Spring/Summer 2010

EMISSARY

Mathematical Sciences Research Institute

www.msri.org

MSRI: Furthering Research and Reaching Out

A word from Director Robert Bryant

It has been an eventful year at MSRI. Not only have the programs in Tropical Geometry, Contact and Symplectic Geometry and Topology, and Homology Theories of Knots and Links been popular and their workshops heavily attended, but we've had a number of exciting additional workshops, such as last September's Black Holes in Relativity.

In a few weeks, I hope to be able to announce the results of our quinquennial reapplication for NSF funding. It has been a long process — two years — from our initial planning for the NSF proposal until now, but it is nearly complete, so do watch our web site and our emailed OUTLOOK newsletter for updates.

The stewardship of MSRI's scientific programs and their support via public and private sources naturally leads me to issues of finance and fundraising. It is vital to MSRI's continued success that we ensure that our programs and their participants are funded at a level that will assure continuing excellence and within a time frame that will allow for a meaningful planning horizon. (We are already considering programs for 2014-15!)

I look to endowment as the best form of support both to ensure excellence and to provide assurance that funds will be available for future programs. MSRI is most fortunate to have a $10 million challenge grant from the Simons Foundation for MSRI's endowment. Half of this grant funds the Eisenbud Professors at MSRI, and the remainder, $5 million, will be available for general endowment if MSRI's friends and supporters match these funds with endowment gifts.

This is a critical challenge for MSRI. Successful development campaigns need many things, but chief among them is a campaign chairman with the will, desire, and contacts to succeed. I am greatly pleased to report that we have a commitment from just such a person, MSRI Trustee Andrew J. Viterbi, to chair our campaign for matching Endowment funds for the Simons Challenge. Many of you know Dr. Viterbi for the Viterbi algorithm, the standard for cell phone networks, and the Viterbi Family Endowed Postdoctoral Scholars program at MSRI (page 2). I look forward to working with Andrew on a successful campaign to provide MSRI the endowment it so badly needs and to the excellence in our currently planned programs that will result.

Beyond our scientific programs, MSRI is involved in so many more activities and modes of serving the mathematics community. As the following pages will show, MSRI has taken a leading role in

continuing the dialog between mathematics educators and mathematical researchers, in outreach to minority and underserved communities (at all levels, beginning with K-12 mathematics education), and in sponsoring cultural events that explore the roles of mathematics in our society and the lives of those involved in math.

One recent event was particularly interesting: At the Joint Mathematics Meetings in San Francisco this January, MSRI sponsored a production of Gioia de Cari's *Truth Values: One Girl's Romp through MIT's Male Math Maze*. This one-woman play, which was a hit in Boston and New York, turned out to be a great success with the JMM attendees (as was the post-performance discussion); we essentially sold out the performances, added an extra performance, and even turned a profit (which, since we are a nonprofit organization, we donated to the Association for Women in Mathematics).

(continued on page 8)

Contents

Named Positions at MSRI

Each year MSRI awards special Research Professorships to support distinguished researchers, as well as 2 one-semester long special postdoctoral Fellowhips to support exceptional postdoctoral fellows.

The Eisenbud Professorships are funded by a generous endowment to MSRI from the Simons Foundation. The Simons Visiting Professorships are funded by a grant to MSRI, also from Simons Foundation. Endowed Postdoctoral Scholars are funded by a generous endowment to MSRI from Trustee Andrew Viterbi, Erna Viterbi and the Viterbi Family Fund of the Jewish Community Foundation. The Cha Scholars are funded by a generous grant to MSRI by former Trustee Johnson M. D. Cha. The Cha Scholars will be named in August 2010. Here are the recipients of the Eisenbud and Simons professorships and of the Viterbi postdoctoral fellowship for the next two semesters. (See also the article on the Clay and Chancellor's awards on page 14.)

Fall 2010

Random Matrix Theory, Interacting Particle Systems and Integrable Systems

Eisenbud Professorships:
Gerard Ben Arous, Courant Insitute
Herbert Spohn, Technische Universität München
Pierre van Moerbeke, Université Catholique de Louvain

Simons Professorship:
Percy Deift, Courant Institute of Mathematical Sciences, New York University

Inverse Problems and Applications

Eisenbud Professorships:
Kari Astala, University of Helsinki
Margaret Cheney, Rensselaer Polytechnic Institute
Christopher Croke, University of Pennsylvania
Graeme Milton, University of Utah

Simons Professorship:
Plamen Stefanov, Purdue Univerity

Spring 2011

Arithmetic Statistics

Eisenbud Professorships:
Manjul Bhargava, Princeton University
Henri Cohen, Université de Bordeaux I
John Keating, University of Bristol

Simons Professorship:
Henryk Iwaniec, Rutgers University

Viterbi Postdoctoral Fellowship:
Brooke Feigon, University of Toronto

Free Boundary Problems Theory and Applications

Eisenbud Professorships:
Mikhail Feldman, University of Wisconsin
Charles Martin Elliot, University of Warwick
Juan Luis Vazquez, Universidad Autonoma de Madrid
Georg Sebastian Weiss, University of Tokyo

Simons Professorship:
Henrik Shahgholian, Royal Institute of Technology, Sweden

Viterbi Postdoctoral Fellowship:
Cristina Caputo, University of Texas at Austin

Spring Bloom for Symplectic and Contact Geometry

Paul Seidel

"Too much cool stuff going on here," is Mohammed Abouzaid's complaint about the ongoing year-long program in Symplectic and Contact Geometry and Topology. (He has admitted to not being completely serious about this.) Certainly, the areas of mathematics covered by the program are very active ones. The article by Eliashberg and Ionel in the previous Emissary gives a good overall picture of the subject and its history, highlighting the important role that MSRI has played throughout. Still, enough progress is being made right under our eyes to warrant an update for the spring semester, and some further comments.

A good strategy for getting the attention of a seminar audience is to give the name of a major open question as the title of your talk. This certainly applied to Michael Hutchings' seminar talk "The chord conjecture in three dimensions" (see sidebar on next page). The lecture turned out to live up fully to expectations: thanks to work of Hutchings and Taubes, done during their stay at MSRI, that conjecture is now proved.

This continues a recent series of breakthroughs in the classical area of symplectic geometry and dynamical systems, such as the proof of the three-dimensional Weinstein conjecture by Taubes, and of various forms of the Conley conjecture by Hingston, Ginzburg, and several others. With this in mind, we chose dynamical aspects of symplectic geometry as a major focus for our March workshop.

From an organizational viewpoint, we've dipped our toes in the "Web 2.0" world by having a small dedicated Wikipedia, set up for the organizers by Sheel Ganatra, one of the graduate students visiting the program.[1] Besides its usefulness for coordinating activities, this has been a natural place to note down some of the questions and ideas from our two working groups, on "Quantitative symplectic topology" and "Symplectic geometry and representation theory". For readers wondering about the quantitative

[1] http://sheel.scripts.mit.edu/~sheel/msri09/index.php?title=Main_Page

The chord conjecture in three dimensions

Take a closed three-dimensional manifold M together with a one-form $\alpha \in \Omega^1(M)$ such that $\alpha \wedge d\alpha \neq 0$ everywhere. Such an α is said to define a contact structure. The associated Reeb vector field R is uniquely defined by $\alpha(R) = 1$ and $d\alpha(R, \cdot) = 0$. A knot $k : S^1 \hookrightarrow M$ is called Legendrian if $k^*\alpha = 0$. The chord conjecture says that for any Legendrian knot, there is a trajectory of the Reeb vector field which both starts and ends on $K = k(S^1)$.

This question has a long history. In particular, the theory of pseudo-holomorphic curves has given rise to algebraic structures that encode such chords. The question is then to show that these structures are not trivial! In Hutchings and Taubes' proof, the algebraic structure is a cobordism map in monopole Floer homology (or embedded contact homology). The argument combines several of the deepest threads in symplectic geometry and gauge theory in a very satisfactory way.

part, the sidebar below gives an example of the kind of questions considered in that area, namely the existence or nonexistence of symplectic embeddings.

Mentoring and training of beginning researchers is an important concern at MSRI. One activity specifically addressing this is a special joint seminar, in which postdocs give talks of a more introductory nature. This provides training in communication (important for the job market), as well as a chance to enlarge one's horizon and make connections across programs and disciplines. To preserve the special nature of the seminar, senior researchers, and in particular the program organizers, were strongly discouraged from attending.

In the spring, this seminar was run by Yanki Lekili, jointly with Joshua Greene from the concurrent program on knot homology theories. In general, it is worthwhile mentioning how well the two programs have been meshing. Besides the natural overlap in the objects of study, for instance in the case of Legendrian knots which appear in the chord conjecture, there is a large body of common techniques, namely Floer homology in its various forms.

Quantitative symplectic topology

Take two open subsets U and V inside $2n$-dimensional space $\mathbb{R}^{2n}$. When can one embed U into V while preserving the (two-dimensional) symplectic areas? This is a surprisingly deep question, even for simple shapes like balls or ellipsoids.

Here's a sample recent result by Guth, Hind (currently here at MSRI), and Kerman. Inside $\mathbb{R}^6$, take a disc-times-ball $U = B^2(1) \times B^4(S)$, where the radius S of the ball is very large. We try to embed this symplectically into the ball-times-plane $V = B^4(R) \times \mathbb{R}^2$. This is possible if $R > \sqrt{3}$ (technically speaking, for some $S \gg 0$ which may depend on R), and impossible if $R < \sqrt{3}$. The appearance of $\sqrt{3}$ as a threshold came as a surprise to experts; and the boundary case $R = \sqrt{3}$ is still open.

At the time of writing, program activities are still in full swing. There will be a further workshop in May, sponsored by the Hayashibara Foundation, and dedicated to interdisciplinary aspects of symplectic geometry, from string theory to noncommutative geometry. Symplectic geometry traditionally sits at a crossroads of various areas of mathematics and physics, and the resulting multiplicity of viewpoints is one of its appealing features. By emphasizing this, the program will come to a fitting conclusion.

Focus on the scientist: Dusa McDuff

Leonid Polterovich

For the last 25 years, Professor Dusa McDuff of Columbia University has been a major contributor to the spectacular development of symplectic topology into a central area of modern mathematics. Among her many breakthrough results are the first example of symplectic forms on a closed manifold that are cohomologous but not diffeomorphic and the classification of rational and ruled symplectic four-manifolds, completed with Francois Lalonde — a work that laid foundations for four-dimensional symplectic topology.

In recent years, McDuff, partly in collaboration with Sue Tolman, has pioneered applications of powerful methods of 'hard' symplectic topology to the theory of Hamiltonian torus actions. For instance, she discovered the astonishing fact that every closed symplectic manifold admitting an effective Hamiltonian circle action is necessarily uniruled. Her work has changed the face of this field.

McDuff and Dietmar Salamon have written two highly influential textbooks, considered nowadays as classic references on symplectic topology. McDuff's numerous honors include a plenary lecture at the ICM (Berlin) and the Satter Prize of the AMS. She is a Fellow of the Royal Society of London and a member of the US National Academy of Sciences.

Homology Theories of Knots and Links at MSRI

Mikhail Khovanov and Peter Ozsváth

The three streams of link homology

Link homology is a new source of tools for studying low-dimensional phenomena. Although its goal is to explore the topology of familiar low-dimensional objects — knots, links, and indeed three- and four-manifolds — this rapidly developing subject draws on many seemingly unrelated branches of mathematics.

The field can be roughly divided into three streams: invariants inspired by representation theory, resulting in the so-called *categorifications* of knot polynomials; invariants which are derived from Lagrangian Floer homology and symplectic geometry; and thirdly, invariants which have their roots in gauge theory. Of the first type, the paradigmatic invariant is Mikhail Khovanov's categorification of the Jones polynomial (which has since had a number of generalizations, including the Khovanov–Rozansky categorifications of the 2-variable HOMFLYPT polynomial and of its one-variable specializations). Of the second type of invariant, one key example is the Heegaard Floer homology introduced by Peter Ozsváth and Zoltán Szabó, which has generalizations to knots indepedently discovered by Jacob Rasmussen. Indeed, there is a further generalization to sutured manifolds introduced by András Juhász. Another example of invariants defined using symplectic techniques is *symplectic knot homology*, constructed by Paul Seidel and Ivan Smith, and generalized by Ciprian Manolescu. The third stream has its origins in Simon Donaldson's invariants for smooth four-manifolds, and its closely-related three-dimensional counterpart, the *instanton homology* defined by Andreas Floer. This area has evolved naturally with the introduction of new ideas from mathematical physics, leading to Seiberg–Witten invariants for four-manifolds, along with a three-dimensional counterpart, *monopole Floer homology*, pioneered by Peter Kronheimer and Tomasz Mrowka. The aim of the MSRI program on link homologies has been to help bring these three independently-growing areas into closer contact with one another, and help tie them together with their close cousins, symplectic and contact geometry.

Khovanov homology is a bigraded theory of links, functorial with respect to link cobordisms, with the Jones polynomial as its Euler characteristic. Bigraded, here, means that the Khovanov homology groups $\mathcal{H}(L)$ of a link L split as a direct sum $\mathcal{H}(L) = \bigoplus_{i,j} \mathcal{H}^{i,j}(L)$ indexed by integers i and j. Taking the Euler characteristic in one direction, and recording the other direction as an exponent in a formal variable q, we obtain a Laurent polynomial in q,

$$\sum_{i,j} (-1)^i q^j \mathrm{rk}(\mathcal{H}^{i,j}(L)).$$

This graded Euler characteristic in fact coincides with the Jones polynomial.

Since its discovery around 2000, Khovanov homology has generated a great deal of activity. In 2004, this invariant, along with a deformation discovered by E. S. Lee, was used by Jacob Rasmussen to obtain a purely combinatorial proof of the Milnor conjecture which computes the unknotting numbers of positive knots. This inherently four-dimensional conjecture was first proved by Kronheimer and Mrowka via gauge-theoretical methods in 1993. In a different direction, Lenny Ng discovered Legendrian Thurston–Bennequin bounds which can be extracted from Khovanov homology. When extended from links to tangles, Khovanov homology immediately relates to homological algebra and representation theory, including that of highest weight categories, modular representation theory, and representation theory of Lie superalgebras. For instance, it was proved recently by Jonathan Brundan and Catharina Stroppel that blocks of categories of finite-dimensional $\mathfrak{gl}(n|m)$-modules are controlled by modifications of Khovanov arc algebras (which originally appeared in the minimal extension of Khovanov homology to tangles). Relation of link homology to highest weight categories is a bit older, and has led to a new viewpoint on this venerable object in representation theory, originally introduced by J. Bernstein, I. Gelfand, and S. Gelfand in the early 70's.

Categorification, a term coined by L. Crane and I. Frenkel, involves lifting algebraic structures and their topological counterparts one dimension up. Crane and Frenkel conjectured that Reshetikhin–Turaev invariants of 3-manifolds can be lifted one dimension up, to invariants of 4-manifolds and a homology theory for 3-manifolds. The past 16 years saw gradual progress towards understanding their informal conjecture, starting with the discovery of various link homology theories categorifying the simplest Reshetikhin–Turaev invariants of links, such as the Jones polynomial. More recently, a progress has been made on the categorification of quantum groups (certain Hopf algebras that control Reshetikhin–Turaev invariants of links and that can be realized as deformations of universal enveloping algebras of simple Lie algebras). Khovanov and Lauda found monoidal categories whose Grothendieck groups are integral forms of quantum universal enveloping algebras of positive (or negative) halves of simple Lie algebras. They have also managed to categorify the entire quantum $\mathfrak{sl}(n)$. Similar constructions have been introduced by Rouquier. Brundan and Kleshchev found striking applications of these algebras and their relations to fundamental structures in representation theory. For instance, these algebras introduce a mysterious grading on blocks of symmetric groups in finite characteristic. They also lead to a canonical grading on completions of affine Hecke algebras, the latter related to the representation theory of p-adic groups.

A very recent exciting development, due to Ben Webster, is a categorification of Reshetikhin–Turaev invariants of links associated to arbitrary simple Lie algebras and their irreducible representation. His construction is based on a distributive version of Khovanov–Lauda–Rouquier algebras. Webster's framework promises to be truly fundamental for the further unification of link homology and representation theory.

Heegaard Floer homology was originally conceived as a geometric realization of the more analytic four-manifold invariants coming from gauge theory. For example, the corresponding three-manifold invariant is defined as the homology group of a chain complex whose generators are combinatorially associated to a Heegaard diagram for a three-manifold. The differentials, however, are less concrete: they count pseudo-holomorphic curves in a naturally associated symplectic manifold. Nonetheless, it was immediately conjectured that Heegaard Floer homology for three-manifolds is isomorphic to Seiberg–Witten monopole Floer homology. Shortly after its original discovery, a variant of Heegaard Floer homology was defined for knots, called *knot Floer homology*.

Generators for knot Floer homology are once again combinatorial. Indeed, there are several different models for the knot Floer complex, corresponding to several possible Heegaard diagrams. A particularly useful model is the one introduced by Manolescu, Ozsváth, and Sucharit Sarkar: the complex associated to *grid diagrams* for knots. In this model, both the generators and the differentials are purely combinatorial (though the price to pay is that the number of generators is rather large).

The formal connections with Khovanov's homology are quite striking. Like Khovanov's theory, knot Floer homology is bigraded; that is, writing knot Floer homology groups of a knot K as $\widehat{\mathrm{HFK}}(K)$, we have a splitting

$$\widehat{\mathrm{HFK}}(K) = \bigoplus_{m,s\in\mathbb{Z}} \widehat{\mathrm{HFK}}_m(K,s),$$

where m is the "Maslov grading", and s is the "Alexander grading". Taking the Euler characteristic in the Maslov direction, we obtain another famous knot polynomial: the Alexander polynomial.

The close connection between gauge theory and the intrinsic topological properties of the low-dimensional manifold under study has been understood for some time. For example, it is natural to ask, given a two-dimensional homology class in a three-manifold, what is the minimal genus of any embedded surface representing that homology class? In 1997 (before the discoveries of either Khovanov homology or Heegaard–Floer homology) Kronheimer and Mrowka showed that monopole Floer homology encodes this minimal genus function. Their result builds on David Gabai's theory of sutured manifolds, which is used to define suitable foliations, corresponding contact geometric constructions of Yasha Eliashberg and William Thurston, and properties of gauge theory over symplectic manifolds pioneered by Clifford Taubes.

A corresponding result for Heegaard Floer homology was established in 2003, following a similar overall pattern to the Kronheimer–Mrowka proof, but relying on somewhat different results. In place of Taubes' perturbations of the Seiberg–Witten equations using symplectic forms, the Heegaard Floer constructions rely on Donaldson's Lefshetz pencils for symplectic manifolds, combined with constructions of Etnyre and Eliashberg. These arguments were later streamlined considerably with Juhász's *sutured Floer homology*, a tool for going straight from sutured manifolds to Floer homology, entirely bypassing symplectic geometry. An analogous gauge theory construction was developed by Kronheimer and Mrowka, giving both Seiberg–Witten and instanton invariants of sutured Floer homology. In particular, they use the sutured perspective to give a Seiberg–Witten analogue of knot Floer homology: this, too, is a bigraded Abelian group, whose graded Euler characteristic is the Alexander polynomial. (Indeed, this invariant is conjectured to be isomorphic to Heegaard Floer knot homology). They also use this to streamline their proof that instanton Floer homology for knots detects the unknot.

Interrelationships. We have already identified some formal similarities between categorification and the other two streams of link homology. But there are in fact stronger than merely formal ties between Khovanov's homology and the other link invariants, which can be formalized using spectral sequences.

For the tie with Heegaard Floer homology, note that its knot Floer homology is an extension of another invariant $\widehat{\mathrm{HF}}(Y)$ for closed, oriented three-manifolds Y. In turn, this closed three-manifold invariant can be used to give a different invariant for links in S^3, as follows: given L, construct its branched double-cover $\Sigma(L)$, and then consider $\widehat{\mathrm{HF}}(\Sigma(L))$. According to work of Ozsváth and Szabó from 2005, there is a spectral sequence starting at the (reduced) Khovanov homology of any link L in S^3 and converging to $\widehat{\mathrm{HF}}(\Sigma(L))$. This relationship is suggested by the fact that both theories agree for the unlink, and they satisfy the same skein exact sequences. Work of Grigsby and Wehrli from 2008 generalizes this result to give a spectral sequence starting at Khovanov's categorification of the n-colored Jones polynomial of L and converging to the link Floer homology of the branched n-fold cover of L.

More recently, Kronheimer and Mrowka have announced another spectral sequence that starts at Khovanov's original categorification of the Jones polynomial (the case $n = 1$ above) and converges to the instanton knot homology of knots.

Chern Centennial to Be Marked by Festivities

The hundredth anniversary of the birth of the extraordinary geometer Shiing-Shen Chern will occur in 2011, and MSRI is celebrating. Chern was a towering figure in 20th century mathematics. Aside from his fundamental contributions in geometry, including the eponymous Chern classes and Chern–Simons theory, he mentored many mathematicians both in the United States and in China. He also cofounded MSRI, along with Calvin Moore and Isadore Singer, and was its first director.

In honor of the occasion, MSRI, in conjunction with the Chern Institute of Mathematics in Tianjin, China, is planning a conference in his honor. It will be held in both Berkeley and Tianjin between October 30, 2011 and November 12, 2011. In addition, MSRI will place a statue of Chern in a bosque of trees near the entrance to the Institute, where the sun will shine on the statue's face. Finally, MSRI is sponsoring two documentary films on Chern's life produced by award-winning filmmaker George Csicsery. A 15-minute documentary will be presented at the 2010 International Congress of Mathematicians in Hyderabad, India on August 19, 2010 on the occasion of the inauguration of the Chern prize. And a 30 minute-film to be premiered at Berkeley at the conference in honor of Chern.

The Simons Foundation is generously sponsoring all three commemorations at MSRI.

These results shed light on both the categorification side — the starting point of the spectral sequences — and the geometric end-product. In one direction, since Khovanov homology is typically easier to compute, these spectral sequences can be used to help compute the end-product in suitable circumstances. For example, both of the aforementioned spectral sequences involving Khovanov's $\mathfrak{sl}(2)$ homology collapse. Hence, the rank of Heegaard Floer homology of the branched double-cover of an alternating knot is given by the determinant of the knot (i.e., the evaluation of the Alexander polynomial at $T = -1$). Similarly, the rank of the instanton knot homology of an alternating knot is determined by the determinant of the knot.

More strikingly, these spectral sequences can be used to draw conclusions about categorification. The Grigsby–Wehrli theorem, together with properties of knot Floer homology, shows that for $n > 1$, Khovanov's categorification of the n-colored Jones polynomial detects the unknot. The announced theorem of Kronheimer and Mrowka shows that the corresponding theorem also holds when $n = 1$: Khovanov's original categorification of the Jones polynomial detects the unknot.

Another very exciting development currently unfolding at MSRI is the confluence of Heegaard Floer homology with Seiberg–Witten theory. Before explaining this, we put it into a little bit of context.

Pioneering work of Taubes from the mid-90's identified Seiberg–Witten theory over a symplectic manifold with a suitable Gromov invariant. Concretely put, this states that a suitable count of Seiberg–Witten fields over a symplectic four-manifold is identified with a suitable count of pseudo-holomorphic curves.

It is natural to ask what the corresponding Floer homology is. Such a theory was provided by Michael Hutchings: *embedded contact homology*. This is an invariant of contact three-manifolds which is the homology of a chain complex whose generators are periodic orbits of a Reeb vector field and whose differentials count certain embedded pseudo-holomorphic curves in the symplectization of the three-manifold. In 2008, Taubes showed that embedded contact homology is identified with Kronheimer and Mrowka's monopole Floer homology. This has dramatic consequences for contact geometry, including (by the non-triviality of monopole Floer homology) the existence of periodic orbits of any Reeb vector field on a compact three-manifold (this verifies the Weinstein conjecture in dimension three).

It is clear that we are on the cusp of understanding the relationship between Heegaard Floer homology and Seiberg–Witten theory. In March, Taubes gave a talk in which he outlined an identification between Heegaard Floer homology and embedded contact homology. The proof involves extending the identification between Seiberg Witten homology and embedded contact homology for *stable Hamiltonian structures*, pursued in joint work with members Cagatay Kutluhan and Yi-Jen Lee. A different approach to this problem was outlined by Ko Honda during the conference in March. Honda and his collaborators Vincent Colin and Paolo Ghiggini study embedded contact homology for open book decompositions. In the presence of these structures, they have announced a proof that $\widehat{HF}$ of the underlying three-manifold coincides with its embedded contact homology.

The Spring 2010 program at MSRI

The current program began with a Connections for Women program followed by an Introductory workshop on Homology theories of knots and links. The introductory workshop consisted of lecture courses on Heegaard Floer homology, Khovanov homology, Sutured Floer homology, and Khovanov–Rozansky homology, as well as a number of more specialized individual lectures. In March, there was a research workshop focused on recent developments in link Floer homologies. This was followed immediately by a research workshop in symplectic geometry, which also featured some lectures that reached across subjects boundaries.

During weeks not associated with workshops, the knot homology program runs a number of seminars. These are typically scheduled on Mondays and Fridays, leaving Tuesdays and Thursdays for the symplectic geometers, and Wednesdays for interaction with the topology seminar at Berkeley.

On Mondays, there is a postdoctoral seminar, intended as lectures by postdocs for postdocs. There is also a working group aimed

Two MSRI-UP Students get NSF Fellowships

Talea Mayo (photo) and Gina Pomann have received 2010 NSF graduate research fellowships. Both were students in the 2007 MSRI-UP program.

MSRI-UP (http://www.msri.org/up) is a summer program designed to identify talented undergraduate students — especially those from underrepresented groups — who show potential in mathematics and would like to conduct research in the mathematical sciences.

It makes 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. It is open to undergraduates who are US citizens or permanent residents, and who have completed two years of university-level mathematics courses.

The academic component of this summer's program, on Elliptic Curves and Applications, will be led by Edray Goins of Purdue University.

at exploring *bordered Floer homology*, which studies new invariants for three-manifolds with boundary defined by Robert Lipshitz, Ozsváth, and Dylan Thurston. Evans lectures, a series intended to connect the MSRI program with the mathematics department at Berkeley, are also held on certain Mondays.

Wednesdays include a "learning seminar" which, although formally affiliated with the symplectic geometry program, often reached across the divide, including topics such as invariants in Heegaard Floer homology for contact manifolds. Wednesday afternoons are left open so that interested participants can make their way down to the mathematics department at Berkeley for the topology seminar. Speakers there are often closely affiliated with the MSRI program. In fact, the seminar room is frequently flooded by the large influx of MSRI participants!

On Fridays, there is a joint seminar with the symplectic program, organized by Vera Vértesi, on sutured Floer homology. Fridays also feature the main seminar of the workshop, coorganized by Matt Hedden and Peter Teichner. Speakers include shorter-term visitors, including Ciprian Manolescu, who spoke about recent progress in combinatorializing Heegaard Floer homology.

The first few weeks included a series of lectures by Mrowka (starting during the Introductory Workshop), in which he recalled the constructions of instanton homology, with the aim of explaining his work with Kronheimer on their theorem that Khovanov homology detects the unknot.

There are a number of informal working groups, which help stimulate the exchange of ideas between the two programs. Paul Seidel organized a seminar on representation theory and Floer homology, which featured speakers including S. Cautis, Y. Lekili, R. Rezadegan, and C. Stroppel, who were investigating the interactions between categorification and Floer homology. Lectures by D. Auroux explored the relationship between Fukaya categories and bordered Floer homology.

Other informal working groups include a "branched double covers support group", which meets to discuss aspects of branched covers and their interactions with both Heegaard Floer homology and Khovanov's theory. Participants include J. Baldwin, E. Grigsby, M. Hedden, S. Levine, T. Mark, Y. Ni, O. Plamenevskaya, L. Roberts, S. Sarkar, and S. Wehrli. Another group of members are investigating the curious interaction of the theory of foliations, findamental group orderability, and Floer homology. Participants in the endeavor include J. Baldwin, J. Greene, R. Roberts, and L. Watson. Another interdisciplinary group is investigating the relationship between symplectic fillability and knot homologies. This group includes I. Baykur, J. Etnyre, D. Gay, M. Hedden, and B. Jöricke.

A number of members are also actively pursuing representation-theoretic aspects of categorification. Stroppel is involved with multiple projects, including studying categorification of spin networks of sl(2) representations. Aaron Lauda is investigating the fine structure of his graphical calculus for categorified quantum sl(2). Some of this work is joint with other members, including Sabin Cautis and Khovanov. Cautis continues with the project to clarify the role played by categorified quantum groups in derived categories of coherent sheaves on quiver varieties. Radmila Sazdanovich introduced diagrammatics for categorification of Chebyshev and Hermite polynomials and the polynomial ring.

The MSRI Academic Cycle: An Overview

Have you ever wondered how MSRI chooses its academic programs and workshops? For **semester- and year-long programs**, the process starts years in advance. Say you'd like MSRI to host a program on Deterministic Randomness. Together with three or four colleagues in the field, you are willing to organize this program. You first submit a preproposal outlining the scientific merit of the program, listing the organizers, and identifying key possible participants.

If submitted now, this will be considered by MSRI's Scientific Advisory Committee, or SAC (http://www.msri.org/governance), at its November annual meeting (there is another in January), for possible scheduling in the 2013–2014 academic year or the next. If the SAC tentatively judges the preproposal to have merit, you will proceed to prepare a full-fledged proposal, in consultation with the MSRI directorate and the SAC; see http://www.msri.org/propapps under "Propose a program".

These are the programs already approved for the next four years (see http://www.msri.org/calendar/index_activities for details):

- Random Matrix Theory, Interacting Particle Systems and Integrable Systems (Fall 2010)
- Inverse Problems and Applications (Fall 2010)
- Free Boundary Problems (Spring 2011)
- Arithmetic Statistics (Spring 2011)
- Quantitative Geometry (Fall 2011)
- Random Spatial Processes (Spring 2012)
- Commutative Algebra (Fall 2012 / Spring 2013)
- Cluster Algebras (Fall 2012)
- Noncommutative Algebraic Geometry and Representation Theory (Spring 2013)
- Model Theory, Arithmetic Geometry, and Number Theory (Spring 2014)

You are encouraged to apply now for participation in the 2011–2012 programs (Quantitative Geometry and Random Spatial Processes); see http://www.msri.org/propapps under "Application Materials".

Workshops not subordinate to programs include an annual **Hot Topics workshops** (apply by October 31 for consideration for next spring) and four 2-week long **Summer Graduate Workshops**, some of which are held outside MSRI. To be considered for the summer of 2011, proposals should be submitted by July 1, 2010, and so on. For details, see http://www.msri.org/propapps under "Propose a workshop".

A Word from the Director

(continued from page 1)

Our collaboration continues with SF Playground, a local theater company and playwrights pool, with which we sponsor an annual competition for short plays on a mathematical theme. This year, having so many knot theorists around, we chose the theme "To Knot or not to Knot". A lively evening ensued when the writers met the mathematicians and heard them describe their work. The best six submissions were performed at the Berkeley Repertory Theatre, setting an attendance record for a Playground event!

A third cultural event that MSRI sponsored this year was a discussion of the 2009 graphic novel *Logicomix: An Epic Search for Truth*, by Apostolos Doxiadis and Christos Papadimitriou. This novel follows the personal and professional life of Bertrand Russell, in his quest to place mathematics on a firm logical foundation. The community response to these events shows that a meaningful dialog about mathematics possible with nonmathematicians is a fruitful and important task for our community, and one in which I am pleased to say that MSRI remains fully engaged.

We continue to cosponsor, with the Chicago Mercantile Exchange, the CME Group-MSRI Prize for innovation in financial mathematics and economics. The fourth award of the prize took place in Chicago in September, and one of our newest trustees, Sanford Grossman, was the recipient. (The next award of the Prize will be on September 13 at the CME in Chicago, and I hope some of you can attend.)

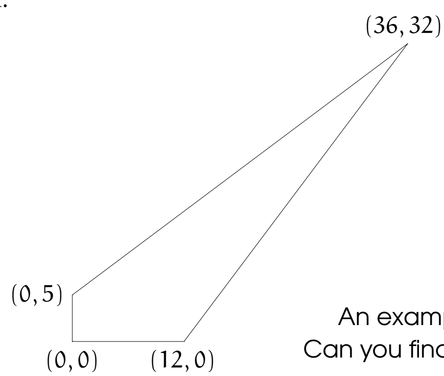
We were also delighted to host, this past month, the opening ceremony of the triennial Joint Meeting of the American Mathematical Society and the Mexican Mathematical Society. It was a great pleasure to host our neighbors to the south as we continue to reach out to mathematicians, both at home and abroad, in MSRI's continuing mission to serve the mathematics community and our society.

Puzzles Column

Joe P. Buhler and Elwyn Berlekamp

1. All vertices of a polygon P lie at points with integer coordinates in the plane, and all sides of P have integer lengths. Prove that the perimeter of P must be an even number.

Comment: Taken from the 2010 Bay Area Mathematical Olympiad exam.



An example for P.
Can you find others?

2. Let $f(x)$ be a real polynomial with $f(0) = 0$. Let N_x be the normal line to the graph of $y = f(x)$ at the point $(x, f(x))$, and let T_x be the triangle (if it exists) formed by the coordinate axes and N_x. Find necessary and sufficient conditions so that the limit of the area of T_x, as x goes to 0, exists and is nonzero.

Comment: This is a variation on a question asked by Dan Asimov.

3. Find an orientation of the edges of a 3-cube so that each of the 8 vertices either has out-degree 3 or 1; i.e., each vertex is either a source, in the sense that all edges are oriented outward from it, or it has exactly one outward bound edge adjacent to it.

Solve the same problem for the 5-cube: orient its edges so that each vertex is a source or has out-degree 1.

Comment: Inspired by a talk by Hirokazu Iwasawa at this year's Gathering for Gardner meeting on "hat puzzles."

4. Fix a positive integer n. Consider the graph G_n with n vertices labeled $1, 2, \dots, n$, with edges x and y joined if and only if $x+y$ is a perfect square.

A. Find the smallest n such that G_n has a chain, i.e., a path that starts at one vertex and visits all others.

B. Find the smallest n such that G_n has a loop, i.e., a path that starts at one vertex, visits all others, and ends back at its starting point.

C. Prove that there are infinitely many n such that G_n has a chain.

Comment: The question of whether there are infinitely many G_n with loops is open.

5. Suppose we have a collection of line segments lying in the unit square $[0, 1] \times [0, 1]$ on the plane. The total length of the segments is 18. Show that some line in the plane intersects 10 of them.

Comment: Mark Krusemeyer, the author of this problem, used it as part of a Math Olympiad camp entrance quiz for the Canada/US Math Olympiad summer camp.

6. Your department chair says that your tenure decision will be determined by the following game. You choose a positive integer n. Your chairperson flips a fair coin n times, and you flip a biased coin n times, which has probability of heads equal to p. You receive tenure if and only if the number of heads that you flip is strictly larger than the number that your chair flips. Unfortunately, p is less than $\frac{1}{2}$ so this isn't a fair game. (The value of p is known to you and your chair.)

Given p, let $n(p)$ be a choice of n that maximizes your probability of getting tenure. Prove that $n(p)$ is always larger than 1. For which interval I is $n = 3$ optimal for p in I? Prove that $n(p)$ goes to infinity as p goes to $\frac{1}{2}$.

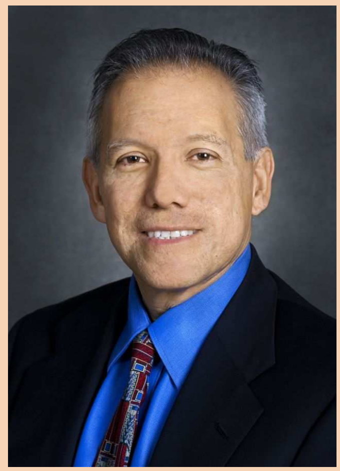
Comment: The paper "How to lose as little as possible" (arXiv 1002.1763), by Vittorio Addona, Stan Wagon and Herb Wilf, considers a more general version of this question in great detail. The problem was created by Addona.

Members of the MSRI Human Resources Advisory Committee receive honors

Sylvia Trimble Bozeman of Spelman College, Robert Megginson of the University of Michigan, and Juan Meza of the Lawrence Berkeley National Laboratory were elected fellows of the American Association for the Advancement of Science (AAAS). Election as a Fellow of AAAS is an honor bestowed upon members by their peers. Fellows are recognized for meritorious efforts to advance science or its applications.

In addition Ivelisse Rubio (University of Puerto Rico, Humacao) won the Dr. Etta Z. Falconer Award for Mentoring and Commitment to Diversity. This award recognizes individuals who have demonstrated a professional commitment to mentoring and increasing diversity in the sciences, and in particular the mathematical sciences. We can't help but mention that Sylvia Bozeman was the 2007 recipient of this award.

From left to right: Robert Megginson, HRAC member April 1997 to 1999, July 2002 to 2004, and April 2010 to present; Sylvia Bozeman, HRAC member April 1996 to 1999 and April 2008 to present; Juan Meza, HRAC member April 2001 to 2005; Ivelisse Rubio, HRAC member April 2007 to present.



Academic Sponsor Day Includes Math Talks, Panel on Math Teacher Preparation

A festive annual event at MSRI, overlapping with our governance meetings, is the day devoted to meetings of the Committee of Academic Sponsors. From its inception, MSRI has been partly supported by universities and institutes, first on the West Coast of North America and now around the world: there are currently over 90 Academic Sponsors (http://www.msri.org/sponaff/Support_Academic).

MSRI's academic sponsors are the glue between MSRI and the mathematical community. Benefits of academic sponsorship include a voice in MSRI governance, participation (at MSRI's expense) at the annual meeting, support for visits by MSRI members to sponsoring institutions, a subscription to the MSRI book series and, perhaps most significantly, the right to send up to 3 graduate students to MSRI summer programs each year, at the Institute's expense.

This year the Committee of Academic Sponsors (CAS) meeting took place on Friday, March 5. A business meeting was followed by several exciting scientific talks, aimed at a general mathematical audience and highlighting recent advances in the areas of the Spring 2010 scientific programs at MSRI. They were "Symplectic topology today", by Dusa McDuff (see her profile on page 3); "From Whitney disks to the Jacobi identity", by Peter Teichner; "On knot homology theories", by Elisenda Grigsby; and "Transverse knots and Heegaard Floer homology", by Lenhard Ng.

After the scientific talks there was a panel discussion on "K–12 math teacher preparation: what math departments can do", with the participation of Deborah Ball (University of Michigan), Sybilla Beckman (University of Georgia), Mark Daniels (UT Austin), Peter March (NSF), and Eric Stade (University of Colorado). The panel, moderated by MSRI Associate Director David Auckly, is the subject of the next article (page 10).

The Committee's activities concluded with the Annual Banquet for Trustees and Sponsors at UC Berkeley's landmark International House. The splendid Chevron Auditorium, with wrought-iron chandeliers, an ornately hand-painted ceiling, dark wood wainscoting, and Moorish arched windows provided the perfect setting for the end of a day of fraternization.

K-12 Mathematics Education: What Can Math Departments Do?

Julie Rehmeyer

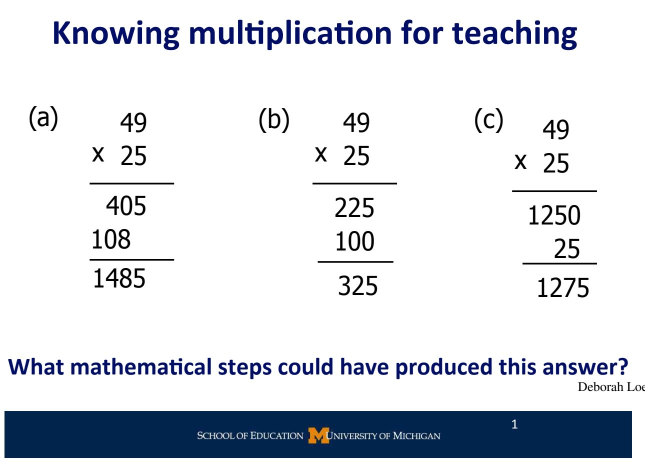
Math departments have both an opportunity and an obligation to help improve elementary and secondary mathematics education.

That was the consensus of leaders in mathematics education during the panel discussion at MSRI's Committee of Academic Sponsors meeting in March. Aspiring teachers need to develop a deep, flexible, and intuitive understanding of basic mathematics, they need to learn how to think mathematically, and they need to be exposed to the beauty and delight of mathematics. Mathematicians have a responsibility, both to their own profession and to the nation, to help them develop this.

Deborah Loewenberg Ball has spent much of her career figuring out just what the mathematical skills teachers need really are. She's found that even when teaching quite elementary mathematics, teachers need a depth of mathematical understanding that few non-mathematicians have.

For example, a teacher might intuitively define an even number as one that can be divided into two equal parts. This definition is too loose, though, since the number 7 can be divided into $3\frac{1}{2}$ and $3\frac{1}{2}$. Defining an even number as "an integer multiple of 2" will hardly help a six-year-old who doesn't know what an integer or a multiple is. What definition is mathematically honest but still accessible to a child? Teachers need to answer questions like this every day.

They also need to be able to look at a student's error and quickly identify the mistake in reasoning. Then they have to find a way to make it clear to the student why his method didn't work. Doing so requires an understanding of mathematics far beyond the simple mastery of mathematical algorithms. Here is a slide from her talk illustrating this principle:



Deborah Loewenberg Ball

Once Ball and her collaborators had developed a theory about the mathematics teachers need, they created a test to evaluate teachers' mathematical knowledge for teaching (MKT). They didn't just find out how much math teachers know; they found that the students of teachers who score well on the MKT test have higher scores on their own standardized tests. This is a remarkable finding, because few other attributes of teachers directly translate to higher test scores in their students: not having a teaching credential, not having a master's degree, and not having higher standardized test scores. So proper mathematical training of teachers matters.

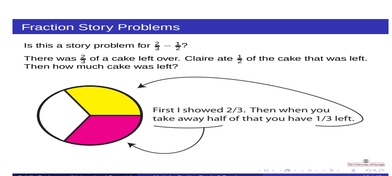
What, then, can math departments do to help teachers acquire the skills they need?

One university that has taken teacher education very seriously is the University of Texas at Austin. Mark Daniels, a math professor at UT Austin, described how in 1997 the University of Austin started UTeach, a collaboration between the College of Natural Sciences and the College of Education to train secondary school teachers. The university decided that teacher preparation was as important — and hence should receive the same level of internal funding — as research.

Prospective secondary school math teachers major in math, not education, and so they take a broad array of mathematics courses along with two that are specifically designed for future teachers. In the teacher preparation classes, as well as several of their other math classes, they go beyond passively absorbing mathematical ideas and instead become engaged in doing mathematics themselves: pondering mathematical questions, struggling with hard problems, presenting their results.

UTeach has been hugely successful. The year UTeach began, 16 math majors and 6 science majors became certified, out of 5000 undergraduates. Today, more than 400 students are in UTeach, and 70 certified teachers graduate each year. The program has received praise from both President Bush and President Obama, and it is being emulated in 20 universities around the country.

Even without a university-wide commitment to teaching, mathematicians and math departments can help improve teacher preparation by simply teaching good math courses for elementary teachers, as Sybilla Beckmann of the University of Georgia argued. Such classes can be quite fun and thought-provoking: the point is to ask the right questions (see example slide below).



Sybilla Beckmann

Even at an elementary level, Beckmann says, there is real mathematics going on, math that calls for proof skills. Take, for example, the commutative property of multiplication. We are so familiar with it that it seems trivial, but it's a profound result: Why should three packets of eight items have the same total number of items as eight packets of three items? It only becomes clear when we appeal to geometry, pointing out that both 3×8 and 8×3 can be represented by a three-by-eight array of objects. "There's something really deep about that geometric connection," Beckmann says.

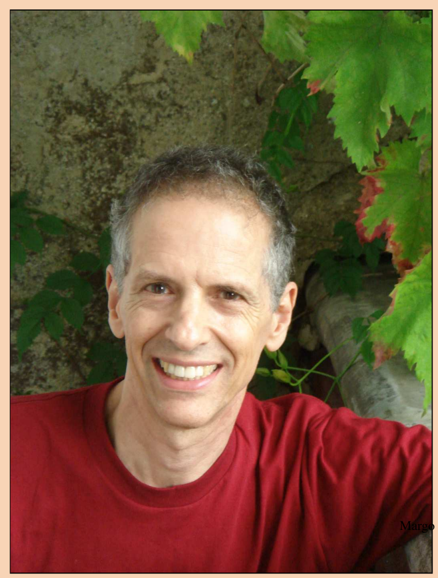
Furthermore, mathematicians who don't teach classes for future teachers still play a role in primary education. After all, students in regular math classes may well go on into teaching, and their experiences in their math classes will affect their understanding of math, their beliefs about best teaching practices, and their joy in mathematics. So modeling excellent teaching throughout university courses is key to improving elementary and secondary math education.

The University of Colorado has recognized this and developed a program to simultaneously improve classes for all math and science students, recruit more undergraduates into teaching, and improve teacher preparation. They hire undergraduates as "learning assistants" for all their large math and science classes. The learning assistants lead weekly recitation sessions in which they get small groups of students working together to solve open-ended problems. Learning assistants attend a weekly seminar where they learn about pedagogy and issues in K-12 education. These students are also encouraged to pursue a teaching license and are eligible for a $6,000 to $10,000 scholarship.

Eric Stade is one of the directors of this program, and he notes that it has helped create a culture shift throughout the university. Students who had never considered teaching get hooked and find themselves working toward a teaching license. Professors note that many of their best students were working as learning assistants and were more interested in becoming teachers than going to graduate school in mathematics, and they start thinking more broadly about their own role in preparing them. Graduate students who help lead the class on pedagogy for learning assistants start talking about pedagogical issues with their friends. "It spreads like wildfire," Stade says.

These examples show a variety of models math departments can follow to support future teachers. The future of the mathematics community relies on having a mathematically well-educated public that understands the importance of funding mathematics, that will make mathematically informed decisions in public policy, and that will provide the pool from which future mathematicians will come. So mathematics departments cannot afford to let K-12 teacher preparation be someone else's problem.

Conference Honors Alan Weinstein, Highlights Wide-Ranging Links



Margo Weinstein

Symplectic and Poisson Geometry in Interaction with Algebra, Analysis and Topology was the title of a conference that took place at MSRI from May 4 to 7, 2010, as part of the year-long program on Symplectic and Contact Geometry (page 2). It was dedicated to Alan Weinstein of UC Berkeley, who, though retired from teaching, continues to supervise several Ph.D. students and to do research on symplectic geometry, groupoids, and related subjects.

Weinstein has been one of the most influential figures in symplectic geometry, Poisson geometry and analysis in the past forty years. His work inspired many others and led to the development of central concepts in symplectic and Poisson geometry, as well as to the establishment of symplectic geometry as an independent discipline within mathematics. Weinstein's contribution extends to other branches of mathematics, and this conference organized by Yakov Eliashberg (Stanford), Alvaro Pelayo (UC Berkeley), Steve Zelditch (Northwestern University), and Maciej Zworski (UC Berkeley), highlights the breadth of concepts that have benefited from advances in symplectic and Poisson geometry.

Symplectic geometry originated as a mathematical language for Hamiltonian mechanics, but during the last three decades it witnessed spectacular developments in the mathematical theory and the discovery of new connections and applications to physics. The new discipline of noncommutative geometry, which in some sense extends algebraic geometry and topology to noncommutative structures that can be interpreted as rings of functions on some "noncommutative space", also has fertile connections with symplectic geometry.

These connections were explored in a second conference, *Symplectic Geometry, Noncommutative Geometry and Physics*, which ran from May 10 to 14, 2010. Though held at MSRI, the conference was funded by the Hayashibara Foundation, whose unusually broad-ranging philanthropic activities include assistance to skilled athletes and welfare groups, recognition of young researchers, and management of a scholarship program to support the preservation of fading arts and traditions. This second conference was organized by Robbert Dijkgraaf (Amsterdam), Tohru Eguchi (Kyoto), Yakov Eliashberg (Stanford), Kenji Fukaya (Kyoto), Yoshiaki Maeda (Yokohama), Dusa McDuff (Stony Brook), Paul Seidel (Cambridge, MA), and Alan Weinstein (UC Berkeley).

Circle on the Road Gets Fast Start

David Auckly

Soccer, piano lessons, math circle — wait a second. Who put math in the after school mix?

Answer: MSRI and the National Association of Mathematical Circles. The National Association of Math Circles (NAMC) was created by MSRI to provide support for Math Circles and similar programs.

The objective of the NAMC is to promote math circles, with the goal that extra-curricular mathematical activities will become as common as sports or music. These circles are part of the mathematical culture in other countries, and they have much potential here in the U.S. to meet the needs of each community with circles of different styles.

The math circle ecosystem has at least three different "species": Some circles (such as the Berkeley Math Circle, BMC) are aimed at students who are already tracking to math), other circles (such as San Francisco Math Circle, SFMC) are aimed at recruiting new students into mathematics, and yet other circles are aimed at teachers (e.g. the Bay Area Circle for Teachers, BACT). Math circles also interact with other extracurricular mathematics programs: mathematics festivals (such as the Julia Robinson Mathematics Festivals), math contests (e.g. Bay Area Math Olympiad), and summer math programs.

A web page for the NAMC (http://mathcircles.org) was unveiled at the MAA MathFest in Portland, Oregon, in August of 2009. This web page was developed with generous support from the Akamai Foundation, and we are in the process of adding more features and more material with continued support from Akamai. The NAMC was one of the sponsors of the MathFest and used this opportunity to reach out to a huge group of potential new math circle members and attract new math circle leaders. In addition to sponsoring the MathFest, we partnered with we partnered with the Special interest group of the Mathematical Association of America on Math Circles for Students and Teachers (SIGMAA MCST) The SIGMAA organized a special session on a Saturday afternoon that included a demonstration math circle.

In January 2010, the NAMC had a booth at the Joint Meeting of the AMS and MAA in San Francisco where there was also a special session on math circles. As a result of these efforts, there are now more than 80 math circles registered with the NAMC in the United States.

The NAMC will try to hold its meetings at locations that are underserved by mathematical outreach programs. These meetings will bring together people with experience running math circles with teams of people who are interested in learning how to start and run a math circle.

The NAMC hosted its first national meeting, Circle on the Road, from March 13 to March 15, 2010. We chose Tempe, Arizona, as the site of the first meeting because Phoenix is a large, diverse metropolitan area with no math circle program.

On Saturday March 13, over 300 students, parents and teachers flooded Arizona State University's recently established School of Mathematical and Statistical Sciences. Hands-on activities immediately captured the attention of participants of all ages. Helped by experienced graduate students and research faculty, the visitors quickly transitioned from simply playing fun games to raising and exploring mathematical questions. At a table with a number of sample tiling patterns and lists of questions, they discovered how to show that some tasks were impossible by studying color patterns and used mathematical induction to prove that other patterns could be generalized. Using Zome tools to construct buckyballs and other polyhedra led quickly to observations about the Euler characteristic. Next door, students drew flows and vector fields on helium balloons, discovering that the Euler characteristic could be used to show that there must always be places on the Earth where there is no wind. Math-fair activities were complemented by parallel sessions that were repeated over the day. Led by some of the best mathematics communicators in the nation, students explored topics such as solving cubic equations, decrypting secret messages, exploring tangled ropes using number theory.

Students, teachers, and math circle leaders alike enjoyed the festival. Student Nura Patani wrote, "It really was a fantastic festival!ă We all had a wonderful time and learned some very interesting things." One student came 300 miles to attend the festival.

The festival culminated in a keynote lecture given by ASU's award-winning professor Glenn Hurlbert. In a mesmerizing mix of magic and mathematics, he demonstrated several card tricks and dissected the mathematics behind them. To some, it may have seemed to be a big step from card-tricks to cell-phones, ATMs, and satellite TV, but Hurlbert helped students recognize common underlying patterns and principles.

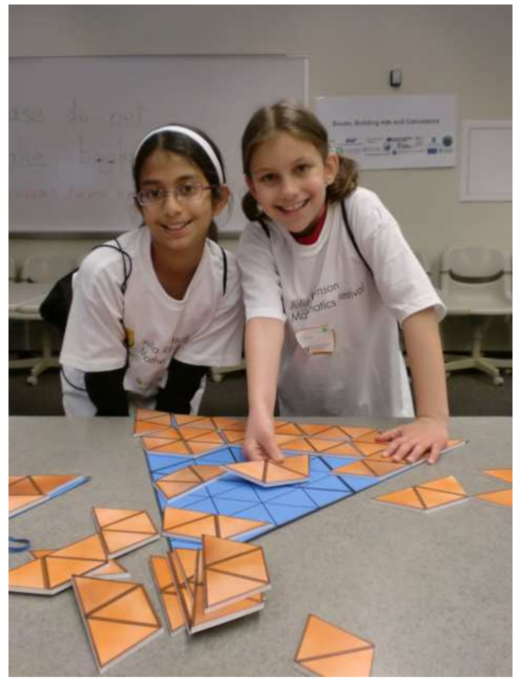
The Tempe festival was one of five Julia Robinson Mathematics Festivals that took place this spring. These events are named after Julia Robinson, a former mathematics professor at UC Berkeley, famous for her work on Hilbert's tenth problem. They were started in the San Francisco Bay Area to encourage more students to pursue mathematics and to honor Robinson's legacy.

From the Julia Robinson festival in Tempe, March 13–15.

Before the festival, apprentices were teamed with experienced circle leaders to plan and run circle sessions. After watching an experienced leader run a session in the morning, each apprentice took over and ran a session in the afternoon. The following two days were packed with 10 presentations, 5 panel discussions, and an evaluation session. Experienced leaders had the pleasure of participating, of learning new tricks and approaches, and of seeing old friends and meeting new ones. People new to the world of math circles came away with inspiration and are looking forward to starting circles in the future. In addition to the circle starting in Phoenix, twelve teams in such diverse places as India, the Philippines, Minnesota, Oregon, North Carolina, Kentucky, Maryland, Arizona, and Texas are thinking about starting math circles in the fall.

Lesson plans, handouts, and video from the workshop will appear on the NAMC web site later this spring or summer.

The festival and workshop were organized by Dave Auckly, Matthias Kawski, Omayra Ortega, Hugo Rossi, and Mark Saul, with help from the staff at MSRI and the staff at Arizona State University. Funding was provided by the National Science Foundation. Additional support, including books, materials, and presenters, were supplied by AK Peters, Oxford University Press, Taylor and Francis, Pearson, the MAA, the AMS, Texas Instruments, Salt River Power, On Semiconductor, Freeport-McMoran Copper & Gold, the desJardins/Blachman fund, the Clowes Fund, and anonymous donors.



More scenes from the Julia Robinson festival in Tempe, March 13–15.

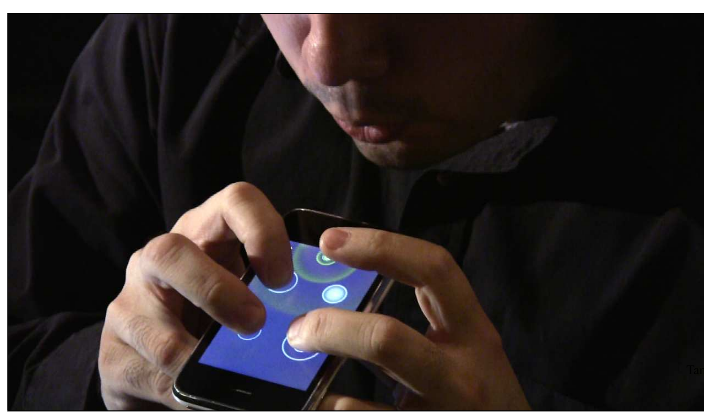
Making Music in the 21st Century: An Unorthodox Musical Event

For a couple of hours on May 7, members' and visitors' iPhones and iPads became musical instruments in MSRI's Simons Auditorium, under the baton of Stanford's "computer musicians" Ge Wang and Jieun Oh. Audience members brought their mobile gadgets and enjoyed an interactive iPhone/iPad music class that was unlike any other event in MSRI's Music and Mathematics series.

Ge Wang, an Assistant Professor at Stanford's Center for Computer Research in Music and Acoustics (CCRMA), is the founder and director of SLOrk, the Stanford Laptop Orchestra, and MoPhO, the Stanford Mobile Phone Orchestra http://mopho.stanford.edu. Graduate student and virtuoso flute player Jieun Oh codirects the two orchestras.

A second part of the program, following a reception, featured a lecture and demonstration of *Ocarina* for the iPhone and *Magic Piano* for the iPad, played by Wang with Oh. They were joined by MSRI's Director Robert Bryant and UC Berkeley Professor David Eisenbud for a discussion about state-of-the-art technologies in music-making.

Ge Wang's research (http://ccrma.stanford.edu/~ge) focuses on interactive software systems for computer music, programming



Ge Wang playing Ocarina on iPhone

languages, mobile music, and education at the intersection of computer science and music. In addition to founding SLOrk and MoPhO, he has created ChucK, an audio programming language.

Jieun Oh received her B.S. in Symbolic Systems at Stanford in 2008, focusing in computer music, and is now a Ph.D. student at CCRMA working with Ge Wang. Her research interests include new music-making paradigms, music cognition, sonification/visualization, and, more broadly, how music and technology change the way people interact. She was a member of the Stanford Symphony Orchestra from 2004 to 2008 and the Stanford Wind Ensemble in 2005 and 2006.

Wang and Oh are tentatively scheduled to return to MSRI with SLOrk to give a concert sometime this fall. Stay tuned for the next exciting event!

Clay and Chancellor's Scholarships Announced

The Clay Mathematics Institute (http://www.claymath.org) has announced the 2010–2011 recipients of its **Senior Scholar** awards. As in previous years, a number of them are connected with MSRI.

The Senior Scholar Program provides support for established mathematicians who will play a leading role in a topical program at an institute or university away from their home institution. The MSRI model of bringing together for a semester many researchers in a given field, from postdocs to Fields Medal winners, has been so successful that several other institutes around the world have adopted it, and "senior scholars" play a key role in this model. The Clay Institute, dedicated to increasing and disseminating mathematical knowledge, recognizes the effectiveness of the model and fosters it by providing financial support for a selected few such scholars, thus enabling host institutes to invite more participants.

These are the 2010–2011 Clay Senior Scholars announced so far:

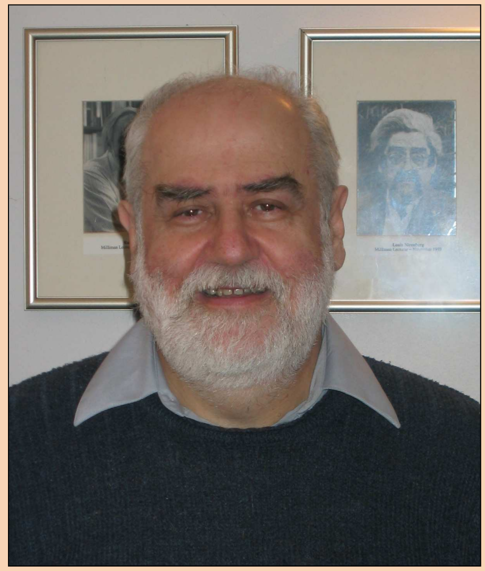
- Haruzo Hida (UCLA)
- Pierre-Louis Lions (Collège de France)
- Percy Deift (Courant Institute)
- Gunther Uhlmann (University of Washington and UC Irvine)
- Barry Mazur (Harvard University)
- Henryk Iwaniec (Rutgers University)

The last four of these were nominated by MSRI; they will be part of our two programs this fall (Deift with Random Matrices and Uhlmann with Inverse Problems) and of the Arithmetic Statistics program next spring (Mazur, Iwaniec).

Equally prestigious is the UC Berkeley **Chancellor's Scholarship** award, which carries a purse of $50,000 and is open to nominees from MSRI only. Chancellor's Scholars must be top researchers, of course, but must also be known for excellent teaching credentials. The mathematics department chooses one of the three or four candidates put forward by MSRI and recommends that candidate to the Chancellor's office, which makes the award.

The Chancellor's Scholar in 2009–2010 was Denis Auroux (MIT), who took part in the year-long Symplectic Geometry program. For 2010–2011 it will be Gunther Uhlmann (see sidebar on the right); his 2010 course at UC Berkeley, which is one of things taken into account by the University in making the award, will be on Calderón's Inverse Problem.

Focus on the scientist: Gunther Uhlmann



Gunther Uhlmann is the recipient of both the MSRI / UC Berkeley Chancellor's Award and a Clay Senior Scholarship for 2010–2011. Having graduated from the Universidad de Chile in Santiago, Uhlmann then went to MIT, where he received a Ph.D. in Mathematics in 1976, under the direction of Victor Guillemin. Since 1985 he has been at the University of Washington in Seattle, where he holds the Walker Family Endowed Professorship in Mathematics.

Uhlmann works on inverse problems, that is, problems where causes for a desired or an observed effect are to be determined. Specifically, one attempts to determine the internal properties of a medium by probing the medium with different types of waves and measuring the response to these waves. The techniques for solving such problems have tremendous practical applications, such as medical imaging, location of oil and mineral deposits, creation of astrophysical images from telescope data, finding cracks and interfaces within materials, shape optimization, model identification in growth processes and modeling in the life sciences.

Uhlmann, who has received numerous professional awards including an Alfred P. Sloan Fellowship and a John Simon Guggenheim Fellowship, started to work on inverse problems at MSRI in the Institute's very first year of operation (1982–1983). He was chair of the organizing committee of the Fall 2001 program on inverse problems at MSRI.

Forthcoming Workshops

Most of these workshops are offered under the auspices of one of the current programs. For more information about the programs and workshops, see www.msri.org/calendar.

June 07, 2010 to June 09, 2010: *Critical Issues in Mathematics Education: Reasoning and Sense-Making in the Math Curriculum*, organized by Dave Auckly, Scott Baldridge, Deborah Loewenberg Ball, Aaron Bertram, Wade Ellis, Deborah Hughes Hallett, Gary Martin, and William McCallum

June 12, 2010 to July 25, 2010: *MSRI-UP 2010: Elliptic Curves and Applications*, organized by Duane Cooper (Morehouse College), Suzanne Weekes (Worcester Polytechnic Insitute), Ricardo Cortez (Tulane University), Ivelisse Rubio (University of Puerto Rico, Río Piedras), and Herbert Medina (Loyola Marymount University)

July 06, 2010 to July 23, 2010: *Summer Institute for the Professional Development of Middle School Teachers on Algebra 2010*, organized by Hung-Hsi Wu (University of California, Berkeley)

August 19, 2010 to August 20, 2010: *Connections for Women: Inverse Problems and Applications*, organized by Tanya Christiansen (University of Missouri, Columbia), Alison Malcolm (Massachusetts Institute of Technology), Shari Moskow (Drexel University), Chrysoula Tsogka (University of Crete), and Gunther Uhlmann (University of Washington)

August 23, 2010 to August 27, 2010: *Introductory Workshop on Inverse Problems and Applications*, organized by Margaret Cheney (Rensselaer Polytechnic Institute), Gunther Uhlmann (University of Washington), Michael Vogelius (Rutgers), and Maciej Zworski (UC Berkeley)

September 13, 2010 to September 17, 2010: *Random Matrix Theory and Its Applications. I*, organized by Jinho Baik (University of Michigan), Percy Deift (Courant Institute), Alexander Its (Indiana University-Purdue University Indianapolis), Pierre van Moerbeke (Université Catholique de Louvain and Brandeis University), and Craig A. Tracy (UC Davis)

September 20, 2010 to September 21, 2010: *Connections for Women: An Introduction to Random Matrices*, organized by Estelle Basor (American Institute of Mathematics, Palo Alto), Alice Guionnet (Ecole Normale Supérieure de Lyon), and Irina Nenciu (University of Illinois at Chicago)

October 25, 2010 to October 29, 2010: *Hot Topics: Kervaire invariant*, organized by Mike Hill (University of Virginia), Michael Hopkins (Harvard University), and Douglas C. Ravanel (University of Rochester)

November 08, 2010 to November 12, 2010: *Inverse Problems: Theory and Applications*, organized by Liliana Borcea (Rice University), Carlos Kenig (University of Chicago), Maarten de Hoop (Purdue University), Peter Kuchment (Texas A&M University), Lassi Paivarinta (University of Helsinki), and Gunther Uhlmann (University of Washington)

November 17, 2010 to November 19, 2010: *SIAM/MSRI workshop on Hybrid Methodologies for Symbolic-Numeric Computation*, organized by Mark Giesbrecht (University of Waterloo), Erich Kaltofen (North Carolina State University), Daniel Lichtblau (Wolfram Research), Seth Sullivant (North Carolina State University), and Lihong Zhi (Chinese Academy of Sciences, Beijing)

December 06, 2010 to December 10, 2010: *Random Matrix Theory and its Applications, II*, organized by Alexei Borodin (California Institute of Technology), Percy Deift (Courant Institute of Mathematical Sciences), Alice Guionnet (Ecole Normale Supérieure de Lyon), Kenneth McLaughlin (University of Arizona), and Craig A. Tracy (UC Davis)

January 13, 2011 to January 14, 2011: *Connections for Women: Free Boundary Problems, Theory and Applications*, organized by Catherine Bandle (University of Basel), Claudia Lederman (University of Buenos Aires), and Noemi Wolanski (University of Buenos Aires)

January 18, 2011 to January 21, 2011: *Introductory Workshop: Free Boundary Problems, Theory and Applications*, organized by Tatiana Toro (University of Washington)

January 27, 2011 to January 28, 2011: *Connections for Women: Arithmetic Statistics*, organized by Chantal David (Concordia University) and Nina Snaith

January 31, 2011 to February 04, 2011: *Introductory Workshop: Arithmetic Statistics*.

February 14, 2011 to February 16, 2011: *Workshop on Mathematics Journals*, organized by James M Crowley (Society for Industrial and Applied Mathematics), Susan Hezlet (London Mathematical Society), Robion C. Kirby (UC Berkeley), and Donald E. McClure (American Mathematical Society)

March 07, 2011 to March 11, 2011: *Free Boundary Problems, Theory and Applications Workshop*, organized by John King (University of Nottingham), Arshak Petrosyan (Purdue University), Henrik Shahgholian (Royal Institute of Technology), and Georg Weiss (University of Tokyo)

April 11, 2011 to April 15, 2011: *Arithmetic Statistics*.

Current and Recent Workshops

Most recent first. For information see www.msri.org/calendar.

May 10, 2010 to May 14, 2010: *Symplectic Geometry, Noncommutative Geometry and Physics*, organized by Robbert Dijkgraaf (Amsterdam), Tohru Eguchi (Kyoto), Yakov Eliashberg (Stanford), Kenji Fukaya (Kyoto), Yoshiaki Maeda* (Yokohama), Dusa McDuff (Stony Brook), Paul Seidel (Cambridge, MA), Alan Weinstein (Berkeley).

May 04, 2010 to May 07, 2010: *Symplectic and Poisson Geometry in interaction with Algebra, Analysis and Topology*, organized by Yakov Eliashberg (Stanford University), Alvaro Pelayo (UC Berkeley), Steve Zelditch (Northwestern University), Maciej Zworski (UC Berkeley)

Mathematical Sciences Research Institute

17 Gauss Way, Berkeley CA 94720-5070
510.642.0143 • FAX 510.642.8609 • www.msri.org

ADDRESS SERVICE REQUESTED

MSRI Staff Roster

Phone area code 510. Add @*msri.org* to email addresses.

Scientific Staff

Robert Bryant, Director, 643-6142, *bryant*
Hélène Barcelo, Deputy Director, 643-6040, *hbarcelo*
David Auckly, Associate Director, 643-4745, *auckly*
Robert Osserman, Special Projects Director, 643-6019, *osserman*

Administrative Staff

Jackie Blue, Housing/International Scholar Advisor, 643-6468, *jblue*
Marsha Borg, Facilities and Administrative Coordinator, 642-0143, *marsha*
Kelly Chi, Webmaster, 643-0906, *kellyc*
David Dowell, Interim CFO, 643-8321, *cfo*
Nathaniel Evans, Accounting Manager, 642-9238, *nate*
Jennifer Fong, Senior Systems Administrator, 643-6070, *ferfong*
Anna Foster, Programs Coordinator, 642-0555, *anna*
Arne Jensen, Senior Network Engineer, 643-6049, *arne*
Konia Johnson, Desktop Systems Administrator, *konia*
Vanessa Kääb-Sanyal, Workshop Coordinator, 643-6467, *vanessa*
Silvio Levy, Editor, 524-5188, *levy*
Rizalyn Mayodong, Accounts Payable/Member Relations, 642-9798, *rizalyn*
Hope Ning, Executive Assistant to the Director, 642-8226, *hyunjin*
Megan Nguyen, Program Analyst, *megan*
Larry Patague, Director of Information Technology, 643-6069, *larryp*
Anne Brooks Pfister, Press Relations Officer/Board Liaison, 642-0448, *annepf*
Linda Riewe, Librarian, 643-1716, *linda*
Jonathan Rubinsky, Assistant Programs Coordinator, 643-6467, *rubinsky*
James T. Sotiros, Director of Development, 643-6056, *jsotiros*
Nancy Stryble, Director of Corporate Relations, 642-0771, *nancys*
Brandy Wiegers, Assistant Program Manager, 643-6019, *brandy*
Joshua Zucker, Assistant Program Manager, *joshua.zucker@gmail.com*