

Model Theory in Geometry and Arithmetic

May 12 - 16, 2014

MSRI, Berkeley, CA, USA

Organizers:

Raf Cluckers (Université de Lille I)

Jonathan Pila (University of Oxford)

Thomas Scanlon (University of California, Berkeley)

Final report on MSRI Workshop 686

Model Theory in Geometry and Arithmetic

MSRI, Berkeley, May12-16 2014

Organisers:

Raf Cluckers (Leuven and Lille),
Jonathan Pila (Oxford), and
Thomas Scanlon (Berkeley)

Background

Model theory proper is the study of the mathematical structures providing the semantic interpretations of the syntax of formal logical languages. While such foundational concerns have been at the core of the internal development of the subject, from its earliest days, its practitioners have recognized that its methods and its perspective which is somewhat askew to that of more classical mathematics may be applied to solve problems in number theory and geometry or at the very least to put the problems on a new footing. For example, with their work in the 1960s on the logical theory of the p -adic numbers, Ax and Kochen gave a precise sense to the idea that in the limit the fields \mathbb{Q}_p and $\mathbb{F}_p((t))$ are the same thereby proving an asymptotic version of Artin's conjecture on homogeneous forms while suggesting where counterexamples to the original conjecture may be found.

In recent years, the web of connections between model theory, number theory and arithmetic geometry has both broadened and deepened, with deep results and techniques from model theory finding their way into the study of diophantine equations, algebraic differential equations, p -adic analytic geometry, additive combinatorics, and the theory of special points on Shimura varieties to name just a few areas. The Spring 2014 MSRI semester long program on Model Theory, Arithmetic Geometry and Number Theory provided a concentrated, but extended, period during which experts in model theory and these allied fields to work in close proximity learning from each other in an interdisciplinary context.

In keeping with the theme of the parent programme, this Concluding Workshop aimed to present a diverse picture of the current state of these interactions. It further provided a venue for those mathematicians working at the boundary between model theory, geometry and arithmetic, but who were unable to participate in the longer programme, to meet and to present their work. The organisers were also mindful to achieve a balanced mix of those whose background is primarily in model theory with those whose background is primarily in number theory/geometry, and of senior and early-career researchers.

The workshop

The scientific contributions of the workshop speakers can be divided into the following broad areas (though several talks had relevance under more than one area):

- Diophantine geometry
- O-minimality
- Algebraic differential and difference equations
- Valued fields and motivic integration
- NIP and simple theories
- Other: Non-commutative geometry, additive combinatorics.

Diophantine geometry. By this we mean the study of algebraic relations and inequalities on arithmetically interesting points from the point of view of their relation to algebraic geometry, is a multifaceted subject on which model theory impinges at many junctures.

The talk by Rossler described recent progress in the area of the function field Mordell-Lang conjecture. This is the site of perhaps the most celebrated application of model theory to diophantine geometry, namely Hrushovski's proof of the Mordell-Lang conjecture over function fields in positive characteristic.

The earliest, and still the deepest, connections between logic and number theory come from Gödel's Incompleteness Theorem. With Matiyasevich's theorem that every recursively enumerable subset of \mathbb{Z} may be realized as a diophantine set, one sees that it is impossible to find an algorithm to decide whether a general system of diophantine equations has a solution. Using the Hasse principle for quadratic forms, J. Robinson showed that there is no general procedure to decide the truth or falsity of formal first-order statements about the rational numbers. If it were possible to represent the integers as a diophantine subset of the rational numbers, then by relativizing Matiyasevich's theorem, one would deduce the impossibility of deciding the solvability of polynomial equations in the rationals.

The talk by Eisentraeger described generalisations of Hilbert's 10th problem in which one seeks to study degrees of unsolvability.

The talk by Koenigsmann, on the absolute Galois groups of fields, is cognate with Diophantine geometry.

O-minimality. The defining condition underlying o-minimality was isolated in the 1980s by van den Dries (for structures on the real numbers) and then generally by Pillay and Steinhorn as the appropriate axiomatic framework for studying real analysis as geometric theory. Using the theory of o-minimality, the methods and results for real algebraic geometry have been widely generalized and improved to such theories as that of exponential geometry, semi-local real analytic geometry, and of quasi-analytic geometry. The Counting Theorem of Pila-Wilkie has, via a strategy proposed by Zannier, found startling recent application in Diophantine geometry. A basic ingredient in this strategy is a suitable functional transcendence statement which in many cases has also been achieved via o-minimality. Two talks in this area described recent progress.

A talk by Wilkie described a theorem giving finer control of rational points using o-minimal techniques.

A talk by Tsimerman described an "Ax-Schanuel" theorem for the j -function, obtained by a combination of methods from complex geometry and o-minimality (including point counting). It is related to the Zilber-Pink conjectures in Diophantine geometry, in particular to strategies to prove cases of the conjecture via o-minimality.

A related talk by Loeser described recent work (with Cluckers and Comte) establishing analogues of the Counting Theorem, and the parameterisation techniques which go into it, in the context of valued fields.

Algebraic differential and difference equations. The theories of difference and differential fields and the classification of the definable sets in these structures have played important roles in the applications of model theory to diophantine geometry. At a more fundamental level, the model theoretic treatments have enriched the theories of algebraic difference and differential equations. For example, the work of A. Robinson and Blum provided universal domains for the study of algebraic differential equations in characteristic zero. Differential Galois theory, by which we mean the study of the relation between symmetries of differential equations and algebraic or differential algebraic groups, has been studied for well over a century, but model theoretic approaches and algebraic approaches influenced by the model theoretic treatments are actively studied now.

The talk by Moosa showed how to apply the model theory of differential fields to solve an open problem in Poisson algebras.

The talk by Tsimerman (already mentioned under o-minimality and Diophantine geometry) is also relevant here, as the theorem can be expressed as a result in differential algebra and continues a line of results starting with those of Ax in the 1960s using methods from differential algebra.

The model theory of difference fields has been developed in parallel to the theory of differential fields. Many results, including the fundamental twisted Lang-Weil estimate of Hrushovski, have found significant applications in algebraic dynamics.

The talk by Chatzidakis described further applications of the model theory of differential fields to algebraic dynamics. The theorem gives conditions under which an algebraic dynamical system defined over a function field $k(t)$ is dominated by a system defined over the base field k , and depends on a study of types and internality.

Valued fields and motivic integration. As we noted in the introduction, one of the first sophisticated applications of model theory came from the model theory of valued fields as initiated by Ax, Ershov and Kochen. Over the years, the class of valued fields and expansions of the structures for which theorems in the style Ax-Kochen-Ershov have been proven has greatly expanded so as to include, for example, structures admitting actions by continuous automorphisms and p -adic analytic functions.

The talk by Chambert-Loir described (joint with Loeser applying the Hrushovski-Kazdan motivic Poisson summation formula to motivic height zeta functions connected with geometric analogues of the Manin conjectures about asymptotic point-counting.

The talk by Haskell reported on joint work with Ealy and Marikova in studying the extent to which a T -convex expansion of a real closed field is determined by its value group and residue field.

The talk by Rideau (joint work with Hrushovski and Martin) explained how to transfer elimination of imaginaries from algebraically closed valued fields to the p -adics.

The talk by Loeser explained his recent work with Cluckers and Comte giving an analogue of Yomdin-Gromov parametrizations in non-archimedean settings with application to analogues of the Pila-Wilkie point-counting theorem in these settings.

The talk by Gordon described applications of motivic integration to harmonic analysis.

NIP and simple theories. The model-theoretic classification of theories (stable, NIP, simple,...) and their basic properties is a central part of pure model theory, and the fundamental theorems describing definable sets in such structures have long been a source of applications.

The talk by Simon described the structure of definably amenable NIP groups.

The talk by Pillay described results on definable topological dynamics in such settings.

The talk by Malliaris described complexity classes of simple theories determined by certain criteria in infinite combinatorics.

Other.

The talk by Zilber described his approach to a model-theoretic semantics for non-commutative geometry.

The talk by Helfgott surveyed the current state in approximate subgroups. The work of Hrushovski applying stability theory to approximate subgroups was a key part of the recent enormous progress in this area.

Conclusion

Anecdotal reports indicate that the workshop was very successful, with a uniformly high standard of talks and a lot of interaction around the talks and in the breaks.

The organisers are grateful to MSRI for their excellent organisation, and to the NSF and NSA, who provided funding for participants.

Organizers

First	Last	Institutions
Raf	Cluckers	Universite de Lille I (Sciences et Techniques de Lille Flandres Artois)
Jonathan	Pila	University of Oxford
Thomas	Scanlon	University of California, Berkeley

Speakers

First	Last	Institutions
Antoine	Chambert-Loir	Universite Paris-Sud (Orsay)
Zoe	Chatzidakis	Centre National de la Recherche Scientifique (CNRS)
Kirsten	Eisentraeger	Pennsylvania State University
Julia	Gordon	University of British Columbia
Deirdre	Haskell	McMaster University
Harald	Helfgott	Centre National de la Recherche Scientifique (CNRS)
Jochen	Koenigsmann	University of Oxford
Francois	Loeser	Universite de Paris VI (Pierre et Marie Curie)
Maryanthe	Malliaris	University of Chicago
Rahim	Moosa	University of Waterloo
Anand	Pillay	University of Notre Dame
Damian	Rosler	Universite de Toulouse III (Paul Sabatier)
Silvain	Rideau	Ecole Normale Superieure
Pierre	Simon	Centre national de la recherche scientifique (CNRS)
Jacob	Tsimmerman	Harvard University
Alex	Wilkie	University of Manchester
Yimu	Yin	University Pierre and Marie Curie
Boris	Zilber	University of Oxford



Model Theory in Geometry and Arithmetic

May 12 - 16, 2014

Schedule

Monday, May 12, 2014			
9:15 AM - 9:30 AM	Simons Auditorium		Welcome
9:30 AM - 10:30 AM	Simons Auditorium	Chambert-Loir	Hrushovski-Kazhdan's motivic Poisson formula and motivic height zeta functions
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00 PM	Simons Auditorium	Haskell	Towards a theory of residue field domination for convexly valued ordered fields
12:00 PM - 2:00 PM	Atrium		Lunch
2:00 PM - 3:00 PM	Simons Auditorium	Chatzidakis	An application of difference fields to algebraic dynamics.
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:30 PM	Simons Auditorium	Rideau	Transferring imaginaries: from ACVF to \mathbb{Q}_p (joint work with E. Hrushovski and B. Martin)

Tuesday, May 13, 2014			
9:30 AM - 10:30 AM	Simons Auditorium	Loeser	Non-archimedean Yomdin-Gromov parametrizations and points of bounded height
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00 PM	Simons Auditorium	Gordon	Applications of motivic integration to harmonic analysis
12:00 PM - 2:00 PM	Atrium		Lunch
2:00 PM - 3:00 PM	Simons Auditorium	Helfgott	Growth in groups: ideas and perspectives
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:30 PM	Simons Auditorium	Pillay	Definable topological dynamics
4:30 PM - 6:20 PM	Atrium		Reception

Wednesday, May 14, 2014			
9:30 AM - 10:30 AM	Simons Auditorium	Tsimerman	An Ax-Schanuel theorem for the modular curve and the j -function
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00	Simons Auditorium	Wilkie	Uniform bounds for derivatives of definable functions with a diophantine application

Thursday, May 15, 2014			
9:30 AM - 10:30 AM	Simons Auditorium	Moosa	An application of the model theory of differential fields to Poisson algebras
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00 PM	Simons Auditorium	Zilber	On the semantics of non-commutative geometry and exotic summation formulas.
12:00 PM - 2:00 PM	Atrium		Lunch
2:00 PM - 3:00 PM	Simons Auditorium	Koenigsmann	To $\mathbb{S}_p\mathbb{S}$ or not to $\mathbb{S}_p\mathbb{S}$: Galois' first glimpse of Hensel on wild grounds
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:30 PM	Simons Auditorium	Eisentraeger	Generalizations of Hilbert's Tenth Problem

Friday, May 16, 2014			
9:30 AM - 10:30 AM	Simons Auditorium	Malliaris	Complexity classes of simple theories
10:30 AM - 11:00 AM	Atrium		Tea
11:00 AM - 12:00 PM	Simons Auditorium	Simon	Definably amenable NIP groups
12:00 PM - 2:00 PM	Atrium		Lunch
2:00 PM - 3:00 PM	Simons Auditorium	Rossler	On the group of purely inseparable points of an abelian variety defined over a function field of positive characteristic
3:00 PM - 3:30 PM	Atrium		Tea
3:30 PM - 4:30 PM	Simons Auditorium		

Participants		
First	Last	Institutions
Nate	Ackerman	Harvard University
Uri	Andrews	University of Wisconsin
Will	Anscombe	University of Leeds
Matthias	Aschenbrenner	University of California, Los Angeles
Franck	Benoist	Universite Paris-Sud (Orsay)
Thomas	Blossier	Universite Claude-Bernard (Lyon I)
Anton	Bobkov	University of California, Los Angeles
Will	Boney	Carnegie-Mellon University
Lee	Butler	University of Bristol
Santiago	Camacho	University of Illinois at Urbana-Champaign
Mei-Chu	Chang	University of California
Artem	Chernikov	Institut de Mathematiques de Jussieu - Paris Rive Gauche
Derya	Ciray	Universitat Konstanz
Georges	Comte	Universite de Savoie (Chambery)
Gabriel	Conant	University of Illinois
Gregory	Cousins	University of Notre Dame
Reid	Dale	University of Washington
Joao Alberto	de Faria	Florida Institute of Technology
Jamshid	Derakhshan	University of Oxford
Antoine	Ducros	Universite Paris VI
Taylor	Dupuy	University of California, Los Angeles
Clifton	Ealy	Western Illinois University
Pantelis	Eleftheriou	Universitat Konstanz
Arthur	Forey	Ecole Normale Superieure
James	Freitag	University of California, Berkeley
Dario	Garcia	Universidad de los Andes
Allen	Gehret	University of Illinois at Urbana-Champaign
Petr	Glivicky	Academy of Sciences of the Czech Republic
Haydar	Goral	Universite Claude-Bernard (Lyon I)
Rebecca	Gordon	Rutgers University
Vincent	Guingona	University of Notre Dame
Adam	Gutter	Carnegie Mellon University
Charlotte	Hardouin	Universite de Toulouse III (Paul Sabatier)
Gwyneth	Harrison-Shermoen	UC Berkeley Math Faculty
Michael	Haskel	University of Notre Dame
Robert	Henderson	University of East Anglia
Martin	Hils	Universite de Paris VII (Denis Diderot)
Meng-Che	Ho	University of Wisconsin
Remi	Jaoui	Ecole Normale Superieure
William	Johnson	University of California, Berkeley
Byungheup	Jun	Yonsei University
Tobias	Kaiser	University of Passau
Mary	Karker	Wesleyan University
Hiroataka	Kikyo	Kobe University
Byunghan	Kim	Yonsei University

Inkang	Kim	Korea Institute for Advanced Study
Jonathan	Kirby	University of East Anglia
Piotr	Kowalski	University of Wroclaw
Holly	Krieger	Massachusetts Institute of Technology
Alex	Kruckman	University of California, Berkeley
Krzysztof	Krupinski	Uniwersytet Wroclawski
Tristan	Kuijpers	Katholieke Universiteit Leuven
JUNGUK	LEE	Yonsei University
Eva	Leenknecht	Purdue University
Omar	Leon Sanchez	McMaster University
Yun	Lu	Kutztown University of PA
Matthew	Luther	McMaster University
H.	Macpherson	University of Leeds
Edson	Makuluni	University of Wisconsin
Vincenzo	Mantova	Universita di Camerino
Jana	Marikova	Western Illinois University
David	Marker	University of Illinois
Chris	Miller	Ohio State University
Samaria	Montenegro-Guzman	Universite de Paris VII (Denis Diderot)
Eudes	Naziazeno	Federal University of Pernambuco
Victoria	Noquez	University of Illinois
le gal	olivier	Universite de Savoie
Alf	Onshuus	Universidad de los Andes
Donghoon	Park	Yonsei University
Rehana	Patel	Olin College of Engineering
Ya'acov	Peterzil	University of Haifa
Luis	Pinto Castaneda	Universite de Paris VII (Denis Diderot)
Francoise	Point	Universite de Mons
Michel	Raubaut	Universite de Savoie
Serge	Randriambololona	Galatasaray Universitesi
Nathalie	Regnault	Universite Libre de Bruxelles
Philip	Scowcroft	Wesleyan University
Alisa	Sedunova	Ecole Normale Superieure
Alexandra	Shlapentokh	East Carolina University
Michael	Singer	North Carolina State University
Jozsef	Solyosi	University of British Columbia
Sergei	Starchenko	University of Notre Dame
Charles	Steinhorn	Vassar College
Dmitry	Sustretov	Hebrew University
Caroline	Terry	University of Illinois at Chicago
Margaret	Thomas	Universitat Konstanz
Adam	Topaz	University of California, Berkeley
Thomas	Tucker	University of Rochester
Pinar	Ugurlu	Istanbul Bilgi University
Sebastien	Vasey	Carnegie Mellon University
Carlos	Videla	Mount Royal University
Somayeh	Vojdani	University of Notre Dame

Frank	Wagner	Universite Claude-Bernard (Lyon I)
Michael	Wan	University of California, Berkeley
Roman	Wencel	University of Wroclaw
Nicholas	Wentzlaff	Ecole Polytechnique
Carol	Wood	Wesleyan University
Daniel	Wood	University of Leeds
Austin	Yim	University of Oxford

Officially Registered Participant Information

Participants		120
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Gender		120
Male	74.17%	89
Female	22.50%	27
Declined to state	3.33%	4

Ethnicity*		120
White	59.17%	71
Asian	13.33%	16
Hispanic	5.83%	7
Pacific Islander	0.00%	0
Black	1.67%	2
Native American	0.00%	0
Mixed	1.67%	2
Declined to state	18.33%	22

* ethnicity specifications are not exclusive

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

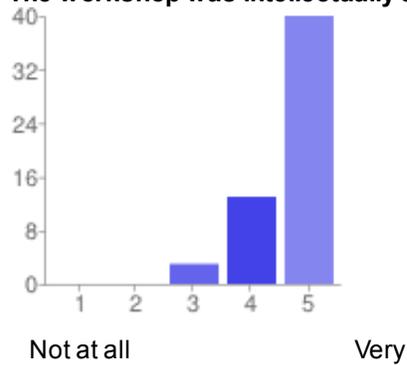
56 [responses](#)

56 responses/120 participants = 47% response rate

Summary [See complete responses](#)

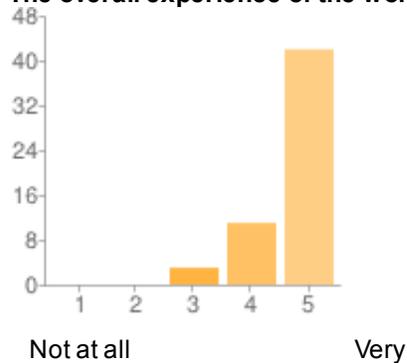
Workshop assessment

The workshop was intellectually stimulating



1 - Not at all	0	0%
2	0	0%
3	3	5%
4	13	23%
5 - Very	40	71%

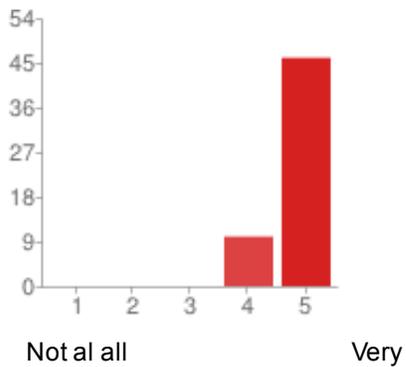
The overall experience of the workshop was worthwhile



1 - Not at all	0	0%
2	0	0%
3	3	5%
4	11	20%
5 - Very	42	75%

The time between lectures was adequate for discussion

1 - Not at all	0	0%
2	0	0%
3	0	0%
4	10	18%
5 - Very	46	82%

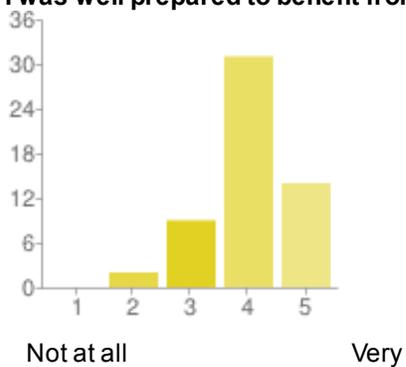


Additional comments on the workshop organization

The organization was fantastic! Thank you! the talks were quite good and the schedule was well organized There are not so many bus to go to MSRI. Thank you It ran extremely smoothly -- organization was ...

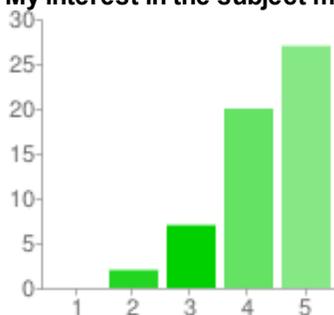
Personal assessment

I was well prepared to benefit from the lectures



1 - Not at all	0	0%
2	2	4%
3	9	16%
4	31	55%
5 - Very	14	25%

My interest in the subject matter was increased by the workshop

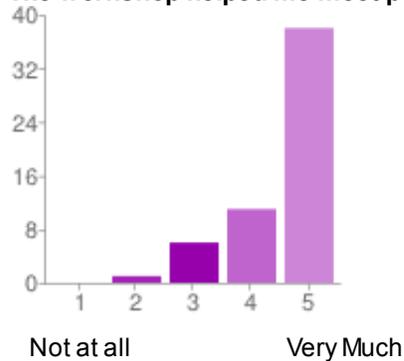


1 - Niot at all	0	0%
2	2	4%
3	7	13%
4	20	36%
5 - Very	27	48%

Not at all

Very

The workshop helped me meet people with similar scientific interests



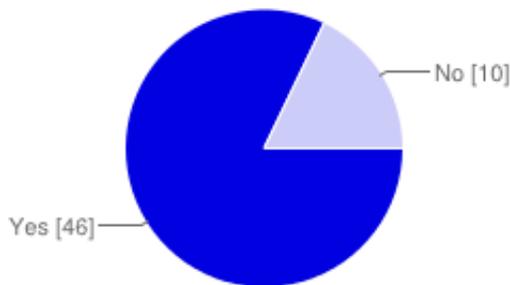
1 - Not at all	0	0%
2	1	2%
3	6	11%
4	11	20%
5 - Very Much	38	68%

Additional comments on your personal assessment

the workshop was a very satisfactory conclusion to the program
 The only reason why the "interest question" is 3 is that I already was very interested in the material
 There were several speakers from o ...

Additional Activities

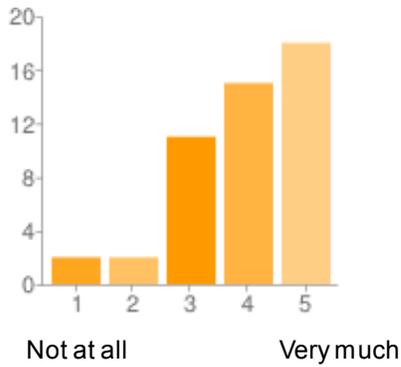
Did you attend the reception?



Yes	46	82%
No	10	18%

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

1 - Not at all	2	4%
2	2	4%
3	11	20%



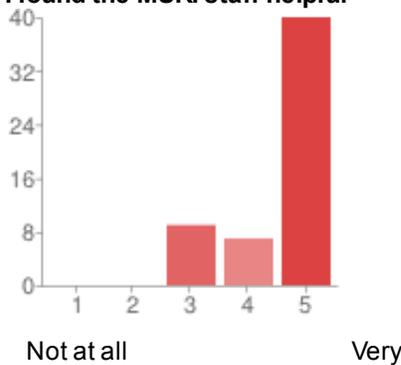
4	15	27%
5 - Very much	18	32%

Please provide any comments on the reception

The catered food was of very poor quality. It was great, thank you! It seemed to me that there was more food at the reception for the workshop earlier in the semester, or at least that the food ran out ...

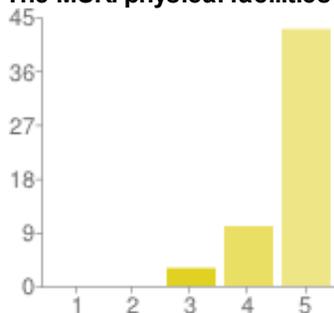
Venue

I found the MSRI staff helpful



1 - Not at all	0	0%
2	0	0%
3	9	16%
4	7	13%
5 - Very	40	71%

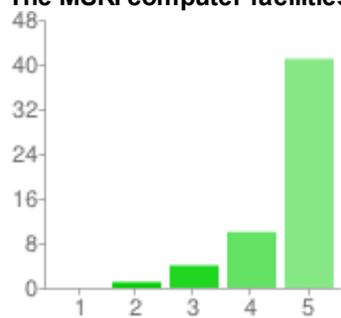
The MSRI physical facilities were conducive for such a workshop



1 - Not at all	0	0%
2	0	0%
3	3	5%
4	10	18%
5 - Very	43	77%

Not at all Very

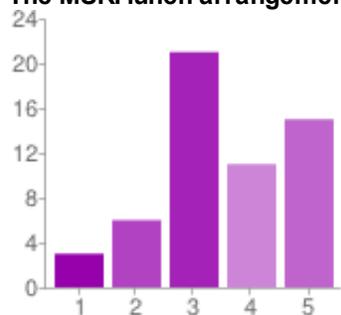
The MSRI computer facilities were adequate for such a workshop



1 - Not at all	0	0%
2	1	2%
3	4	7%
4	10	18%
5 - Very	41	73%

Not at all Very

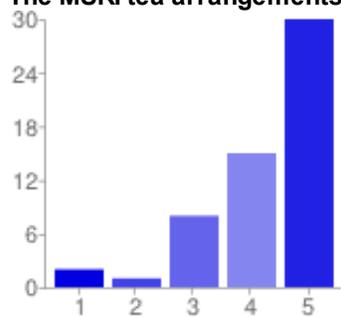
The MSRI lunch arrangements were satisfactory



1 - Not at all	3	5%
2	6	11%
3	21	38%
4	11	20%
5 - Very	15	27%

Not at all Very

The MSRI tea arrangements were satisfactory



1 - Not at all	2	4%
2	1	2%
3	8	14%
4	15	27%
5 - Very	30	54%

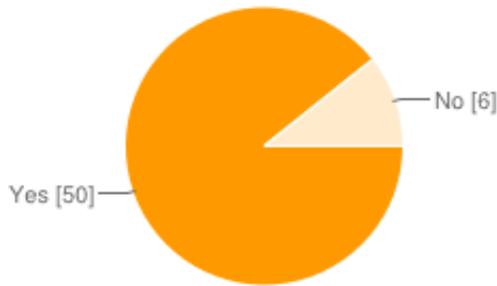
Not at all Very

Additional comments on the venue

The catered lunches were even worse than the catered reception. The lunch organization is not so good. And in the main auditorium there are a lot of seats from which one does not see very well the bl ...

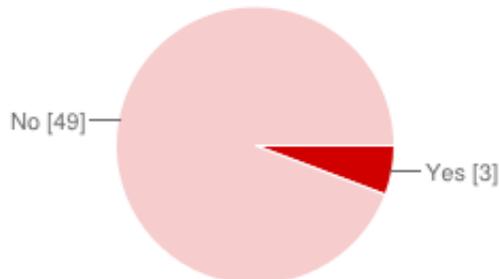
MSRI Wireless Network

Did you use MSRI's wireless network?



Yes	50	89%
No	6	11%

Did you experience any difficulties with the network?



Yes	3	5%
No	49	88%

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

It was pretty slow
sometimes, . In my
case, my labtop said it was accessed to the wireless but I couldn't use the wiress in real. I think, the wireless
signal was so weak.

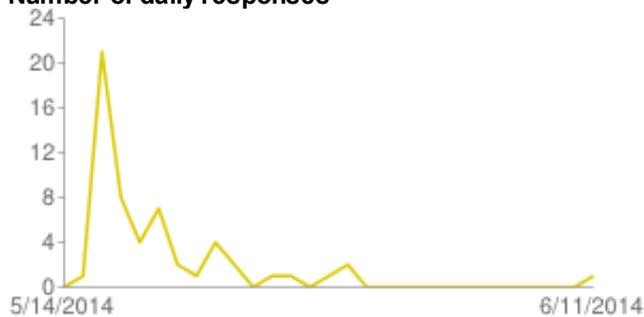
Thank you for completing this survey

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

provide more funding
hill each day. People are forced to change their plans to try to avoid the busiest two or three
buses,

You should have an extra bus up and down the
It was a very well organised, i ...

Number of daily responses



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May 12 - 16, 2014

Additional Survey Responses

Additional comments on your personal assessment

- the workshop was a very satisfactory conclusion to the program
- The only reason why the "interest question" is 3 is that I already was very interested in the material
- There were several speakers from outside model theory whom I had not heard previously, and who gave tremendous talks.
- Powerful talks and time to talk with colleagues--a great workshop!
- The conference offered the opportunity to meet up with people I know who work in my area, as well as make new contacts.
- It was a good experience to meet mathematicians of other branch who have same interests.

Additional comments on the venue

- The catered lunches were even worse than the catered reception.
- The lunch organization is not so good. And in the main auditorium there are a lot of seats from which one does not see very well the blackboard.
- the fact that the building is on the hills facilitate the exchanges between the participants since people have lunch together
- Lunch: The caterer for the first two days of the workshop was very bad (disorganized, overpriced, low quality). The second caterer (Stuffed Inn) was better. Tea: The mango one day was an exciting change, though there was not enough for everyone.
- The lunches were minimal but adequate, but at tea and coffee time there often were people who missed the food and most times the plates and spoons ran out. One time there was a big bowl of diced mango but no plates or spoons for 100 people. The venue can cope with the extra 100 people arriving for the workshop, but the staff need to act to make sure these basic things work right.
- The building needs air conditioning.
- The staff were wonderful and the refreshments were really good.
- There were problems communicating with msri staff by email before the conference. my feeling was that most of the staff work done before the workshop consisted of copy-pasting done in non-timely fashion
- I didn't have call to use the computer facilities or ask anything of the staff, but I only heard good things about them.
- MSRI's remote location makes outside catering difficult, but greater variety of food options would be beneficial.
- It was enough to enjoy the workshops.
- Lunch served at the venue is expensive and not very filling. The tea arrangements wastes a lot of paper cups

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

- provide more funding
- You should have an extra bus up and down the hill each day. People are forced to change their plans to try to avoid the busiest two or three buses,
- It was a very well organised, interesting workshop.
- improve communication by email before the workshop
- The workshops and MSRI were all great, nice view, nice place to discuss, nice library. But the wireless was a little unsatisfied.

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

- It was pretty slow sometimes,
- In my case, my laptop said it was accessed to the wireless but I couldn't use the wireless in real. I think, the wireless signal was so weak.

Please provide any comments on the reception

- The catered food was of very poor quality.
- It was great, thank you!
- It seemed to me that there was more food at the reception for the workshop earlier in the semester, or at least that the food ran out more quickly this time.
- There should have been more, and more varied, food and drink.
- Was a bit on the short side.
- The reception was very appreciated; the only issue may be that the space was perhaps too small for the number of people interacting.
- Local food was great.

Additional comments on the workshop organization

- The organization was fantastic! Thank you!
- the talks were quite good and the schedule was well organized
- There are not so many bus to go to MSRI.
- Thank you
- It ran extremely smoothly -- organization was ideal.
- Good that there were not too many lectures.
- I really liked the longer breaks between talks, as it provided time to chat about/recover from(!) the mathematics of the previous talk.
- Very well organised with nice selection of topics.
- A very well-organized workshop with a consistent and reliable schedule
- This workshops were highly motivated to me!