

Reimagining the Foundations of Algebraic Topology

April 7 - 11, 2014

MSRI, Berkeley, CA, USA

Organizers:

Vigleik Angeltveit (Australian National University)

Mark Behrens (Massachusetts Institute of Technology)

Julie Bergner (University of California)

Andrew Blumberg (University of Texas)*

1. WORKSHOP DESCRIPTION

The topical workshop, “Reimagining the foundations of algebraic topology”, occurred towards the end of the MSRI semester, and provided a reinvigorating infusion of new ideas and energy into the program. Building on the background provided by the Introductory Workshop, the topical workshop provided a view of work at the frontier in algebraic topology.

Algebraic topology derives its strength and effectiveness from a deep interplay of algebraic and geometric methods, using algebraic tools to make tractable problems in geometry and geometric insights to inform algebraic constructions. In the last decade, there has been a flurry of work rebuilding and reinvigorating the foundations of the subject based on insights and ideas coming from higher category theory.

This workshop featured lectures (described below) by a diverse collection of researchers, with talks centered around the use of recent innovations in higher category theory to reimagine the basic tools and constructions in algebraic topology. In particular, many of the talks described the interplay between these higher and ∞ -categorical techniques with classical algebraic topology.

The workshop was extremely well-attended, and reactions were very positive; the talks provided a broad and exciting sense of new developments in the field.

2. LECTURES

The workshop consisted of eighteen research lectures, loosely thematically organized. The overall quality of the talks given was very high, and we were particularly pleased by the interactions and collaborations that were sparked by the lectures. Full videos and careful notes for all of the lectures are available at <http://www.msri.org/workshops/689>, but we provide here a short description of each talk.

MONDAY: FIELD THEORIES AND GEOMETRY

David Ben-Zvi: Algebraic geometry and topological field theories

Ben-Zvi explained joint work with Nadler, Neitzke, and Nevins on understanding supersymmetric gauge theories from the perspective of topological field theories. Much of the talk emphasized the connection to the modern geometric perspective on representation theory in terms of homotopical categories of representations.

David Ayala: Poincare/Koszul duality

Ayala described recent work with Francis and Tanaka that studies Poincare duality in the setting of factorization (co)homology. The main theorem connects factorization homology with coefficients in an E_n algebra to factorization cohomology in the Koszul dual coalgebra. The method of proof required investigation of stratified spaces and certain categories of manifolds, as well as the study of the connection between Goodwillie calculus and embedding calculus.

John Francis: Poincare/Koszul duality and formal moduli

In a continuation of the previous talk, Francis described an interpretation of his work with Ayala on Poincare duality for factorization homology in terms of formal moduli problems. This work provided a setting for completion phenomena that arise in studying duality in Hochschild homology and has applications to describing the correct duality of topological field theories.

2

Kirsten Wickelgren: Sullivan's conjecture and applications to arithmetic

Wickelgren described her recent progress on Grothendieck's anabelian conjectures. These are central and difficult conjectures in equivariant algebraic geometry. A very nice aspect of the talk was that it motivated the algebraic geometry for a topological audience by making a precise analogy to the (affirmed) Sullivan conjecture.

TUESDAY: HIGHER CATEGORY THEORY

Emily Riehl: The formal theory of adjunctions, monads, algebras, and descent

Riehl described her on-going work with Verity that uses the 2-category of quasi-categories to give new proofs of foundational results about adjunctions and monadic algebras in the ∞ -categorical setting. These new proofs are comparatively easy and reflect classical proofs of these results in ordinary category theory.

Hugo Bacard: co-Segal algebras and Deligne's conjecture

Bacard described his approach to obtaining multiplicative structures on derived endomorphism algebras (the generalized Deligne's conjecture) using model structures on co-Segal objects in suitable model categories.

Andre Joyal: What is an elementary higher topos?

Joyal presented a conjectural description of an elementary higher topos in the context of higher category theory. His talk included a completely homotopy-theoretic interpretation of homotopy type theory, as part of the motivation for his definition.

Angelica Osorno: Modeling stable 2-types

Osorno described her joint work with Gurski and Johnson that obtains a categorical model for stable 2-types, inspired by the classical work of Thomason on modeling connective spectra via symmetric monoidal categories (and the K -theory functor). They construct a suitable K -theory functor that applies to Picard bicategories.

WEDNESDAY

Thomas Nikolaus: Aspects of differential cohomology

Nikolaus presented work on a higher categorical construction of differential cohomology. Traditionally, differential cohomology theories are constructed in a very direct geometric fashion which can obscure formal properties. Nikolaus explained how this new perspective allowed for a natural decomposition, an elegant theory of integration, and straightforward construction of twistings.

Christopher Schommer-Pries: The unicity of the homotopy theory of higher categories

Schommer-Pries presented his joint work with Barwick that establishes that any two theories of (∞, n) categories satisfying a small collection of reasonable axioms coincide up to a well-understood automorphism.

THURSDAY: DERIVED ALGEBRAIC GEOMETRY

Clark Barwick: Redshift and higher categories

Barwick explained a conjectural approach to proving the redshift conjecture in algebraic K -theory (which roughly speaking states that algebraic K -theory increases chromatic filtration) in terms of a higher-categorical algebraic K -theory and attendant operations arising from a theory of homotopical plethories.

Michael Hill: Derived equivariant algebraic geometry

Motivated by the observation that certain phenomena in the calculational study of topological modular forms suggests some kind of underlying equivariant algebraic geometry, Hill outlined questions and some speculative answers about the foundations of derived equivariant algebraic topology. In the equivariant setting, even basic questions about the meaning of commutative ring and the correct definition of the Zariski topology have subtle answers and admit many possible choices.

Vesna Stojanoska: Duality, algebro-homotopically

Stojanoska talked about work aimed at understanding Brown-Comenetz duality in spectra arising from chromatic homotopy theory through the lens of derived algebraic geometry. She focused on her work on self-duality for topological modular forms.

Charles Rezk: Calculations in multiplicative stable homotopy theory at height 2

Rezk explained how the theory of power operations in Morava E -theory and their explicit description can be used to make calculations, focusing on examples coming from the Bousfield-Kuhn functor and from twisted E -theory.

FRIDAY: ORIENTATIONS

Michael Mandell: E_n genera

Mandell described recent work with Chadwick in which they showed that any maps from certain Thom spectra (notably MU and MSO) to an even E_2 ring spectrum can be refined to an E_2 map. Such multiplicative refinements of genera have played an important role work on elliptic cohomology, for example.

Goncalo Tabuada: Motives vs. noncommutative motives

Tabuada explained the connection between his program for studying Kontsevich-style noncommutative motives and classical commutative motives. Most notably, he explained the connections between the standard conjectures on both sides, focusing on cases where the noncommutative setting might be an easier place to work.

David Gepner: Thom spectra and twisted Umkehr maps

Gepner described his joint work with Ando and Blumberg that explained how the ∞ -categorical perspective on the Thom spectrum functor and parametrized homotopy theory can be used to provide an elegant construction of twisted Umkehr maps.

Andre Henriques: A $K(\mathbb{Z}, 4)$ in nature

Henriques described a byproduct of his work on von Neumann algebras in the context of topological field theories, which is a natural construction of a geometric model of a $K(\mathbb{Z}, 4)$.

Organizers

| First | Last | Institutions |
|---------|------------|---------------------------------------|
| Vigleik | Angeltveit | Australian National University |
| Mark | Behrens | Massachusetts Institute of Technology |
| Julie | Bergner | University of California |
| Andrew | Blumberg | University of Texas *Lead Organizer |

Speakers

| First | Last | Institutions |
|-------------|----------------|--|
| David | Ayala | Montana State University |
| Hugo | Bacard | University of Western Ontario |
| Clark | Barwick | Massachusetts Institute of Technology |
| David | Ben-Zvi | University of Texas |
| John | Francis | Northwestern University |
| David | Gepner | Purdue University |
| Andre | Henriques | Rijksuniversiteit te Utrecht |
| Michael | Hill | University of Virginia |
| Andre | Joyal | University of Quebec |
| Michael | Mandell | Indiana University |
| Ieke | Moerdijk | Radboud University Nijmegen |
| Thomas | Nikolaus | Universitat Regensburg |
| Angelica | Osorno | Reed College |
| Charles | Rezk | University of Illinois at Urbana-Champaign |
| Emily | Riehl | Harvard University |
| Christopher | Schommer-Pries | Max-Planck-Institut für Mathematik |
| Vesna | Stojanoska | Massachusetts Institute of Technology |
| Goncalo | Tabuada | Massachusetts Institute of Technology |
| Kirsten | Wickelgren | Georgia Institute of Technology |



Reimagining the Foundations of Algebraic Topology

April 7 - 11, 2014

Schedule

| Monday, April 7, 2014 | | | |
|-----------------------|----------------------------|--------------------|--|
| 9:15 AM - 9:30 AM | Simons Auditorium | | Welcome |
| 9:30 AM - 10:30 AM | Simons Auditorium | David Ben-Zvi | Algebraic geometry of topological field theories |
| 10:30 AM - 11:00 AM | Atrium | | Tea |
| 11:00 AM - 12:00 PM | Simons Auditorium | David Ayala | Poincaré/Koszul duality and formal moduli |
| 12:00 PM - 2:00 PM | Atrium | | Lunch |
| 2:00 PM - 3:00 PM | Simons Auditorium | John Francis | Poincaré/Koszul duality |
| 3:00 PM - 3:30 PM | Atrium | | Tea |
| 4:10 PM - 5:00 PM | 60 Evans Hall, UC Berkeley | Kirsten Wickelgren | Sullivan's conjecture and applications to arithmetic |

| Tuesday, April 8, 2014 | | | |
|------------------------|-------------------|-----------------|---|
| 9:30 AM - 10:30 AM | Simons Auditorium | Emily Riehl | The formal theory of adjunctions, monads, algebras, and descent |
| 10:30 AM - 11:00 AM | Atrium | | Tea |
| 11:00 AM - 12:00 | Simons Auditorium | Hugo Bacard | co-Segal algebras and Deligne's conjecture |
| 12:00PM- 2:00 PM | Atrium | | Lunch |
| 2:00PM - 3:00 PM | Simons Auditorium | Andre Joyal | What is an elementary higher topos? |
| 3:00 PM - 3:30 PM | Atrium | | Tea |
| 3:30 PM - 4:30 PM | Simons Auditorium | Angelica Osorno | Modeling stable 2-types |
| 4:30 PM - 6:20 PM | Atrium | | Reception |

| Wednesday, April 9, 2014 | | | |
|--------------------------|-------------------|----------------------|---|
| 9:30 AM - 10:30 AM | Simons Auditorium | Thomas Nikolaus | Aspects of differential cohomology |
| 10:30 AM - 11:00 AM | Atrium | | Tea |
| 11:00 AM - 12:00 PM | Simons Auditorium | Chris Schommer-Pries | The unicity of the homotopy theory of higher categories |

| Thursday, April 10, 2014 | | | |
|--------------------------|-------------------|------------------|---|
| 9:30 AM - 10:30 AM | Simons Auditorium | Clark Barwick | Redshift and higher categories |
| 10:30 AM - 11:00 AM | Atrium | | Tea |
| 11:00 AM - 12:00 PM | Simons Auditorium | Michael Hill | Derived Equivariant Algebraic Geometry |
| 12:00 PM - 2:00 PM | Atrium | | Lunch |
| 2:00 PM - 3:00 PM | Simons Auditorium | Vesna Stojanoska | Duality, algebro-homotopically |
| 3:00 PM - 3:30 PM | Atrium | | Tea |
| 3:30 PM - 4:30 PM | Simons Auditorium | Charles Rezk | Calculations in multiplicative stable homotopy theory at height 2 |

| Friday, April 11, 2014 | | | |
|------------------------|-------------------|-----------------|--|
| 9:30 AM - 10:30 AM | Simons Auditorium | Mike Mandell | Nilpotence of the algebraic K-theory of the sphere spectrum |
| 10:30 AM - 11:00 AM | Atrium | | Tea |
| 11:00 AM - 12:00 PM | Simons Auditorium | Goncalo Tabuada | Voevodsky's mixed motives versus Kontsevich's noncommutative mixed motives |
| 12:00 PM - 2:00 PM | Atrium | | Lunch |
| 2:00 PM - 3:00 PM | Simons Auditorium | David Gepner | Thom spectra and twisted umkehr maps |
| 3:00 PM - 3:30 PM | Atrium | | Tea |
| 3:30 PM - 4:30 PM | Simons Auditorium | Andre Henriques | A $K(\mathbb{Z}, 4)$ in nature |

| Participants | | |
|---------------------|-----------------|---|
| First | Last | Institutions |
| Elie | Alhajar | George Mason University |
| Nerses | Aramyan | University of Illinois at Urbana-Champaign |
| Manuel | Araujo | University of Oxford |
| Nils | Baas | NTNU |
| Andrew | Baker | University of Glasgow |
| Lauren | Bandklayder | Northwestern University |
| Matthew | Barber | University of California |
| Tarje | Bargheer | Australian National University |
| Tobias | Barthel | Harvard University |
| Yakov | Berchenko-Kogan | Massachusetts Institute of Technology |
| Irina | Bobkova | Northwestern University |
| Anna Marie | Bohmann | Northwestern University |
| Peter | Bonventre | University of Virginia |
| Eric | Bunch | Kansas State University |
| Jonathan | Campbell | University of Texas |
| David | Carchedi | Max Planck Institute for Mathematics |
| Andrea | Cesaro | Universite de Lille I (Sciences et Techniques de Lille Flandres Artois) |
| Safia | Chettih | University of Oregon |
| Michael | Ching | Amherst College |
| Ralph | Cohen | Stanford University |
| Lee | Cohn | University of Texas |
| Reid | Dale | University of Washington |
| Ivo | Dell'Ambrogio | Universite de Lille I (Sciences et Techniques de Lille Flandres Artois) |
| Bjorn | Dundas | University of Bergen |
| William | Dwyer | University of Notre Dame |
| Thomas | Fiore | University of Michigan |
| Daniel | Flores | Instituto de Ciencias Nucleares |
| John | Foley | University of Copenhagen |
| Ernest | Fontes | University of Texas |
| Soren | Galatius | Stanford University |
| Teena | Gerhardt | Michigan State University |
| Paul | Goerss | Northwestern University |
| Chris | Gomes | University of Illinois at Chicago |
| Ilya | Grigoriev | University of Chicago |
| Jesper | Grodal | University of Copenhagen |
| Meng | Guo | Harvard University |
| Nick | Gurski | University of Sheffield |
| Joe | Hannon | Boston University |
| John | Harper | Ohio State University |
| Rune | Haugseug | Max-Planck-Institut fur Mathematik |
| Kathryn | Hess | Ecole Polytechnique Federale de Lausanne (EPFL) |
| Lars | Hesselholt | Nagoya University |
| Justin | Hilburn | University of Oregon |
| Zhen | Huan | University of Illinois at Urbana-Champaign |
| John | Huerta | Instituto Superior Tecnico |
| Niles | Johnson | Ohio State University |
| Brenda | Johnson | Union College |
| Magdalena | Kedziorek | University of Sheffield |

| | | |
|--------------|----------------|---|
| Jonathan | Kirby | University of East Anglia |
| Inbar | Klang | Stanford University |
| Stephan | Klaus | Math. Forschungsinstitut Oberwolfach |
| Benjamin | Knudsen | Northwestern University |
| Valentin | Krasontovitsch | University of Bergen |
| Nicholas | Kuhn | University of Virginia |
| Alexander | Kupers | Stanford University |
| Kathryn | Lesh | Union College |
| Ayelet | Lindenstrauss | Indiana University |
| Cary | Malkiewich | Stanford University |
| Maryanthe | Malliaris | University of Chicago |
| Lennart | Meier | University of Virginia |
| Peter | Nelson | University of Illinois at Urbana-Champaign |
| Justin | Noel | University of Regensburg |
| Kyle | Ormsby | MIT / Reed College |
| Matthew | Pancia | University of Texas |
| Simona | Paoli | University of Leicester |
| Irakli | Patchkoria | University of Copenhagen |
| David | Pengelly | New Mexico State University |
| Mark | Penney | University of Oxford |
| Eric | Peterson | University of California, Berkeley |
| Dorette | Pronk | Dalhousie University |
| Hoel | Queffelec | Universite de Paris VII (Denis Diderot) |
| Sune | Reeh | University of Copenhagen |
| Birgit | Richter | Universitat Hamburg |
| Aaron | Royer | University of Texas |
| Hal | Sadofsky | University of Oregon |
| Brooke | Shipley | University of Illinois at Chicago |
| Charmaine | Sia | Harvard University |
| Yalin | Sinan | Centre Universitaire de Luxembourg |
| Scott | Slinker | University of Virginia |
| Marc | Stephan | Ecole Polytechnique Federale de Lausanne (EPFL) |
| Danny | Stevenson | University of Adelaide |
| Yuri | Sulyma | University of Texas |
| Thomas | Sutton | University of Sheffield |
| Karol | Szumilo | Rheinische Friedrich-Wilhelms-Universität Bonn |
| Markus | Szymik | University of Copenhagen |
| Felicia | Tabing | University of California, Santa Cruz |
| Hiro | Tanaka | Harvard University |
| Sean | Tilson | Royal Institute of Technology (KTH) |
| Adam | Topaz | University of California, Berkeley |
| Philip | Tynan | Harvard University |
| Massimiliano | Ungheretti | University of Copenhagen |
| Ashish | Upadhyay | Indian Institute of Technology Patna |
| Gabriel | Valenzuela | Wesleyan University |
| Nathalie | Wahl | University of Copenhagen |
| Guozhen | Wang | Massachusetts Institute of Technology |
| Thomas | Wasserman | University of Oxford |
| Jacob | West | University of California |
| David | White | Wesleyan University |

| | | |
|-------------|--------|---|
| Dylan | Wilson | Northwestern University |
| W Stephen | Wilson | Johns Hopkins University |
| Aliaksandra | Yarosh | University of Pittsburgh |
| Sarah | Yeakel | University of Illinois at Urbana-Champaign |
| Justin | Young | Ecole Polytechnique Federale de Lausanne (EPFL) |

Officially Registered Participant Information

| | | |
|---------------------|--|------------|
| Participants | | 126 |
|---------------------|--|------------|

| | | |
|--------------------------|--------|------------|
| Gender | | 126 |
| Male | 76.19% | 96 |
| Female | 22.22% | 28 |
| Declined to state | 1.59% | 2 |

| | | |
|--------------------------|--------|------------|
| Ethnicity* | | 126 |
| White | 76.98% | 97 |
| Asian | 4.76% | 6 |
| Hispanic | 3.17% | 4 |
| Pacific Islander | 0.00% | 0 |
| Black | 0.79% | 1 |
| Native American | 0.00% | 0 |
| Mixed | 2.38% | 3 |
| Declined to state | 11.90% | 15 |

* ethnicity specifications are not exclusive

This form will soon be upgraded to the new version of Google Forms. [Learn more.](#)

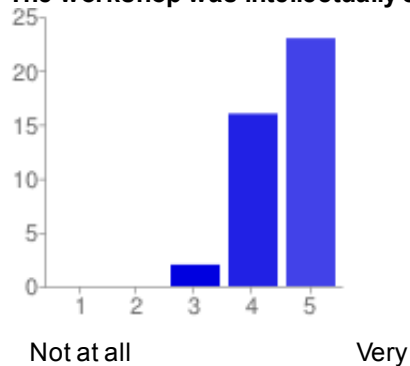
41 [responses](#)

41 responses / 126 participants = 33% response rate

Summary [See complete responses](#)

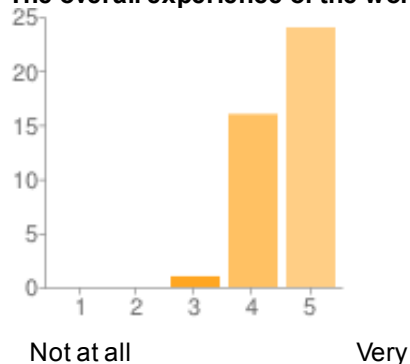
Workshop assessment

The workshop was intellectually stimulating



| | | |
|----------------|-----------|-----|
| 1 - Not at all | 0 | 0% |
| 2 | 0 | 0% |
| 3 | 2 | 5% |
| 4 | 16 | 39% |
| 5 - Very | 23 | 56% |

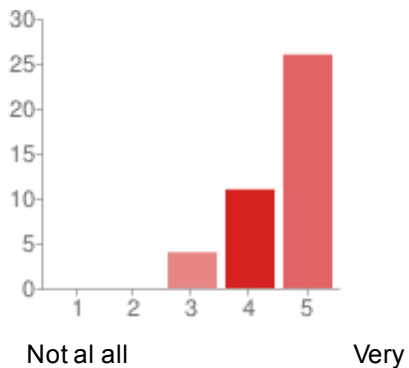
The overall experience of the workshop was worthwhile



| | | |
|----------------|-----------|-----|
| 1 - Not at all | 0 | 0% |
| 2 | 0 | 0% |
| 3 | 1 | 2% |
| 4 | 16 | 39% |
| 5 - Very | 24 | 59% |

The time between lectures was adequate for discussion

| | | |
|----------------|-----------|-----|
| 1 - Not at all | 0 | 0% |
| 2 | 0 | 0% |
| 3 | 4 | 10% |
| 4 | 11 | 27% |
| 5 - Very | 26 | 63% |

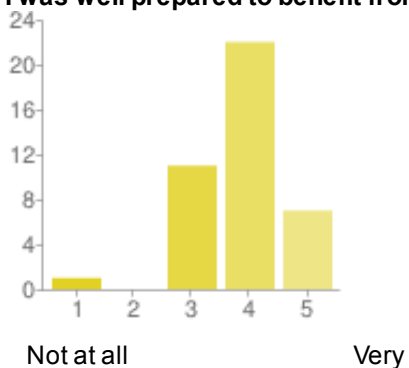


Additional comments on the workshop organization

As a middle aged mathematician, the demographics of the speakers seemed aimed at perpetuating the stereotype that mathematicians over 40 should be put out to pasture. One more grumble: having one le ...

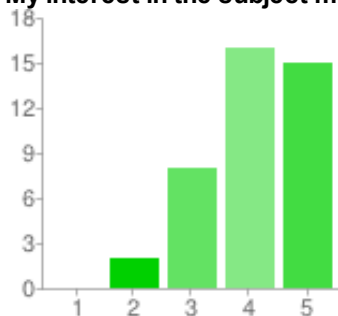
Personal assessment

I was well prepared to benefit from the lectures



| | | |
|----------------|-----------|-----|
| 1 - Not at all | 1 | 2% |
| 2 | 0 | 0% |
| 3 | 11 | 27% |
| 4 | 22 | 54% |
| 5 - Very | 7 | 17% |

My interest in the subject matter was increased by the workshop



| | | |
|-----------------|-----------|-----|
| 1 - Niot at all | 0 | 0% |
| 2 | 2 | 5% |
| 3 | 8 | 20% |
| 4 | 16 | 39% |
| 5 - Very | 15 | 37% |

Not at all Very

The workshop helped me meet people with similar scientific interests



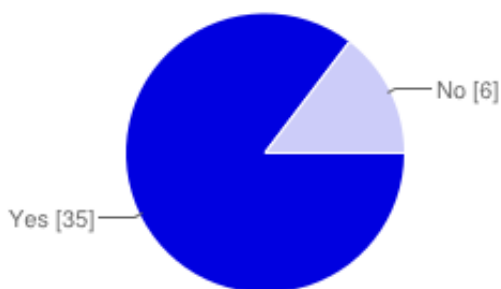
| | | |
|----------------|-----------|-----|
| 1 - Not at all | 0 | 0% |
| 2 | 0 | 0% |
| 3 | 6 | 15% |
| 4 | 10 | 24% |
| 5 - Very Much | 25 | 61% |

Additional comments on your personal assessment

It was a good chance to meet some young folks I hadn't met before. For me it was a great experience to finally find someone who did something that inspires me this much. I decided on what direction t ...

Additional Activities

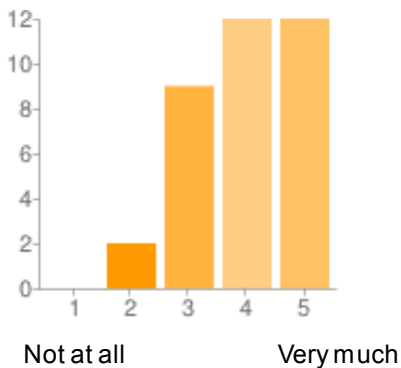
Did you attend the reception?



| | | |
|-----|-----------|-----|
| Yes | 35 | 85% |
| No | 6 | 15% |

If you did attend the reception, did it help to solidify the contacts you made in the workshop?

| | | |
|----------------|----------|-----|
| 1 - Not at all | 0 | 0% |
| 2 | 2 | 5% |
| 3 | 9 | 22% |



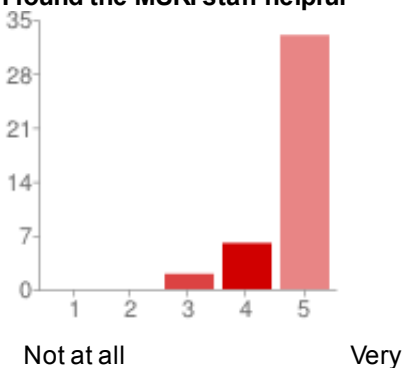
| | | |
|---------------|-----------|-----|
| 4 | 12 | 29% |
| 5 - Very much | 12 | 29% |

Please provide any comments on the reception

very nice and useful the reception allows for lots of time to interact and get to talk about things more concretely It was a good time for me to introduce myself to the more senior people in the field ...

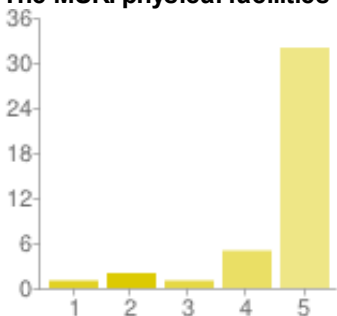
Venue

I found the MSRI staff helpful



| | | |
|----------------|-----------|-----|
| 1 - Not at all | 0 | 0% |
| 2 | 0 | 0% |
| 3 | 2 | 5% |
| 4 | 6 | 15% |
| 5 - Very | 33 | 80% |

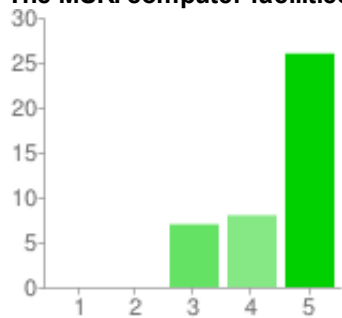
The MSRI physical facilities were conducive for such a workshop



| | | |
|----------------|-----------|-----|
| 1 - Not at all | 1 | 2% |
| 2 | 2 | 5% |
| 3 | 1 | 2% |
| 4 | 5 | 12% |
| 5 - Very | 32 | 78% |

Not at all Very

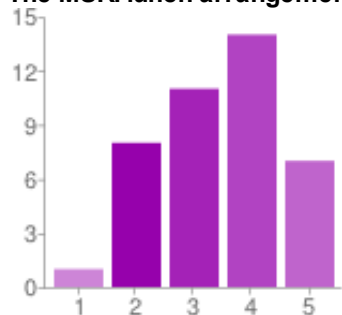
The MSRI computer facilities were adequate for such a workshop



| | | |
|----------------|-----------|-----|
| 1 - Not at all | 0 | 0% |
| 2 | 0 | 0% |
| 3 | 7 | 17% |
| 4 | 8 | 20% |
| 5 - Very | 26 | 63% |

Not at all Very

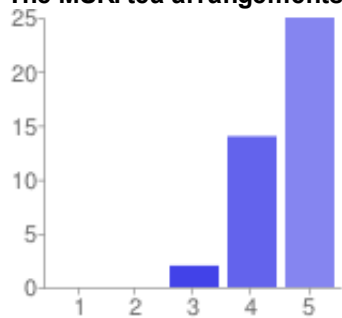
The MSRI lunch arrangements were satisfactory



| | | |
|----------------|-----------|-----|
| 1 - Not at all | 1 | 2% |
| 2 | 8 | 20% |
| 3 | 11 | 27% |
| 4 | 14 | 34% |
| 5 - Very | 7 | 17% |

Not at all Very

The MSRI tea arrangements were satisfactory



| | | |
|----------------|-----------|-----|
| 1 - Not at all | 0 | 0% |
| 2 | 0 | 0% |
| 3 | 2 | 5% |
| 4 | 14 | 34% |
| 5 - Very | 25 | 61% |

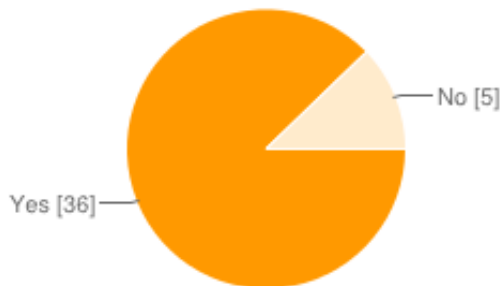
Not at all Very

Additional comments on the venue

the lecture hall was too cold Of the morning snack options, bagels and cream cheese are highly preferable. I spoke with a number of participants who were disappointed in the highly processed and sug ...

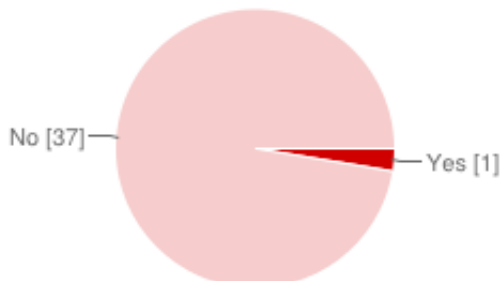
MSRI Wireless Network

Did you use MSRI's wireless network?



| | | |
|-----|-----------|-----|
| Yes | 36 | 88% |
| No | 5 | 12% |

Did you experience any difficulties with the network?



| | | |
|-----|-----------|-----|
| Yes | 1 | 2% |
| No | 37 | 90% |

If you did experience difficulties with the network, please explain:

facetime quality

varied

Thank you. Invaluable.

Thank you for completing this survey

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

future participants.

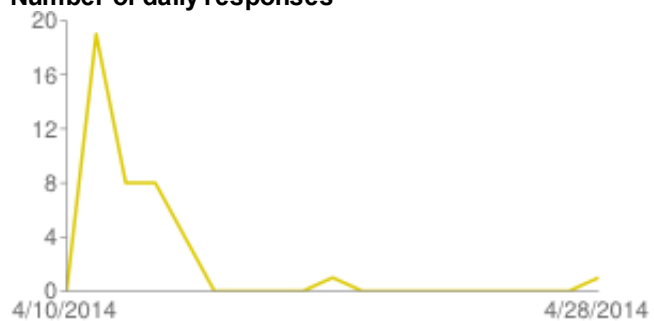
I have been here for the program. The building is great, the staff are friendly and well organized.

The main lecture room is poor.

I think MSRI is one of the few

places where such a conference could ...

Number of daily responses



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April 7 - 11, 2014

Additional Survey Responses

Additional comments on your personal assessment

- It was a good chance to meet some young folks I hadn't met before.
- For me it was a great experience to finally find someone who did something that inspires me this much. I decided on what direction to undertake for my doctorate studies because of the workshop.
- The level of the talks was a bit too high: very little background was presented in most of the talks. This workshop was more like a conference than a workshop. Considering the large number of grad students, I would have expected some "minicourse" lectures. Perhaps the typeset notes will include some additional introduction by the speakers.
- The talks were over my head but I enjoyed meeting and talking to the other participants.

Additional comments on the venue

- the lecture hall was too cold
- Of the morning snack options, bagels and cream cheese are highly preferable. I spoke with a number of participants who were disappointed in the highly processed and sugary plastic-wrapped pastries.
- The main lecture hall is appalling bad. The angles from the side seats make most of them unusable. This dim light makes it hard to see from most of the central seats too. For most talks I had to just guess what we being written. (Yes 6 boards are nice.)
- perhaps more variety in lunch would be nice
- The auditorium is too cold!
- The lecture room was often far too cold because of excessive air conditioning. The side seating was not good for viewing the blackboards.
- Absolutely amazing and inspiring.
- Tea could have somewhat healthier, fewer sweets, options. General drinks could include hot chocolate, for those who don't drink coffee/caffeine tea. Thanks.

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

- I have been here for the program. The building is great, the staff are friendly and well organized. The main lecture room is poor.
- I think MSRI is one of the few places where such a conference could've been held. It's an exciting and motivating place to be around other experts and I hope this place keeps growing and receiving the necessary support from the government and the universities involved.
- Wonderful environment. Love the outside blackboard and plants.

If you did experience difficulties with the network, please explain:

- facetime quality varied
- Thank you. Invaluable.

Please provide any comments on the reception

- very nice and useful
- the reception allows for lots of time to interact and get to talk about things more concretely
- It was a good time for me to introduce myself to the more senior people in the field.

Additional comments on the workshop organization

- As a middle aged mathematician, the demographics of the speakers seemed aimed at perpetuating the stereotype that mathematicians over 40 should be put out to pasture. One more grumble: having one lecture down at UC was impractical to get to, if one had come to MSRI in the morning by car: the case for roughly a dozen people.
- not enough reimagining as announced, varying quality of speakers
- excellent administrators
- It would be nice if there was at least one additional shuttle in the morning.
- Loved the bagels and the brownie bites.
- Excellent! The time between talks was very necessary for discussions.