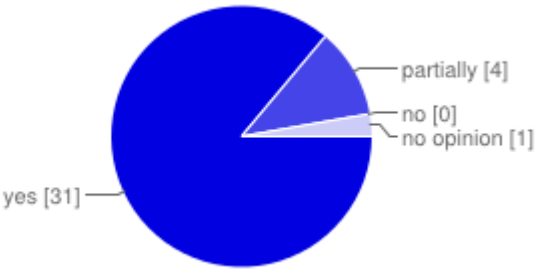
Summary

See complete responses

36 responses out of 50 participants: 72% of total participants.

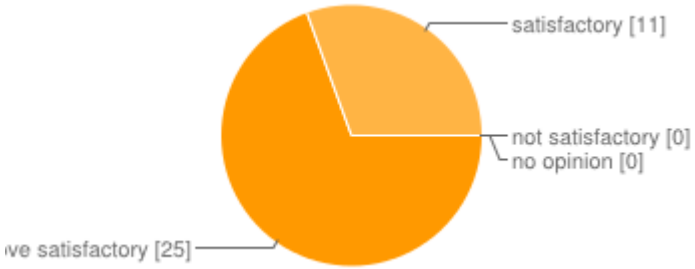
Topic presentation and organization

Did the various topics within the workshop integrate into a coherent picture?



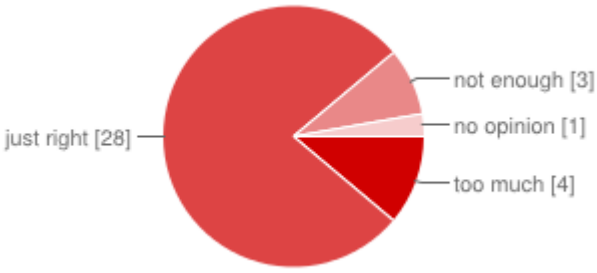
yes	**31**	86%
partially	**4**	11%
no	**0**	0%
no opinion	**1**	3%

Were the speakers generally clear and well organized in their presentation?



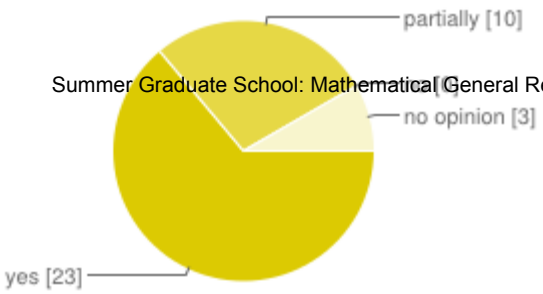
above satisfactory	**25**	69%
satisfactory	**11**	31%
not satisfactory	**0**	0%
no opinion	**0**	0%

Was there too much material presented; was the school too ambitious?



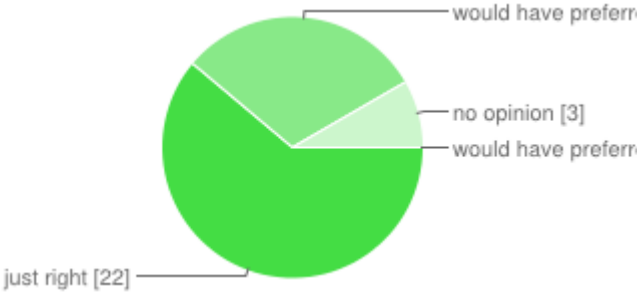
too much	**4**	11%
just right	**28**	78%
not enough	**3**	8%
no opinion	**1**	3%

Was the problem session helpful?



yes	**23**	64%
partially	**10**	28%
no	**0**	0%
no opinion	**3**	8%

What were your thoughts on the structure of the problem sessions?



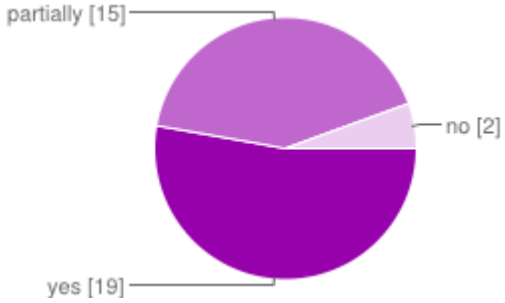
would have preferred a looser structure	**0**	0%
just right	**22**	61%
would have preferred a more rigid structure	**11**	31%
no opinion	**3**	8%

Additional comment on the topic presentation and organization

I think the organizers did a wonderful job. I would have liked to see more topics and less emphasis on the proofs though. I know these are limitations that MSRI has, but it would have been beneficial ...

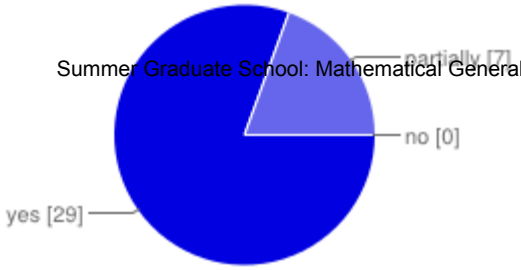
Personal assessment

Was your background adequate to access a reasonable portion of the material?



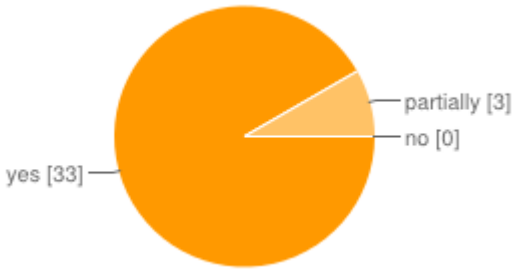
yes	**19**	53%
partially	**15**	42%
no	**2**	6%

Did the workshop increase your interest in the subject?



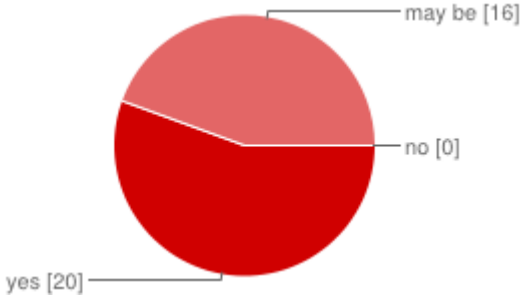
yes	**29**	81%
partially	**7**	19%
no	**0**	0%

Was the school worth your time and effort?



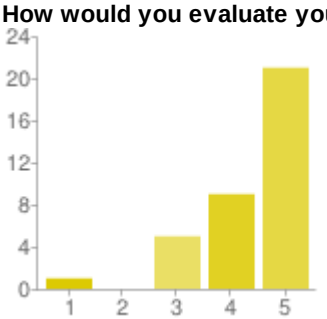
yes	**33**	92%
partially	**3**	8%
no	**0**	0%

Is it likely that you will work in the area of the workshop subject in the future?



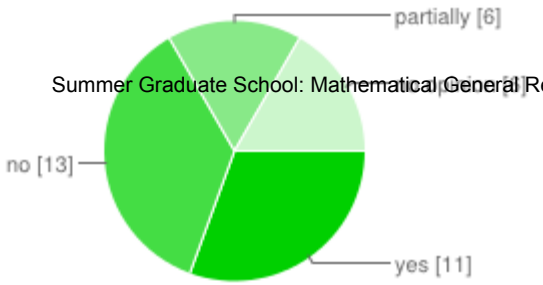
yes	**20**	56%
may be	**16**	44%
no	**0**	0%

How would you evaluate your interaction with other participants?



1 -	not satisfactory	**1**	3%
2		**0**	0%
3		**5**	14%
4		**9**	25%
5 -	above satisfactory	**21**	58%

Would you have liked there to be more organized social activities?



yes	**11**	31%
no	**13**	36%
partially	**6**	17%
no opinion	**6**	17%

Additional comments on your personal assessment

The BBQ was key in helping people get to know each other and a great refresher. see below The material was much more relevant to my research area than I actually expected.

MSRI Venue

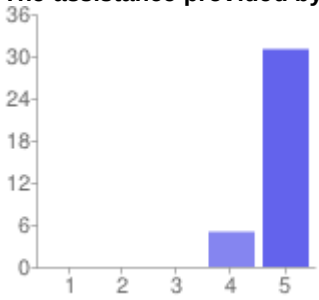
Please rate the different categories

Your overall experience

not satisfactoryabove satisfactory

1 -	not satisfactory	**0**	0%
2		**0**	0%
3		**0**	0%
4		**10**	28%
5 -	above satisfactory	**26**	72%

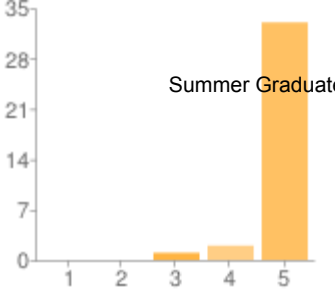
The assistance provided by staff



not satisfactoryabove satisfactory

1 -	not satisfactory	**0**	0%
2		**0**	0%
3		**0**	0%
4		**5**	14%
5 -	above satisfactory	**31**	86%

The physical surroundings



not satisfactoryabove satisfactory

1 -	not satisfactory	**0**	0%
2		**0**	0%
3		**1**	3%
4		**2**	6%
5 -	above satisfactory	**33**	92%

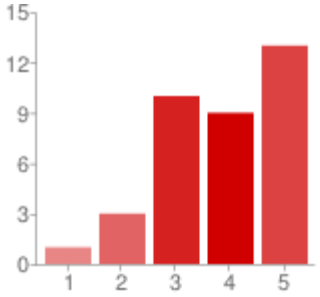
Additional comments on the MSRI venue

This place is awesome. Given the schedule, it was difficult to use the library during the open hours. Climate control was also a bit odd (it was 85+ one afternoon in the library). MSRI is an absolu ...

Accommodation and Food

Please rate the different categories

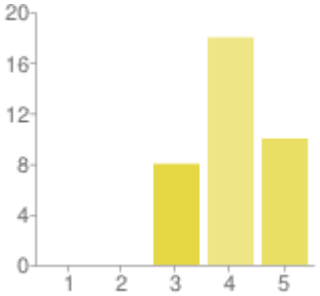
The summer school accommodation



not satisfactoryabove satisfactory

1 -	not satisfactory	**1**	3%
2		**3**	8%
3		**10**	28%
4		**9**	25%
5 -	above satisfactory	**13**	36%

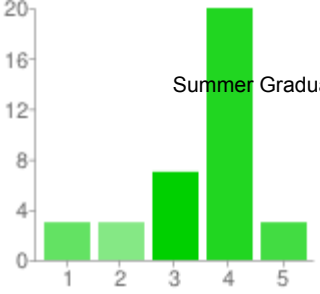
The food at the dormitories



not satisfactoryabove satisfactory

1 -	not satisfactory	**0**	0%
2		**0**	0%
3		**8**	22%
4		**18**	50%
5 -	above satisfactory	**10**	28%

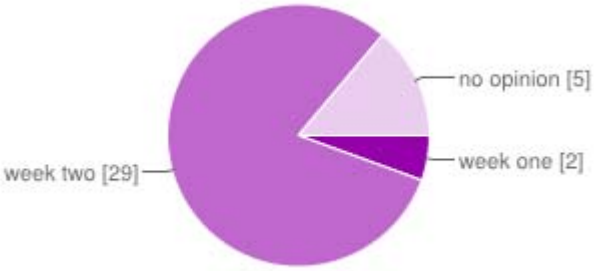
The food provided at MSRI



not satisfactoryabove satisfactory

1 -not satisfactory	**3**	8%
2	**3**	8%
3	**7**	19%
4	**20**	56%
5 -above satisfactory	**3**	8%

Did you prefer the lunch provided at MSRI in week one or week two



week one	**2**	6%
week two	**29**	81%
no opinion	**5**	14%

Additional comments on accommodation and food

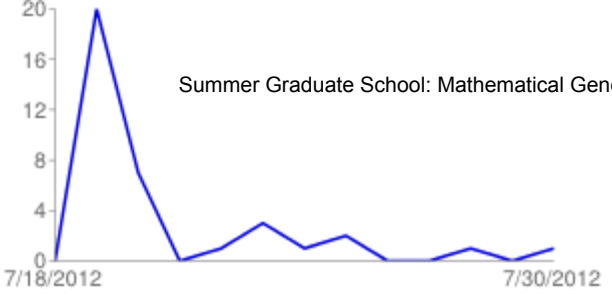
I think that in the first few days of week one there wasn't enough food. I really appreciate the attention paid to people with special diets (vegans...) While the food was very good the first week, t ...

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 only comment I have is on the structure of the presentations. I would suggest that the material not be presented via slides. I understand the temptation to use slides as there is a lot of material. I would try to take notes because I like looking back on previous notes during the presentation and wouldn't be able to because the presenter would be going way too fast. With that said, though, I still learned a great deal and feel infinitely more comfortable with Mathematical GR. I thought it was a great summer school! I learned a lot and am excited to explore GR further. This was a very excit ...

Number of daily responses


20
16
12
8
4
0
7/18/2012
7/30/2012

Summer Graduate School: Mathematical General Relativity
July 9 – 20, 2012

Additional Survey Responses

Additional comments on your personal assessment

- The BBQ was key in helping people get to know each other and a great refresher.
- The material was much more relevant to my research area than I actually expected.

Additional comments on the venue

- This place is awesome.
- Given the schedule, it was difficult to use the library during the open hours. Climate control was also a bit odd (it was 85+ one afternoon in the library). MSRI is an absolutely beautiful place, I just wish it were open longer (or we could access it more easily to work in the evenings).
- Great venue.
- MSRI staff was great. Thanks!
- Never seen a more efficient staff before.
- It would be better if participants could access the library after dinner.
- Beautiful!

We welcome any additional comments or suggestions you may have to improve the overall experience for future participants

- The only comment I have is on the structure of the presentations. I would suggest that the material not be presented via slides. I understand the temptation to use slides as there is a lot of material. I would try to take notes because I like looking back on previous notes during the presentation and wouldn't be able to because the presenter would be going way too fast. With that said, though, I still learned a great deal and feel infinitely more comfortable with Mathematical GR.
- I thought it was a great summer school! I learned a lot and am excited to explore GR further.
- This was a very exciting and useful time for me, as I feel like I learnt a lot in the workshop and got to meet who I hope will be my future collaborators in the field. I have almost only positive things to say about the location, the organizers, the lectures and discussion sessions. The only improvement I see in the workshop might be a bit debatable. I believe there should be a little less emphasis on the proofs of some of the big theorems and more discussion of the 'big picture', as the mathematical and physical implications of such theorems and their consequences in terms of more advanced topics in the theory. Since proofs are an essential part of mathematical education, in many cases (like the positive mass theorem) a brief sketch of the proof (like the fantastic one Justin provided) supplemented by a good reference is more than enough. I would also like to mention that in terms of motivation, a little more info about the history of the subject is key. Thank you for the great time!
- It was a very nice experience which I very much enjoyed.
- The workshop was a good opportunity to see some of the questions being researched in some part of General Relativity. The lecture style was lively and there was a good communication between the audience and the presenters. I never felt like a question was not being answered properly or just skipped. I always felt that the lecturers really wanted to convey a message or idea to the audience. I have to admit that personally I am not a fan of slide talks. But this is just me, and I do not want to blame Pengzi Miao for it. Inevitably, though, I ended up liking the other lectures better. Asking myself what actual, hands-on knowledge I gained during these two weeks I feel slightly at unease, since it is not much more than a review and expansion on some basics of Riemannian Geometry. Apart from a lack of initiative on my part, this also testifies to a general issues with the format of the workshop: The background of people seemed to have been fairly diverse, with some not really meeting the prerequisites posted online. In principle, I do not mind

that, but it must hugely complicate the planning of the lectures. Maybe as a result, to me they seemed to be fairly informal, with little about the techniques ever explained. For me, this makes it very hard to get a better grasp of the material. The exercises compensated for that, in part, but did not provide the necessary bridge to further my understanding of the topics. Most of the time I felt like I got some (often geometric) idea of a proof, but I was left far from able to complete it or fill in the details. I would have preferred a setup, where one requires a basic knowledge - say Lee's book on Riemannian Geometry and Evans' PDE book and then goes on - say in the first week - to explain with some detail the additional technicalities, new geometric and PDE techniques. This should be done in a way that enables people to fill in some gaps, and get a feeling for the techniques involved. In the second week one could have then gone on to more advanced topics and only given sketches and rough ideas, since the audience would have had some idea as to the methods. This way I found myself sitting in quite a few lectures with only a vague idea of the actual math involved. I do not feel confident I will retain a lot of the material for much longer, since I didn't really understand much of it. (Example: There must be a lot of PDE techniques involved in all these scalar curvature questions, ranging from more classical to more modern elliptic estimates. I would have found it very interesting to learn about these, to see some of their limitations and some of the way the geometry actually interacts with the analysis. Now I am left a bit with the feeling that "elliptic PDE can do for you whatever you need".) For specialists in the field these problems will not have occurred, but not being one of them made me lose track of not a few questions. The MSRI (administrative) staff were very helpful and superbly friendly. The environment that is being provided here is simply brilliant, I couldn't think of any way to improve the infrastructure and the way I was being "handled". The only thing that stood out negatively was the food catering in the first week ("Doug's", if I remember correctly). They were fairly unfriendly and restrictive with their food distribution, and the food in the second week was much better. The organizers were extremely friendly and helpful, socializing with the participants and sharing their knowledge, insights and experience, but also their personal advice. This was simply wonderful, and I want to thank them for putting together this workshop and creating such a pleasant environment. This feedback may read more negative than what I feel like, it is just an honest reflection of some of my thoughts and only meant to convey a sense of what I think could have been improved in an already good workshop.
- Thank you very much!
- The entire workshop was very valuable experience, with wonderful mathematical quality. I can only hope that the MSRI organizes more graduate workshops like this one in areas related to differential geometry: I would do everything possible to come back.
- This workshop is the most fun experience I have had since becoming a grad student. The topics were interesting and a little above my level, but this gave me something to strive towards. I had a great time with the other participants and I would be honored to be able to come to another workshop at the MSRI. Thank you so much for this experience!

Additional comments on accommodation and food

- I think that in the first few days of week one there wasn't enough food. I really appreciate the attention paid to people with special diets (vegans...)
- While the food was very good the first week, the staff seemed a bit rude and unprepared to serve such a large group. Limitations such as only allowing one small piece of bread when serving spaghetti seemed a bit odd. The second week, while the food was not substantially better (and perhaps at times not quite as good) provided a much nicer lunch experience.
- Larger portions of food at MSRI please. Week 1 food was better but week 2 had larger portions.
- The service of the second week was really good. They are very nice.
- Week one food was not enough. Week two was definitely an improvement.
- More variety for vegan food
- food at MSRI was good the first week, but portions were too often anemic. Second week was great on both fronts. Food at Foothill was mostly very good. The dorms were okay. Loud kids were annoying at times (yelling, stereos). Beds were a bit rough. Bath was fine. Sharing rooms took some mental adjustment, but went fine.
- The dining hall closed too early for dinner (7pm).

- There was not sufficient food provided for lunch in the first week.
- Week 2 was much better!

Additional comments on the topic presentation and organization

- I think the organizers did a wonderful job. I would have liked to see more topics and less emphasis on the proofs though.
- I know these are limitations that MSRI has, but it would have been beneficial to have problem sessions in the evenings (say, at 7:30 after dinner) instead of following 30 minutes after the last lecture. This would give more time for students to develop questions.
- Great presentations in general.
- Organizers were fantastic. Also enjoyed invited speakers.
- Some of the best lectures I attended in my life.
- There wasn't enough time for the lecturers(except Lan-Hsuan) to complete their topics)
- Justin Corvino's lectures were excellently presented. Pengzi's would have benefitted from a little more overview and foreshadowing.