Mathematical Sciences Research Institute
Annual Report for 2006-2007

Annual 2006-07 Report from the

Mathematical Sciences Research Institute

April 2008

This annual report covers MSRI projects and activities that have been concluded since the submission of the last full report in May 2006 and the interim 2006-07 report in May 2007.

New Developments

The year 2006-07 saw a very rich scientific program. By August 1, 2007, MSRI was comfortably resettled in its greatly expanded quarters, financed through private fund-raising. Improvements to the older part of the building, and the acquisition of appropriate furniture and equipment continued through the year. One consequence was that the Institute could run a more robust program of workshops, often in collaboration with other organizations, since in the expanded quarters the major programs are no longer disrupted by concurrent scientific events. MSRI continues to monitor and improve the balance of non-scientific staff needed to host these scientific events.

The new auditorium and expanded public facilities made it possible to accommodate much larger groups for workshops. This expanded capacity was fully utilized by the large cohorts that attended the two “Hot Topics” workshops (more on these later), the “Algebra & Geometry” workshop, and the “Critical Issues in Education” workshop. While it is too soon to detect a trend, participation in programmatic workshops appears to be significantly increasing as well, which would serve to expand the impact of MSRI’s core research programs.

A significant new program that does not show up in the list below but augments the science of the programs is the Simons Biology Colloquium. The Colloquium brought four famous biologists with a mathematical bent to MSRI, each for a one week stay involving 2-4 major lectures during the spring semester of 2007: Arnold Levine, Mimi Koehl, Robert Schleif, and Sydney Brenner. The biologists had interactions, in particular, with members of the Dynamical Systems program (see below). The long-term goal is to stimulate interactions of mathematics and biology by engaging the mathematicians at MSRI with some biological problems and making the Institute better known to the biological world; this may eventually lead to other sorts of programs with more intense and programmed interactions. The Colloquium, which has substantial funding from the Simons Foundation, will continue in 2007-08.

Another new area for MSRI was the involvement in Climate research, beginning with a summer graduate workshop in July 2006 (joint with the National Center for Atmospheric Research), and continuing with the "Symposium on Climate Change: From Global Predictions to Local Action" that took place in April 2007. The series will continue with a Summer School in July 2007, and is expected to lead to future activities of larger scale.

The following summary of demographic data can also be viewed in detail later in this report.

In its 2006-07 workshops, MSRI hosted 2439 separate visits (some visitors attended multiple events). 2062 participants gave us gender data. Of these 588 or 28.5%, were females. There were 109 self-reported under-represented minorities.

In its 2006-07 programs, MSRI had a total of 196 members. All but one member provided gender data. Of these, 34 or 17.4% were female. 3 members were black; there were no self-identified Hispanic/Latino or Native American members, although it should be recognized that half the members declined to state Hispanic/Latino ancestry. It should recognized that the data are "noisy." (People choose not to fill out those spaces on the forms; for some reason they are more reluctant to specify racial and ethnic data than gender data.)

We now turn to the fundamental scientific programs and workshops that make MSRI such an intensely active center. There are too many to describe in detail in this space, but a listing of topics will give an idea of what has been going on. Two types of workshops may need a little explanation:

1. "Connections for Women". While MSRI had hosted occasional "workshops for women" in the past, it was decided last year to have a "Connections for Women" workshop at the start of every semester- or year-long program, following a suggestion from then-Trustee Joyce McLaughlin. Starting with August 2006, one of these workshops now immediately precedes every MSRI Introductory Workshop. Its goal is to increase the numbers and cohesiveness of the women in the introductory workshops and, ultimately, in the whole program. The format is simple: there are scientific lectures (to which both men and women are invited and come) and networking events (to which only the women are invited). Within these parameters, formats chosen by the organizers of Connections workshops vary widely and it is not yet clear whether one can identify a "best model," particularly since feedback from the participants has been very positive independent of format. MSRI pays some expenses for a number of women to attend, and attendance is generally in the 15-25 range. The women attending are encouraged, and supported to a significant degree, to attend the following Introductory Workshop. It should be noted that the "Connections" workshops continue to remain controversial with some female mathematicians, including potential organizers.

2. "Hot Topics" Workshops. Instituted in 2000, these are events that are planned with little lead time -- typically just 3 or 4 months -- to focus on some rapidly developing breakthrough. MSRI has averaged about one per year, though in 2006-07 there were two. The workshops gather the super-specialists to talk with each other intensely over a week and push hard on the frontier of research. The first Hot Topics workshop was titled "GL(2) and Beyond." It goal was to spur advances in proving modularity of objects, taking off from the fact that the past few years have seen three outstanding modularity conjectures settled in a large number of cases: Serre's conjectures on mod p Galois representations; the Fontaine-Mazur conjecture for p-adic Galois representations; and the

Sato-Tate conjecture for elliptic curves. The aim of this workshop was to summarize the results and techniques in these directions and to sketch out a research program that will take us from GL(2) to unitary groups of higher rank. The meeting was capped by a lecture by Robert P. Langlands in which he outlined his hopes that application of techniques of analytic number theory to the trace formula would lead to proofs of his functoriality conjectures in situations inaccessible to other available techniques. The year's second Hot Topics Workshop, "Minimal and Canonical Models", compared the two proposed proofs of the Finite Generation of the Canonical Ring (a completion of the Mori Program, in all dimensions, and more!) in a very useful way.

Scientific Program and Workshops

A. Major Programs and their associated workshops:

There were three major Programs for the MSRI fiscal year 2006-07, and fourteen workshops associated to them:

1. Geometric Evolution Equations and Related Topics
August 14, 2006 to May 25, 2007, organized by Bennett Chow, Panagiota Daskalopoulos, Gerhardt Huisken, Peter Li, Lei Ni, and Gang Tian.

The focus was on geometric evolution equations, function theory, and related elliptic and parabolic equations. With serendipitous timing, this program was positioned to capitalize on the spectacular recent work of Perelman and earlier work of Hamilton on Ricci flow relating to the Poincaré and geometrization conjectures. The year-long program focused on: geometric flows of metrics and connections such as Ricci and Kähler-Ricci, Yang-Mills and Hermitian-Einstein, Calabi, and Yamabe and other conformal flows; geometric flows of submanifolds such as mean, inverse mean, Gauss curvature and Willmore flows; harmonic map heat flow and related topics, heat equation and function theory; and nonlinear parabolic equations, computational methods, and the discrete heat equation on graphs.

Connections for Women: Geometric Analysis and Nonlinear Partial Differential Equations
Sept. 8-9, 2006, organized by Christine Guenther and Panagiota Daskalopoulos.
This intensive two-day workshop for women introduced advanced graduate students and recent PhDs to current topics in nonlinear partial differential equations related to geometric analysis. It consisted of introductory mini-courses and talks as well as a poster session where all participants were encouraged to present their work.

Introductory Workshop on Geometric Flows and Function Theory in Real and Complex Geometry
September 11, 2006 to September 15, 2006, organized by: Bennett Chow, Peter Li, and Gang Tian.
The goal of this Workshop was to survey recent developments in geometric evolution equations and function theory in real and complex geometry.

Analytic and Computational Aspects of Elliptic and Parabolic Equations
October 23, 2006 to October 27, 2006, organized by Panagiota Daskalopoulos, Peter Li, and Lei Ni.
In this workshop, nonlinear elliptic and parabolic methods in geometry and analysis were considered, including Kähler-Einstein metrics, the Yamabe problem, and the porous medium equation.

Geometric Evolution Equations
March 12, 2007 to March 16, 2007, organized by Bennett Chow, Gerhard Huisken, Chuu-Lian Terng, and Gang Tian.
This workshop concentrated on geometric flows that have been applied to a variety of geometric, topological, analytical and physical problems. Applications included the Geometrization Conjecture, the Penrose inequality, uniformization theorems in Kähler geometry, existence of canonical metrics, connections and maps such as Einstein, Hermitian-Einstein, constant scalar curvature, and extremal metrics, Yang-Mills connections, and harmonic maps.

Recent Developments in Numerical Methods and Algorithms for Geometric Evolution Equations
March 16, 2007 to March 17, 2007, organized by Charles Elliott, Xiaobing Feng, Michael Holst, and Hongkai Zhao.
This workshop focused on recent, significant progress in computational methods and algorithms for geometric evolution equations. Powerful numerical methods, which are based on the level set and the phase field methodologies and combine well-known discretization methods, have greatly increased the capability of computing solutions of complicated nonlinear geometric evolution equations.

2. Computational Applications of Algebraic Topology

August 14, 2006 to December 15, 2006, organized by Gunnar Carlsson, Persi Diaconis, Susan Holmes, Rick Jardine, and Günter M. Ziegler.

This program was focused on applications of algebraic topology in various contexts related to data analysis, object recognition, discrete and computational geometry, combinatorics, algorithms, and distributed computing. Two of the key applications discussed were to signaling networks and the analysis of high-dimensional data.

Connections for Women: Computational Applications of Algebraic Topology
August 31, 2006 to September 1, 2006, organized by Susan Holmes.
This workshop for women introduced advanced graduate students and recent PhDs to current areas of research in Statistics and Computational Topology, with emphasis on: showing how multidimensional scaling and other eigenvector based methods have been successful in finding structure in high dimensional data; exhibiting topological methods for dynamical systems; and multidimensional statistical analyses and computational topology.

Introductory Workshop on Computational Application of Algebraic Topology
September 5, 2006 to September 8, 2006, organized by G. Carlsson, P. Diaconis, and G. M. Ziegler.
The goal of this workshop was to survey the "Algebraic Topology toolbox" from the view of applications, and to present areas of current interest where topological tools have been applied, are being employed or should be brought into play.

Workshop on Application of Topology in Science and Engineering
September 18, 2006 to September 22, 2006, organized by G. Carlsson, P. Diaconis, and S. Holmes.
The workshop focused on areas where algebraic topology can be applied effectively to a number of applied problems in science and engineering such as: Protein docking; Algorithmic and geometric problems in robotics; Exploratory and qualitative analysis of high-dimensional data sets; Coverage and routing problems for networks of sensors; Analysis of chaotic non-linear dynamical systems

Workshop on Topological Methods in Combinatorics, Computational Geometry, and the Study of Algorithms
October 2, 2006 to October 6, 2006, organized by G. Carlsson, P. Diaconis, R. Jardine, and G. M. Ziegler.
Exhibition of recent successes in the application of topological methods in combinatorics, discrete and computational geometry, and algorithms was the aim of this workshop. A goal was to learn more about the tools that can lead to further, future successes.

3. Dynamical Systems
January 8, 2007 to May 25, 2007, organized by Christopher Jones, Jonathan Mattingly, Igor Mezic, Andrew Stuart, and Lai-Sang Young.
This program took place at the interface of the theory and applications. The four main themes were (1) Extended dynamical systems, (2) Stochastic dynamical systems, (3) Control theory, and (4) Computation and modeling.

Connections for Women: Dynamical Systems
January 18, 2007 to January 19, 2007, organized by Debra Lewis (UC Santa Cruz), Mary Pugh (U Toronto), and Mary Lou Zeeman (Bowdoin College).
This intensive two-day workshop spotlighted several innovative applications of dynamical systems theory, offering advanced graduate students and recent PhDs an insider's tour of recent developments in the field and setting the stage for the semester-long program in Dynamical Systems.

Introductory Workshop on Dynamical Systems with Emphasis on Extended Systems
January 22, 2007 to January 26, 2007, organized by Chris Jones (U North Carolina), Edgar Knobloch (UC-Berkeley-Physics), Nancy Kopell (Boston U), and Lai-Sang Young (chair, Courant).
The introduction emphasized the extended dynamical systems that occur as high-dimensional systems, such as on lattices or as partial differential equations.

Stochastic Dynamical Systems and Control
March 26, 2007 to March 30, 2007, organized by Jonathan Mattingly (Duke), Igor Mezic (UCSB-Chair), and Andrew Stuart (Warwick).
This workshop marked the transition in the program. Whereas the first part emphasized extended systems, the focus shifted with this meeting to random dynamical systems. Of particular interest was the relationship between random systems and control theory. The workshop was followed by a short course on methods for multiscale systems given by Andrew Stuart and Greg Pavliotis,

An Introduction to Multiscale Methods
April 2, 2007 to April 5, 2007, organized by Greg Pavliotis and Andrew Stuart.
The workshop provided an introduction to the theory of multiscale methods and the techniques of averaging and homogenization in particular. The theory was exemplified by application to ordinary and stochastic differential equations, Markov chains, and partial differential equations.

Mathematical Issues in Stochastic Approaches for Multiscale Modeling
May 21, 2007 to May 25, 2007, organized by Roberto Camassa (UNC - Chapel Hill), Jinqiao Duan (Illinois Institute of Technology - Chicago), Peter E. Kloeden (U of Frankfurt, Germany), Jonathan Mattingly (Duke U), and Richard McLaughlin (UNC - Chapel Hill).
Complex physical, biological, geophysical, and environmental systems display variability over a broad range of spatial and temporal scales. To make progress in understanding and modeling such systems, a combination of computational, analytical, and experimental techniques is required. The issues that were discussed emerge prominently in each of these categories and, in all of these, stochastic methods are playing a fundamental role.

In addition, there were 17 non-programmatic workshops and scientific events:

B. Summer Graduate Workshops

Summer Graduate Workshop on Data Assimilation for the Carbon Cycle
July 17, 2006 to July 28, 2006
Organized by: Inez Fung (University of California, Berkeley).
Projections of future climate require projections of the abundance of carbon dioxide and other trace constituents in the atmosphere. This in turn requires understanding the sources and sinks of atmospheric CO_2 and how they interact with the climate. Participants worked on projects using atmospheric data provided by NCAR.

Summer Graduate Workshop in Computational Number Theory
July 31, 2006 to August 11, 2006
Organized by: William Stein (University of Washington).

This workshop concentrated on computing with modular forms, providing students with the necessary background in both the theoretical and computational aspects of the subject.

Summer Graduate Workshop on Derived Categories in Algebraic Geometry
June 4, 2007 to June 16, 2007 Location: University of Utah
Organized By: Aaron Bertram (University of Utah), Y.P. Lee (university of Utah), and Eric Sharpe (University of Utah and Virginia Tech).
The first week of this two-week course focused on the basics of derived categories of coherent sheaves, including the McKay correspondence and derived categories of toric varieties. The second week was devoted to more advanced topics, including stability conditions, applications to Landau-Ginzburg models, and mirror symmetry.

C. Scientific activities specifically related to the recruitment of members of under-represented groups (in addition to the three "Connections for Women" workshops.)

Modern Mathematics: An Introduction to 2007-08 Programs at MSRI
October 25, 2006 to October 26, 2006
Organized By: Ricardo Cortez, Hugo Rossi, Ivelisse Rubio.
This workshop was held at the Marriott-Waterside in Tampa, Florida, directly preceding the Annual Meeting of SACNAS. The focus was on geometric group theory and representations of finite groups from both the analytic and combinatorial points of view. There was also a session for undergraduates on topics of mathematical biology.

MSRI - UP: 2007 Undergraduate Research Program
June 17, 2007 to July 29,2007
Organized By: Ricardo Cortez, Ivelisse Rubio, Herbert Medina, Suzanne Weekes, and Duane Cooper.
The MSRI-UP is a comprehensive program for undergraduates that aims to increase the number of students from underrepresented groups in mathematics graduate programs. MSRI-UP includes summer research opportunities, mentoring, workshops on the graduate school application process, and follow-up support.

D. Other Scientific Activities

Recent Developments in Arrangements and Configuration Spaces
August 7, 2006 to August 11, 2006
Organized By: Michael Falk (Northern Arizona University), Eva-Maria Feichtner (University of Stuttgart), and Hiroaki Terao (Tokyo Metropolitan University)
The purpose of this workshop is to assess and build upon progress in the theory of hyperplane arrangements and configuration spaces since the 2004 MSRI program Hyperplane Arrangements and Applications.

Lectures on String(y) Topology
October 16, 2006 to October 18, 2006

Organized By: Alejandro Adem (University of British Columbia), Hugo Rossi (MSRI), and Jose Seade (UNAM, Cuernavaca).
This conference was held at UNAM, Cuernavaca (in Mexico). It was a follow-up to the training program held at UNAM, Morelia in January 2006 and the MSRI program in New Topological Structures in Physics, held at MSRI during the Spring 2006 semester.

Mathematics of Visual Analysis
October 16, 2006 to October 17, 2006
Organized By: Pat Hanrahan (Stanford University), William Cleveland (Purdue University), Sanda Harabagiu (University Texas-Dallas), Peter Jones (Yale), and Leland Wilkinson (Northwestern and SPSS).
The goal of this workshop was to bring together computer scientists and mathematicians to discuss mathematical and computational problems involved in visual analysis. A secondary goal was to engage the mathematical community and introduce them to this application area.

CMI/MSRI Hot Topics Workshop: Modularity for GL(2) and Beyond
October 30, 2006 to November 3, 2006
Organized By: Michael Harris, Mark Kisin, Kenneth Ribet, Richard Taylor, and David Ellwood (jointly funded by MSRI and the Clay Mathematics Institute).
To prove that a mathematical object is "modular" is to link it to an automorphic representation. In the past few years and months, three outstanding modularity conjectures have been settled in a large number of cases: Serre's conjectures on mod p Galois representations, the Fontaine-Mazur conjecture for p-adic Galois representations, and the Sato-Tate conjecture for elliptic curves. The aim of this conference was to summarize the results and techniques in these directions and to lay out a research program.

Interactive Parallel Computation in Support of Research in Algebra, Geometry and Number Theory
January 29, 2007 to February 2, 2007
Organized By: Ifti Burhanuddin (USC, Computer Science), James Demmel (Berkeley, Math & CS), Edray Goins (Purdue, Math), Erich Kaltofen (NCSU, Math), Fernando Perez (U Colorado, Applied Math), William Stein (Chair; Washington, Math), Helena Verrill (LSU, Math), Joe Weening (CCR, Research).
The goal of this workshop was to study and formulate practical parallel algorithms that support interactive mathematical research in algebra, geometry, and number theory, and to formulate strategies to encourage implementation and testing of these ideas.

World Congress on Computational Finance: The First Decade
March 26, 2007
Organized By: Jesper Andraesen, Myron Scholes, and Domingo Tavella.
The objective of this event was to mark the first decade of Computational Finance as a discipline in its own right. The event took place in London, England, which offered the advantage of a central location and a substantial local audience.

MSRI Symposium on Climate Change: From Global Models to Local Action
April 12, 2007 to April 13, 2007
Organized By: David Eisenbud, Inez Fung, Chris Jones, and Doug Nychka.
Global models based on current and past observations document the reality of climate change caused by human activity, although the details of when and what will happen where are far from clear. This symposium addressed the problems and research necessary to translate these global, long-term predictions into local predictions on shorter scales of time, where governments and businesses can act. It also addressed the implications for industry and public policy now.

Hot Topics: Minimal and Canonical Models in Algebraic Geometry
April 16, 2007 to April 20, 2007
Organized By: Alessio Corti, Jean-Pierre Demailly, János Kollár, and Shigefumi Mori.
The workshop concentrated on the recent advances on canonical and minimal models of algebraic varieties. Activities focused on expositing the recent proofs of the finite generation of the canonical ring of a variety of general type, surveyed applications and related results, and charted future directions for research.

Advances in Algebra and Geometry
April 28, 2007 to May 04, 2007
Organized By: David Ellwood, Joe Harris, Craig Huneke, Hugo Rossi, Frank-Olaf Schreyer, Bernd Sturmfels, and Julius Zelmanowitz.
The workshop concentrated on the recent advances on canonical and minimal models of algebraic varieties. The plan was to study the very recent proofs of the finite generation of the canonical ring of a variety of general type and thus the existence of "canonical" models for these varieties, to survey applications and related results, and to chart future directions for research.

Computing in Statistics
May 6, 2007 to May 9, 2007
Organized By: Organized By: Mark Hansen (UCLA), Deborah Nolan (UCB), and Duncan Temple Lang (UCD).
This workshop brought together educators interested in expanding the role of computing in the entire statistical sciences curricula. The goal was to discuss how to introduce new courses in computing and to integrate computing into traditional classes in the curriculum in order to train undergraduates to be better prepared for modern data analysis.

Gulliver Multiscale Bioimaging Workshop
May 17, 2007 to May 18, 2007
Organized By: Lawrence Berkeley National Laboratory. Contact: Damir Sudar
The Gulliver multiscale bioimaging workshop was organized by Lawrence Berkeley National Laboratory to survey new imaging modalities over relevant spatial and temporal resolution.

Program Highlights

Combinatorial Applications of Algebraic Topology. One of the stated goals of this program was to generate interest among mainstream topologists and geometers in the area of computational topology. A great deal of progress was made in this direction. For example, four mainstream topologists (Ken Brown (Cornell), Kevin Knudson (Mississippi State), John McCleary (Vassar), and Ross Sta•eldt (New Mexico State)) were long term visitors and a fifth (Bill Dwyer (Notre Dame)) was a short term visitor. Their engagement in the program was as follows.

- Knudson, who had worked on algorithmic aspects of discrete Morse theory, has now written a paper on multidimensional persistence, and is beginning to work with applications to actual data sets.
- Sta•eldt is now applying computational topological techniques to neural recording data from the surface of the skull. He is collaborating with a neuroscientist at New Mexico State.
- Dwyer has developed an interest in geometric random graph theory, as described in M. Penrose's book *Random Geometric Graphs*. He is beginning to work in this area. Dwyer is one of the leaders within the subfield of homotopy theory within algebraic topology.
- Brown and McCleary contributed useful insights and suggestions during their stays, and they are now aware of the range of ideas involved in these computational e•orts. They are both enthusiastic about the research agenda and may ultimately get more seriously involved.

Bob MacPherson (IAS) gave a lecture in one of the workshops on recent work he has been doing related to materials science. This talk was very well received and suggests new possible research directions for the subject. MacPherson-Goresky-Diaconis-Holmes and Shahshahani teamed up on a project of designing algorithms for sampling from the area measure of an embedded manifold. This is being used to generate test problems for the PLEX software developed at Stanford. Matt Kaehle spoke in one of the seminars on his joint work with Chris Ho•man and Eric Babson on the higher homology of geometric random graphs. This work, suitably generalized and refined, will be very important in understanding the degree to which topological invariants computed via Rips complexes represent real geometric information instead of noise. Kaehle is now a Samelson fellow at Stanford, and we expect that there will be collaboration between him and Carlsson and Diaconis on this precise question. Ho•man is a probabilist who is working on algebraic topological questions. Finally, a collaboration between Nicholas Eriksson and Yuan Yao on the study of phylogenetic trees developed at the program and is the basis for an ongoing collaboration.

Other developments included:

- A generalization of Alon's "splitting necklace theorem" was proved by de Longueville and Zivaljevic. This theorem is one of many theorems in computational geometry that attempt to establish the existence of partitions of sets into parts that are equal according to some measure or family of measures. The earliest version is the so-called "Ham Sandwich Theorem". The proof uses equivariant cohomological methods, and uses a notion of topological shellability. The paper is available at

arXiv:math.CO/0610800.

- The theory of multidimensional persistence, which is an extension of ordinary persistent homology that permits the study of multiparameter filtrations on a space, was developed by Carlsson and Zomorodian during the program. The work has appeared in SOCG 2007, one of the main conferences in computer science. The implementation of these ideas in code is now in its final stages at Stanford.
- Volkmar Welker and Persi Diaconis began a collaboration on statistical applications of multivariate orthogonal polynomials. This has morphed into a substantial project that is a main part of the Ph.D. dissertations of two students in the Stanford Statistics department.
- The dissertation of Stanford Statistics student Julia Saltzman was begun and essentially completed during the program. She was a speaker at the *Connections for Women* workshop. She spoke on projection pursuit for discrete data, which was the subject of her thesis. Methods for displaying and analyzing discrete data were actively discussed between Saltzman, Diaconis, and Holmes, and the finished thesis is a direct result of her participation in the program.
- A work on the Klein bottle structure of the space of 3 x 3 image patches in natural images was completed and submitted for publication during the period of the program. This joint e•ort of Carlsson, de Silva, Ishkanov, and Zomorodian will appear in the International Journal of Computer Science, and an expository paper on the work by Rob Ghrist will appear shortly in the Bulletin of the AMS.

Geometric Evolution Equations. This year-long program had significant impacts on the research of the participants including organizers, research professors, key senior scientists, and general members. Some of the leaders in research in this area who made substantial research progress during their MSRI visit includes: Sun-Yung Alice Chang, Panagiota Daskalopoulos, Gerhard Huisken, James Isenberg, Boris Khesin, Peter Li, John Lott, Peng Lu, John Morgan, Lei Ni, Duong Phong, Gang Tian, Peter Topping, Andrejs Treibergs, Je• Viaclovsky, Jiaping Wang, Guofang Wei, Ben Weinkove, Neshan Wickramasekera, Burkhard Wilking, Yu Yuan. A full report is appended to this document.

A couple of examples of seminal research contributions of participants are:

1. Peter Li, Jiaping Wang.

(a) Connectedness at infinity of complete Kähler manifolds and locally symmetric spaces. arXiv:math/0701865

(b) Weighted Poincaré inequality and rigidity of complete manifolds. arXiv:math/0701693

2. John Lott

(a) Optimal transport and Perelman's reduced volume. arXiv:0804.0343

(b) Dimensional reduction and the long-time behavior of Ricci flow. arXiv:0711.4063

Books and research-expository projects on Ricci flow that were worked on during the

MSRI year included:

Morgan, John; Tian, Gang. *Ricci flo*w *and th*e *Poincaré conjecture*. Clay Mathematics Monographs, 3, AMS, Providence, RI, 2007.

AMS books on Ricci flow (GSM vol. 77, MSM vols. 135 and 144) coauthored by MSRI participants Sun-Chin Chu, David Glickenstein, Christine Guenther, James Isenberg, Dan Knopf, Peng Lu, Lei Ni, and others.

Topics in which postdocs made original research contributions centered on:

1 Canonical structures (including Kähler–Einstein and constant scalar curvature metrics) in complex geometry and Kähler–Ricci flow
2 Energy, entropy, and eigenvalues under Ricci flow
3 Special holonomy metrics via geometric flow techniques
4 Pseudolocality for Ricci flow
5 Structure of Ricci solitons
6 Estimates for heat equations with respect to evolving metrics
7 Yamabe flow
8 Degenerate complex Monge-Ampere equation

Dynamical Systems. The program was envisioned to be in two parts: The first half ran roughly from the beginning until mid-March, during which the focus was on large-dimensional dynamical systems. Such so-called extended systems arise from discretizations of partial di•erential equations, lattice models or looking at pde's themselves. The second half emphasized problems at the boundary of dynamical systems and stochastic equations.

The collaborative research of the program was organized largely through a system of ongoing working groups on the following topics listed below, together with examples of notable accomplishments.

1. *Lattice Dynamics:* Lamb and Rink (in collaboration with Guo) worked on the problem of bifurcations of resonant traveling waves in Hamiltonian lattices, and a paper on this will be submitted soon.

2. *Stability and Spectral Theory:* Yuri Latushkin presented a result that he, in collaboration with Anna Ghazaryan and Steve Schecter, had proved while at MSRI. They proved that the linearization about the traveling wave in a certain combustion model satisfies the the hypothesis of Pruss's Lemma, and, as a result, the spectral mapping theorem can be used to conclude that spectral stability implies stability of the wave in the linearized system.

3. *Control Theory*: Significant progress was made on extending tools from dynamical systems theory to control theory with a focus on the stabilizability and the stabilization problems for controlled dynamical systems.

4. *Random Dynamical Systems:* How do positive Lyapounov exponents arise in

random systems? Specific two-degree-of-freedom Hamiltonian systems were considered with small noise $O(\varepsilon)$. It was shown that a positive Lyapounov exponent can be excited of order ε.

6. *Hamiltonian Systems:* Holger Dullin in collaboration with James Meiss discovered a new normal form for volume preserving mappings. During this work, interaction with Lamb was very helpful. Professor Hector Lomeli's work with Meiss leads to the construction of a measure of transport in three-dimensional systems that model mixing of fluids. They also completed work on a canonical formulation of the Melnikov function for mappings.

MSRI Experiences

Each year we write to workshop and organizers and postdoctoral fellows from programs held two, four and ten years ago to ask for an update on the effect of the program on the disciplines and their careers. Here are the responses we have received so far.

From Former Organizers

William McCallum:

The conference I organized (along with Steve Krantz and Estela Gavosto) was unusual for MSRI at that time because it was about education, specifically about the future of mathematics education at research departments. It was a seminal conference, marking a resurgence of interest in education in departments that had been traditionally focused entirely on research. It resulted in "Contemporary Issues in Mathematics Education", MSRI Publications no. 36.

Since it was not a research conference, I can't point to specific effects on further development of mathematics. However, I often run into people who remember it either as a starting point for their own interest in mathematics education or as a validation of the work they had been doing already.

Louis Billera:

I am writing as one of the organizers of the combinatorics program that took place in 1996-7. I will try to recall as many of the postdocs as possible (I was not able to find a list of them -- the record of this year has been removed from the MSRI website.).

Christos Athanasiadis: Arrived directly from his PhD and is now a professor at the University of Athens. He has continued to be active in the field and is currently a major component of EU effforts in algebraic and geometric combinatorics.

Eric Babson: Arrived as NSF postdoc from Cornell. Went on to tenured positions at U. Washington and now UC Davis. At MSRI, he did some strong work with other postdocs Linusson, Shareshian and Kozlov and later did some spectacular work with

Kozlov.

Dmitry Feichtner-Kozlov: Arrived from his PhD at KTH, Stockholm. Is now a chaired professor at the University of Bremen in Germany. He and Babson recently proved a conjecture of Lovasz about certain complexes arising from considering the chromatic numbers of graphs.

Svante Linusson: Also came directly from his PhD in Stockholm. He is now a professor at KTH, leading the group in combinatorics (the former head, Anders Bjorner is currently director of the Mittag-Leffler Institute). Recently proved an important conjecture about random matchings.

John Shareshian: Arrived directly from his PhD at Rutgers on combinatorial methods in group theory. Became involved in the solution of a problem involving complexes of graphs with Babson, Kozlov and Linusson (as well as Bjorner). He went on to a postdoc at CalTech, then to Miami, and now Washington University in St. Louis, where he is in the process of promotion to full professor. His work these days is mostly in topological methods in combinatorics.

Gabor Hetyei: Arrived from a postdoc in Montreal after an MIT PhD. He and I worked together that year and produced what I think is a very nice solution to a question I had been considering. He was on the verge of leaving academic mathematics, but, based on contacts he made that year, he obtained a temporary job at U Kansas and is now a tenured associate professor at the U of North Carolina at Charlotte.

Frank Sottile: was a postdoc that year also, I believe. He has gone on to be a leader in the interface between algebra, algebraic combinatorics, and algebraic geometry. He now is a full professor at Texas A&M.

Two other I can remember, I know less about.

Tom Bohman: Came from his Rutgers PhD and is now an associate professor of mathematics at Carnegie Mellon U. His area is such that I am not aware of what he has been up to, but he appears to have been successful.

David Grabiner: I have lost track of him. It is not clear whether he now has an academic position.

This accounts for nine of the postdocs that year in combinatorics. There were a few others, as I recall, but they don't come to mind at this point.

Andrei Zelevinsky:

Sorry for the delay in replying. I've served indeed as an organizer of one of the workshops (Combinatorial Problems Arising in Knots and 3-manifolds January 21, 1997 to January 24, 1997 Organized By: Joan Birman (Chair), Xiao-Song Lin, Paul Melvin,

and Andrei Zelevinsky), but I am afraid I can't say much about the follow-up. This is not my area of expertise, and most of the activity at the workshop was too far from my own interests. One notable exception is Mikhail Khovanov, who was at the beginning of his career then and has since become one of the leading figures in the field. I believe he is one of the main organizers of one of our future programs. I think participation in that program was definitely beneficial for his rise to stardom.

Estelle Basor:
The workshop's basic area was random matrix theory and its applications to combinatorics, growth processes, and multivariate statistics. Two important applications were presented: (1) In the statistical analysis of large data sets, random matrix theory provides the distribution of the largest principal component of the data matrix in the case of the null hypothesis. (2) In certain growth processes, the fluctuations of the growing interface are described by the distributions of random matrix theory. In addition, several talks addressed the continuing appearance of random matrix theory in many other areas of mathematics.

Continued work in the area of applications has been very active. This is most evident by the numerous conferences that have taken place since the MSRI workshop. A small sampling of these conferences is the following. In 2004, the focus of the Spring Semester of the Newton Institute was applications of random matrix theory to number theory. In the fall of 2006 "High Dimensional Inference and Random Matrices" was the topic of SASMI program. Last September a special meeting in Edinburgh was held to explore the connection between random matrices and Toeplitz operators. Finally, workshops at CRM in Montreal this academic year will explore the connections between random matrices and related topics in physics.

From a personal point of view, I collaborated with three of the participants from the original workshop and this resulted in several papers. It is accurate to say that at least two of these came directly from the workshop and the rest were certainly related to the workshop. My collaborators were Harold Widom, Yang Chen, and Torsten Ehrhardt. Part of the work done with Torsten Ehrhardt led to computing rigorously the Dyson constant, i.e., one of the constants that arises in describing the probability density of the largest eigenvalue of a random matrix. We also computed the asymptotics of determinants of Bessel operators, a problem directly related to the Laguerre random matrix ensembles. At the time of the workshop Torsten Ehrhardt had a temporary position in Germany. He eventually received a full-time tenure-track position at UC Santa Cruz and just recently was granted tenure.

Boris Hasselblatt:

The 2004 workshop definitely had high impact. One measure of this is the Cambridge University Press volume that resulted from it (Silvio Levy has details). This does include a problem list that appears to have attracted significant interest already.

The workshop may have drawn Chengbo Yue back (from neuroscience) into the field of smooth dynamics and geometric rigidity, which is a major boon to this field -- he has recently produced some astonishing results. (I may email a preprint.) The workshop was praised by several participants as the greatest of the year, and there was stiff competition.

Herb Clemens:

The 'Raising the Floor' workshop in May 2006 is slowly beginning to have some impact on mathematician involvement with African-American and Hispanic initiatives in mathematics education. Ricardo Cortez developed a cooperative project with MSRI itself that seems very promising. I have been working with a small group of mathematicians in Chicago and Boston to follow up on the workshop interaction with Bob Moses' Young People's Project.

Paul Zeitz:

I was a co-organizer of a workshop on mathematical circles and olympiads that was held at MSRI in December 2004. This was not a research workshop. The purpose of the workshop was to develop a national network of people interested in, or already participating in, mathematical circles.

The workshop had profound results. The number of math circles nationally has increased tremendously since 2004, and there is a much greater amount of awareness and cross-fertilization than ever before. I met people that I had only heard of for years and now work with them regularly. Besides an increase in sheer number, there has been an increase in diversity of style of instruction as well as audience, including traditionally underrepresented groups (e.g. Latinos and African-Americans). There have also been a number of interesting new programs aimed at middle-school and high-school teachers.

Another direct result of this workshop was a week-long trip to Moscow and St. Petersburg, sponsored by MSRI and the NSF, that took place two years later (November 2006). This trip introduced its 19 participants to the unique Russian math circle culture that in many ways we are trying to emulate here in the U.S. It has inspired at least two initiatives to involve undergraduates in mathematical circles, at SF State and the University of San Francisco.

I cannot overstate the influence of this workshop. Many of the exciting things that I do today originated as ideas or conversations in December 2004 at MSRI.

From Former Postdoctoral Fellows

Arun Ram:

Three things from my Spring 1997 Postdoc at MSRI:
(1) I shared an office with Andrei Okounkov and we became good friends.

(2) I spent the first month of my stay working out the combinatorics of affine Hecke algebra representation (zillions of computations I would not have had time to do if I were teaching/committeeing). These computations directly resulted in 4 papers (listed below) and, more importantly, made me comfortable with the affine Hecke algebra, a tool that has appeared, fundamentally, in nearly every paper I have written since (including the paper I finished yesterday).
(3) I wrote the paper "Combinatorial Representation Theory" with Helene Barcelo, which has caused rather a lot of subsequent organizational work for me (some semester at MSRI where a bunch of people are hanging out doing Combinatorial Representation Theory and having workshops about it).

All three points (1-3) have, quite significantly, affected my post-1997 life.

(29) Representations of rank two affine Hecke algebras, in "Advances in Algebra and Geometry, University of Hyderabad conference 2001", C. Musili ed., Hindustan Book Agency , 2003, 57-91.

(27) Skew shape representations are irreducible, in Combinatorial and Geometric representation theory, S.-J. Kang and K.-H. Lee eds., Contemp. Math. 325, Amer. Math. Soc. 2003, 161–189.

(26) Affine Hecke algebras and generalized standard Young tableaux, J. Algebra, 230 (2003), 367–415.

(25) Representations of graded Hecke algebras (with C. Kriloff), Representation Theory 6 (2002), 31–69.

Eric Babson:

It is difficult to overestimate the positive influence MSRI has had on my professional development. I met and began a long-term collaboration with Kozlov as well as meeting Shareshian and many others with whom I discuss and have shorter collaborations. I often recommend your programs to new PhDs.

David Grabiner:

I was at MSRI for 1996-1997 for the special year in combinatorics, on the first year of an NSF postdoctoral fellowship; I used the remaining year for two years teaching half-time at the University of Michigan.

The year at MSRI gave me an excellent opportunity to work with a variety of collaborators in combinatorics and related areas. I wrote three papers that year, none directly in combinatorics but all three related in some way. The best paper I wrote was "Brownian motion in a Weyl Chamber, Non-Colliding Particles, and Random Matrices", published in the Annales de l'I.H.P. Probabilites et Statistisques, which was related to my thesis results in random walks; my primary contact for this paper was Professor Jim

Pitman, in the Berkeley statistics department. This began my development of a research program, as I wrote two more related papers in subsequent years. I still consider the Brownian motion paper to be my best paper.

I am no longer in academia but remain professionally active in combinatorics.

Alex Kiselev:

The MSRI Postdoc fellowship that I held in 1996-97 played a defining role in my career. During the time I spent at MSRI, I established a collaboration with Michael Christ, which lasted for a while and led, over time, to 10 joint papers.
Even more importantly, I learned a lot in the course of this collaboration. My main background was in functional analysis and differential equations, and exposure to a master Fourier analyst changed my whole mathematical toolbox and influenced all my subsequent work. Even though a year is not a long time in mathematics - especially if you are entering a new area - I believe that the MSRI setting (being free of teaching and free to pursue any direction of research I like) allowed me to benefit maximally from this collaboration and significantly enhanced my career.

Mason Alexander Porter:

I didn't get any specific results or collaborations from my postdoctoral fellowship, but, as I believe I wrote on a prior occasion, it gave me the chance to take time away from my postdoctoral advisor and breathe again. It was during that semester that I got my passion for research back (during the previous semester---the first one I was a postdoc---I was still very much burned out from my doctoral studies), so it was very important in that respect even though I can't cite any specific research, etc.

Anurag Singh:

I found the MSRI year-long program in commutative algebra extremely useful. It gave me an opportunity to attend several talks and working seminars on various topics in commutative algebra, and get a broader view of the field.

The biggest immediate gains for me were the start of collaborations with other researchers. Following the stay at MSRI, I joined Georgia-Tech, where algebra was not well represented; the projects and collaborations started during my MSRI stay enabled me to maintain an active research program, even though I was somewhat geographically isolated from the algebra circles.

The following papers have their roots in discussions started at MSRI; the first was completed during the MSRI year itself. Specifically, I first started working with Irena Swanson, Uli Walther, and Kei-ichi Watanabe while we were at MSRI.

Associated primes of local cohomology modules and of Frobenius powers, with Irena Swanson, International Mathematics Research Notices 33 (2004) 1703-1733.

On the arithmetic rank of certain Segre products, with Uli Walther, Contemporary Mathematics 390 (2005) 147-155.

Annihilators of local cohomology in characteristic zero, with Paul Roberts and V. Srinivas, Illinois Journal of Mathematics, Special Issue in Honor of Phil Griffith, 51 (2007) 237-254.

Local cohomology and pure morphisms, with Uli Walther, Illinois Journal of Mathematics, Special Issue in Honor of Phil Griffith, 51 (2007) 287-298.

Multigraded rings, rational singularities, and diagonal subalgebras, with Kazuhiko Kurano, Ei-ichi Sato, and Kei-ichi Watanabe, preprint.

Ana Bravo:

My stay at the MSRI had an impact in my professional development in different levels:

1. It helped me to meet, contact and interact with many people working in my area of research.

2. It meant an opportunity to learn about many different subjects related to the one of my interest.

3. It also had an impact when I applied for the permanent position that I have now.

Sergi Elizalde:

Aside from all that I learned at MSRI through my participation in the programs in 2004-05, the most valuable experience for me was to interact with Peter Winkler in the program on Probability and Algorithms that spring. Not only did I learn about his work, but after meeting him I ended up coming to Dartmouth College (where Peter Winkler is), first as a post-doc and later as tenure-track.

Another valuable interaction that year was with Bernd Sturmfels, who, even though he wasn't part of any of the MSRI programs, came to talks every now and then. As a result of talking to him I ended up publishing a couple of papers in computational biology, that have been very important in my professional development.

Nicholas Proudfoot:

I was a post-doc at MSRI for the first half of the Fall 2004 semester, participating in the program on hyperplane arrangements. During this time, I did not have much interaction with other members of the institute. I don't recall there being much structure to the program; I remember that there being approximately one seminar talk per week, and

that's about it. Most of the senior members were already active in research projects with each other, and I had two active collaborations with graduate students in the Berkeley Math Department, so I mostly focused my attention on those.

Matt Harrison:

Here are some of my thoughts about my time as an MSRI postdoc:

I was a postdoc at MSRI in the spring of 2005 for the program "Mathematical, Computational, and Statistical Aspects of Image Analysis". This particular program had 5 or 6 separate week-long workshops/emphasis weeks, each of which was basically a full week-long conference. This was a fantastic overview of the field for me and strongly influenced my future direction. A downside is that the continuity of the semester was broken quite regularly and it was difficult (for me, at least) to develop any tight collaborations with the other postdocs and visitors. Nevertheless, I thought the program was excellent and I benefited greatly from the opportunity to participate in it.

Patricia Hersh:

I learned a lot of useful new things during my semester at MSRI in fall 2005, but from the hyperplane arrangements program (especially the learning seminar which Peter Orlik suggested) and also from auditing a class on Combinatorial Commutative Algebra at Berkeley. One paper so far is a direct consequence of these experiences:

(with Alexander Berglund and Jonah Blasiak) Combinatorics of multigraded Poincaré series for monomial rings, J. Algebra, 308 (2007), no. 1, 73-90.

This paper expresses the denominator for Poincaré series when one resolves a residue field over a polynomial ring modulo a monomial ideal in terms of ranks of homology groups for intersection lattice lower intervals for graphic hyperplane arrangements. Simplifies the denominator for several classes of monomial ideals and also proves Golodness in new cases. The published version is 10 pages shorter than the original because we've eliminated some very combinatorial sections; these might perhaps appear in a future paper aimed at combinatorialists.

I've also spent some time working on a project that I hope to pursue more fully at some point in the future (though it hasn't really come to fruition just yet): trying to understand the topology of the complement of a subspace arrangement in (R/Z)^n, i.e. in an n-dimensional real torus, e.g. for unimodular arrangements. Things I learned from the MSRI program, e.g. about how the group structure for the cohomology algebra is determined by the topology while the fundamental group is not, have been invaluable to this project -- in terms of having a good understanding of what are the right questions to ask and what past results might be relevant. One motivation comes from connections to

cyclic and Hochschild homology, where such arrangement complements seem likely to provide information e.g. about Betti numbers.

Jason Schweinsberg:

I think the MSRI program "Probability, Algorithms, and Statistical Physics" was excellent, especially as it helped me to begin some research in an area that was somewhat different from the area of my Ph.D. thesis. Specifically, I began working on two papers concerning the loop-erased random walk and the uniform spanning tree on the four-dimensional torus during my time at MSRI.

Jamylle Carter:

1. Work that I completed during my postdoctoral fellowship at the Mathematical Sciences Research Institute appeared in the following article: Tony F. Chan, Ke Chen, and Jamylle L. Carter. Iterative Methods for Solving the Dual Formulation Arising from Image Restoration. *Electronic Transactions on Numerical Analysis,* 26:299—311, 2007.

2. After teaching in the San Francisco Math Circle for two years, I founded the Oakland Math Circle in 2007. I also began a National Science Foundation Internships in Public Science Education postdoctoral fellowship in the Teacher Institute at the Exploratorium, a hands-on museum of science, art, and human perception in San Francisco.

3. Semester-long postdoctoral fellowships are most fruitful when postdocs have preexisting relationships with organizers.

2006-2007 MSRI Programs

Geometric Evolution Equations and Related Topics (8/14/2006 to 5/25/2007)

Organized By: Bennett Chow, Panagiota Daskalopoulos, Gerhardt Huisken, Peter Li, Lei Ni, Gang Tian

The focus will be on geometric evolution equations, function theory and related elliptic and parabolic equations. Geometric flows have been applied to a variety of geometric, topological, analytical and physical problems. Linear and nonlinear elliptic and parabolic partial differential equations have been studied by continuous, discrete and computational methods. There are deep connections between the geometry and analysis of Riemannian and Kähler manifolds.

Computational Applications of Algebraic Topology (8/14/2006 to 12/15/2006)

Organized By: Gunnar Carlsson, Persi Diaconis, Susan Holmes, Rick Jardine, Günter M. Ziegler

Algebraic topology provides measures for global qualitative features of geometric and combinatorial objects that are stable under deformations, and relatively insensitive to local details. This makes topology into a useful tool for understanding qualitative geometric and combinatorial questions.

Considerable momentum has developed in recent years towards applications of algebraic topology in various contexts related to data analysis, object recognition, discrete and computational geometry, combinatorics, algorithms, and distributed computing.

The MSRI program will gather the workers in these areas for concentrated interactions, and will make a strong effort to communicate the nature of these developments to the more general mathematical public. In addition, there will be tutorials in the early phase of the program on background in topology as well as the relationships between the methods of topology and statistics. We expect that the program will make a substantial contribution to establishing future research directions in the area.

The program will focus on (1) the topology of point cloud data and (2) topological methods in combinatorics and computer science. The study of point cloud data will include work on high dimensional data sets coming from the analysis of images, from neuroscience, from the study of phylogenetic trees, and from shape and feature recognition. In the direction of combinatorics and computer science, we will include work on graph coloring, lower bounds for complexity of computational tasks, discrete and computational geometry, and distributed/concurrent computing.

2006-2007 MSRI Participant Summary

Activity Type	Participants	Underrepresent Minorities	Female	Hispanic	Native American	Asian	Black	Pacific Islander	Permanent Resident	US Citizens
Long Program	79	11	11	0	0	19	0	0	15	22
Short Programs	95	19	16	0	0	7	3	0	14	42
Workshops	2420	577	479	43	13	273	35	7	350	596

2006-2007 MSRI Publication List

Last Name	First Name	Publication Title	Co-Authors
Alexakis	Spyros	The decomposition of global Conformal Invariants	
Alexakis	Spyros	Minimal surfaces in H^3 with smooth boundaries at infinity (tentative)	Rafe Mazzeo
Alexakis	Spyros	On conformally Invariant differential operators.	
Apte	Amit	A Bayesian approach to Lagrangian data assimilation	C.K.R.T. Jones, A.M. Stuart
Apte	Amit	A Unified Approach to the Darwin Approximation	Todd B. Krause, P.J. Morrison
Apte	Amit	Nontwist Maps	Diego del-Castillo Negrete, Alex Wurm, P.J. Morrison
Apte	Amit	Ensemble Data Assimilation	C.K.R.T. Jones, A.M. Stuart, J. voss
Bates	Peter	Approximately normally hyperbolic invariant manifolds and application to the Allen-Cahn equation	Keing Lu and Chongchun Zeng
Baxendale	Peter	Positive Lyapunov exponent for stochastically perturbed shear flows	Jonathon Mattingly, Sri Namachchivaya, Maciej Wojtkowski and Lai-Sang Young
Beck	Margaret	Stability of periodic waves arising through Hopf birfurcation in viscous conservation laws	Bjorn Sandstede
Beck	Margaret	A geometric view of metastability in the viscous Burgers equations	C. Eugene Wayne
Beck	Margaret	Electrical Waves in the Heart	Chris Jones, Martin Wechselberger
Birnir	Björn	Turbulent Rivers	
Blagojevic	Pavle	Mass partitions by two hyperplanes and Borsuk Ulam type theorem for Dihedral group D_8	Gunter Ziegler
Blagojevic	Pavle	Borsuk-Ulam Theorems for Complements of Arrangements	Aleksandra Dimitrijevic Blagojevic, John McCleary
Blagojevic	Pavle	Convex mass partitions	
Blagojevic	Pavle	Inscribing simplexes on Jordan spheres and a Borsuk Ulam type theorem	Aleksandra Dimitrijevic Blagojevic, John McCleary
Blagojevic	Pavle	Mass partition by two hyperplanes and Borsuk-Ulam type theorem for Dihedral group D_8	Gunter Ziegler
Blagojevic	Pavle	Partition of masses by convex sets	
Blagojevic	Pavle	Borsuk-Ulam Theorems for Complements of Arrangements	Aleksandra Dimitrijevic Blagojevic, John McCleary
Blagojevic	Pavle	Borsuk-Ulam Theorems for Complements of Arrangements	Aleksandra Dimitrijevic Blagojevic, John McCleary
Blagojevic	Pavle	Inscribing Simplexes on Jordan spheres and a Borsuk Ulam type theorem	Aleksandra Dimitrijevic Blagojevic, John McCleary
Blagojevic	Pavle	Inscribing simplexes on Jordan spheres and a Borsuk Ulam type theorem	Aleksandra Dimitrijevic Blagojevic, John McCleary
Brown	Ken	Wall complexes	Peter Abramenko
Brown	Ken	Approaches to buildings	Peter Abramenko
Bubenik	Peter	Sup-norm sharp adaptive estimations of functions on manifolds and their persistent homology	Peter Kim, Gunnar Carlsson
Bubenik	Peter	Probabilistic simplicial complexes	
Bubenik	Peter	An alternate model structure for cubical sets	Krysztof Worytkiewicz
Bubenik	Peter	A model category for graphs	Eric Babson
Bubenik	Peter	Sup-norm sharp adaptive estimations of functions on manifolds and their persistent homology	Peter Kim, Gunnar Carlsson
Bubenik	Peter	Probabilistic simplicial complexes	TBD
Cao	Xiaodong	Cross Curvature Flow on Locally Homogenous Three-manifolds	Yilong Ni, Laurent Saloff-Coste
Capogna	Luca	generalized mean curvature flow in the heisenberg group	Giovanna Citti
Capogna	Luca	Regularit yof minimal intrinsic graphs in H^1	Giovanna Citti and Maria Manfredini
Caputo	Maria-Cristina	Highly Degenerate Harmonic Mean Curvature Flow	P. Daskalopoulos
Caputo	Maria-Cristina	Long Time Existence Harmonic Mean Curvature Flow	P. Daskalopoulos
Carlsson	Gunnar	Localized Homology	A. Zomorodian
Carlsson	Gunnar	The Theory of Multidimensional Persistence	A. Zomorodian
Chen	Szu-yu Sophie	Conformal deformation on manifolds with boudnary	
Chen	Wen-Haw	Long-time existence of feasible paths in time evolution of curves	
Chow	Bennett	Hamilton's Ricci Flow	Lu, Ni
Chow	Bennett	Ricci Flow: Analytic and Geometric Aspects Part I	Chu, Glickenstein, Guenther, Isenberg, Ivey, Knopf, Lu, Luo, Ni
Chow	Bennett	Ricci Flow: Analytic and Geometric Aspects Part II	Chu, Glickenstein, Guenther, Isenberg, Ivey, Knopf, Lu, Luo, Ni
Coven	Ethan	A characterization of the Morse Minimal Set	M. Keane, M. LeMasurier
Coven	Ethan	On the genesis of symbolic dynamics as we know it	Z. Nitecki
Coven	Ethan	Every odometer can be embedded in a cellular automaton with local rule x_0+x_1	R. Yassawi
Csorba	Peter	Graph coloring manifolds	Frank Lutz
Csorba	Peter	On homomorphism complexes	
Day	Sarah	Algorithms for entropy bounds and symbolic dynamics	Rafael Frongillo and Rodrigo Trevino
Day	Sarah	Probabilistic and numerical validation of homology computations for nodal domains	William D. Kalies, Konstantin Mischaikow, Thomas Wanner
Day	Sarah	Homology computations of nodal domains: accuracy estimates and validation	William D. Kalies and Thomas Wanner
Day	Sarah	Validated continuation for equilibria of PDEs	Jean-Philippe Lessard and Konstantin Mischaikow
Demers	Mark	Existence and convergence properties of physical measures for certain dynamical systems with holes	Henk Bruin, Ian Melbourne
Demers	Mark	Escape rates for billiards	Paul Wright, Lai-Sang Young
Demers	Mark	Undecided - A family of pseuo-Anosov maps with nonuniform shear	Maciej Wojtkowski
Demers	Mark	Undecided - Banach spaces for hyperbolic maps	Carlangelo Liverani
Denham	Graham	Homology of subgroups of right-angled Artin groups	
Denham	Graham	Partial product complexes and manifolds	Alex Suciu
Dullin	Holger	Nilpotent normal form for divergence free vector fields and volume-preserving maps	James Meiss
Eriksson	Nicholas	Viral population estimation using pyrosequencing	L. Pachter, S.Y. Rhee, Y. Mitsuya, R.W. Shafer, and N. Beerenwinkel
Eriksson	Nicholas	Metric learning for phylogenetic invariants	Yuan Yao
Feichtner	Eva	Tropical Discriminants	Alicia Dickenstein, Bernd Sturmfels

Feichtner	Eva	Tropicalizing cusp components of discriminants	Hannah Markwig
Fisher	David	Coarse differentiation of quasi-isometries II: rigidity for lattices in Sol and lamplighter groups	Alex Eskin, Kevin Whyte
Fisher	David	Harmonic maps with Hilbert manifold targets and cocycle superrigidity	Theron Hitchman
Fisher	David	Local rigidity via Bochner methods	Theron Hitchman
Ghazaryan	Anna	Stability of fronts in porous media combustion.	C.K.R.T. Jones, P.Gordon
Ghazaryan	Anna	Existence of fronts in a model for isothermal autocatalytic system	C.K.R.T. Jones, P.Gordon
Gonzalez-Diaz	Rocio	AT-model and persistent homology	Pedro Real
Goresky	Mark	Closed geodesics and the Chas-Sullivan Product	Nancy Hingston
Goresky	Mark	On the spectrum of the equivariant cohomology ring	Robert MacPherson
Grant	Angela	Finding Optimal Orbits of Chaotic Systems	Brian Hunt
Grant	Angela	Finding optimal orbits: a practical approach.	
Guenther	Christine	Ricci Flow Volume 2, part 2	Ben Chow, Peng Lu, Dave Glickenstein, Feng Luo, Tom Ivey, Michael Chu, Lei Ni
Guenther	Christine	Monotonicity Formulae for Parabolic Equations in Geometry	Ben Chow
Guenther	Christine	Stability of Second Order Renormalization Group Flow	
Guenther	Christine	Ricci Flow Volume 2, part 2	Ben Chow, Peng Lu, Dave Glickenstein, Feng Luo, Tom Ivey, Michael Chu, Lei Ni
Guenther	Christine	Monotonicity Formulae for Parabolic Equations in Geometry	Ben Chow
Guenther	Christine	Stability of Second Order Renormalization Group Flow	Todd Oliynyk
Hairer	Martin	Energy dissipation in systems of anharmonic oscillators	J. Mattingly
Hairer	Martin	From ballistic to diffusive motion in periodic potentials	G. Pavliotis
Hamzi	Boumediene	Stabilization of Nonlinear Control Systems around Relative Equilibria	Jeroen Lamb and Debra Lewis
Hamzi	Boumediene	A new approach for the derivation of Normal Forms for Nonlinear Control Systems	Jeroen Lamb and Debra Lewis
Hamzi	Boumediene	On Normal Forms for Nonlinear Hamiltonian Control Systems	Jeroen Lamb and Debra Lewis
Harbater	David	Patching over fields	Julia Hartmann
Harbater	David	Patching and differential Galois theory	Julia Hartmann
Harbater	David	Admissibility of groups and formal patching	Julia Hartmann, Daniel Krashen
Harbater	David	Galois maximal subfields of division algebras	Julia Hartmann, Daniel Krashen
Harriss	Edmund	Canonical Substitution Tilings	Jeroen Lamb
Hartmann	Julia	Admissibility of Groups and Formal Patching	David Harbater; Daniel Krashen
Hartmann	Julia	Galois Maximal Subfields of Division Algebras	David Harbater; Daniel Krashen
Hartmann	Julia	Reflection Groups and Differential Forms	Anne V. Shepler
Hartmann	Julia	Patching over Fields	David Harbater
Hartmann	Julia	Patching and Differential Galois Theory	David Harbater
Hass	Joel	k-Width of knots	Abigail Thompson and Hyam Rubinstein
Hass	Joel	Minimal graphs over non-convex domains	
Hass	Joel	Low dimensional docking	
Hebey	Emmanuel	Elliptic systems of critical Sobolev growth	Olivier Druet
Hoffman	Chris	Phase transitions for random simplicial complexes	Matt Kahle, Eric Babson
Jardine	John	Representability for model categories	
Jardine	John	Homotopy coherent representability theorems	
Jeffres	Thalia	Vertical Blow Ups	Kirk Lancaster
Jeffres	Thalia	Behavior of Capillary Surfaces at Reentrant Corners	Kirk Lancaster
Jeffres	Thalia	Regularity and Convergence Results in Half Balls	Kirk Lancaster
Jeffres	Thalia	Constant Scalar Curvature Manifolds with Prescribed Singularities	Rafe Mazzeo
Jeffres	Thalia	[No title yet]	Bianca Santoro
Ji	Qingchun	nondivergent parabolic equations on manifolds with nonnegtive cuurvature	
Ji	Qingchun	nondivergent parabolic equations on manifolds	
Jin	Qinian	Symmetry and nonsymmetry: the method of moving spheres	Yanyan Li and Haoyuan Xu
Jones	Christopher	A Baeysian approach to Lagrangian data assimilation	Amit Apte, Andrew Stuart
Jones	Christopher	A symplectic view of a semilinear elliptic problem	Jian Deng
Jones	Christopher	Dynamics of Heart Waves	Margaret Beck, Martin Wechselberger, David Schaeffer
Jones	Christopher	Enssemble data asimilation	Amit Apte, Andrew Stuart, Jochen Voss
Joswig	Michael	approximate title "buildings and tropical convexity"	Bernd Sturmfels and Josephien Yu
Joswig	Michael	approximate title "graph drawing in polymake"	Ewgenij Gawrilow, Thilo Schroeder, and Nikolaus Witte
Joswig	Michael	Algorithmische Geometrie	Thorsten Theobald
Jurado	Pedro	Analisis topologico de imagenes 3d medicas	A. Berciano, R. Gonzalez-Diaz, MJ. Jimenez, B. Medrano, J. Sanchez-Pelaez
Jurado	Pedro	Automatizacion en el analisis de resultados de experimentos de electroforesis de geles	Antonio Suarez-Pliego
Kalies	William	Probabilistic and numerical validation of homology computations for nodal domains	Sarah Day, Konstantin Mischaikow, Thomas Wanner
Kalies	William	Validation of homology computations of nodal domains	Sarah Day, Thomas Wanner
Karigiannis	Spiros	Curvature of the Moduli Space of G_2 Metrics	Christopher Lin
Karigiannis	Spiros	Geometric Flows on Manifolds with G_2 Structure, I.	
Karigiannis	Spiros	Hodge Theory and Abel Jacobi Maps in G_2 Geometry	Naichung Conan Leung
Kevrekidis	Panayotis	Solitary Waves Under the Competition of Linear and Nonlinear Periodic Potentials	Z. Rapti, C.K.R.T. Jones, V.V. Konotop
Kevrekidis	Panayotis	Dynamical Barrier for the Nucleation of Solitary Waves in Discrete Lattices	Y. Drossinos, A. Stefanov
Kevrekidis	Panayotis	Domain Wall Solutions in Spinor Bose-Einstein Condensates	H.E. Nistazakis, D.J. Frantzeskakis, B. Malomed, R. Carretero-Gonzalez
Kevrekidis	Panayotis	Experimental Demonstration of Compactons in Phononic Crystals	M. Porter, C. Daraio
Khesin	Boris	Shock waves for the Burgers equation and curvatures of diffeomorphism groups	Gerard Misiolek

Khesin	Boris	Topological Methods in Hydrodynamics	Vladimir Arnold
Khesin	Boris	Spaces of pseudo-Riemannian geodesics and pseudo-Euclidean billiards	Sergei Tabachnikov
Klingenberg	Wilhelm	A Lagrangian flow in indefinite Kaehler surfaces	Brendan Guilfoyle
Klingenberg	Wilhelm	Mean Curvature Flow for Positive Surfaces in Neutral Kaehler Manifolds	Brendan Guilfoyle
Klingenberg	Wilhelm	On area-Critical Surfaces in indefinite Kaehler Manifolds	
Knopf	Dan	An application of cross curvature flow to topology	Jason Deblois, Andrea Young
Knopf	Dan	Asymptotic stability of nilsolitons	
Knopf	Dan	Cross curvature flow for negatively curved metrics (working title)	Jason Deblois, Andrea Young
Knopf	Dan	Ricci flow on nilmanifolds and solvmanifolds (working title)	Tracy Payne
Knudson	Kevin	Persistent homology and discrete Morse theory	
Knudson	Kevin	Remarks on multi-dimensional persistence	
Kozlov	Dmitry	Combinatorial Algebraic Topology	none
Krener	Arthur	Solution of HJB Equations	
Krener	Arthur	Obsevability of Vortex Flows	J. Hansen
Lamb	Jeroen	Bifurcation from codimension one relative homoclinic cycles.	A.J. Homburg, A.C. Jukes, J. Knobloch
Lamb	Jeroen	Non-wandering dynamics near robust reversible heteroclinic networks.	A.C. Jukes
Lamb	Jeroen	Shift dynamics near T-point heteroclinic cycles.	J. Knobloch, K.N. Webster
Lamb	Jeroen	Bifurcation and branching of equilibria in reversible equivariant vector fields.	P.L. Buono, M. Roberts.
Lamb	Jeroen	On the periodic solutions near a symmetric homoclinic to a reversible saddle-center.	O.Yu. Koltsova
Lamb	Jeroen	Dynamics of the spherical tippe top with sliding friction.	M.C. Ciocci, B. Langerock, B. Malengier.
Lamb	Jeroen	Hamiltonian Hopf bifurcation with symmetry	T. Fujihira
Lamb	Jeroen	Bifurcations of resonant wave trains in a reversible Hamiltonian lattice.	S. Guo, B. Rink.
Lamb	Jeroen	Equivariant Hopf bifurcation for delay differential equations via Lyapunov-Schmidt reduction.	S. Guo
Lanford	Oscar	Parabolic renormalization in complex dynamics	Michael Yampolsky (Toronto)
Latushkin	Yuri	Center manifolds and dynamics near equilibria of quasilinear parabolic systems with fully nonlinear boundary conditions	J. Pruss, R. Schnaubelt
Latushkin	Yuri	Convective stability of combustion waves in one-dimensional solids	A. Ghazaryan, S. Schecter, A. J. de Souza
Latushkin	Yuri	Nonlocal delay equations with forward and backward delays	A. Hoffman
Latushkin	Yuri	The Dichotomy Theorem and ill-posed equations	A. Pogan
LeFloch	Philippe	Injectivity Radius of Lorentzian Manifolds	Bing-Long Chen
LeFloch	Philippe	Entropy solutions of the Euler equations for isothermal relativistic fluids	Mitsuru Yamazaki
LeFloch	Philippe	Paper in preparation	Knut Smoczyk
Lemire	Nicole	Galois module Structure of Galois Cohomology for cyclic extensions of degree p^n.	Jan Minac, Andy Schultz, John Swallow
Lemire	Nicole	Linearisation of Multiplicative group actions	
Lemire	Nicole	Detecting pro-p groups that are not absolute Galois groups	Dave Benson, Jan Minac, John Swallow
Lerman	Lev	Dynamics of a reversible system in a neighborhood of symmetric saddle-focus loop	J. Meiss
Lewis	Debra	Switching in nonlinear optimal control problems	
Lewis	Debra	Stabilization and steering of relative equilibria (very tentative title)	Boumediene Hamzi and Jeroen Lamb
Lewis	Debra	Normla forms for Hamiltonian control systems (very tentative title)	Boumediene Hamzi and Jeroen Lamb
Li	Peter	Connectivity at infinity of complete kahlar manifolds and locally symmetric spaces	Jiaping Wang
Li	Junfang	Eigenvalues and energy functionals with monotonicity formulae under Ricci flow	
Li	Junfang	Affine geometric evolution equations	Dr. M. Zhu
Li	Junfang	Generalized Bernsteim problem	Dr. Shihshu Walter Wei
Li	Junfang	Evolution of Eigenvalues of a family of operators under Ricci flow	Dr. Xiaodong Cao
Li	Junfang	Modified entropy formulas on a locally R^N-invariant Ricci flow	discussed with Professor John Lott and Xiaodong Cao
Lin	Christopher	The curvature of Weil-Petersson metric on G_2 moduli	Spiro Karigiannis
Lin	Christopher	Quantum layers over increasing graphs.	Zhiqin Lu
Lin	Christopher	Quantum layers over surfaces ruled outside a compact set	Zhiqin Lu
Ling	Jun	Some properties of the first eigenvalue under the normalised Ricci flow	Xiaodong Cao
Ling	Jun	On the Frankel Conjecture	Peng Lu
Liu	Fu	A generating function for the lattice points of the dilated Birkhoff polytope	J. De Loera and R. Yoshida
Lott	John	Dimensional reduction and long-time behavior of Ricci flow	
Lutz	Frank	Simplicial manifolds with small valence	John M. Sullivan
Lutz	Frank	Knotted polyhedral tori	JÃ¼rgen Bokowski, Nikolaus Witte
MacKay	Robert	Statistical phases of dynamics on large networks	
MacKay	Robert	Parameter dependence of Markov processes on large networks	
MacKay	Robert	Hamiltonian slow manifolds of high order and with internal oscillation	
MacKay	Robert	Interaction of two charges in a magnetic field: spatial case	D Pinheiro
MacPherson	Robert	On the spectrum of the equivariant cohomology ring	Mark Goresky
MacPherson	Robert	Paper on intersection homology and non-Abelian group ctions	Mark Goresky
MacPherson	Robert	Informal discussions about random walks on manifolds	Persi Dioconis
MacPherson	Robert	Thinking about grains in materials	
Mattingly	Jonathan	Stodchastic Shell models	Scott Mckinley
Mattingly	Jonathan	Anharmonic oscilator chains	Martin Hairer
Mattingly	Jonathan	Positive Lyapunov exp	Ls Young, Sri N. Peter Baxendle
McCann	Robert	Nonlinear diffusion from a delocalized source: affine selfsimilarity, time reversal, and nonradial focusing geometries	Jochen Denzler
McCann	Robert	Continuity, curvature, and the general covariance of optimal transportation	Young-Heon Kim

McCann	Robert	Asymmetric Yamabe flow towards the cigar manifold	Almut Burchard and Aaron Smith
McCleary	John	Borsuk Ulam type theorems for complements of arrangements	Pavle Blagojevic, Aleksandra Blagojevic
McCleary	John	Jordan curves have inscribed squares	Jason Cantarella, Elizabeth Denne
Meiss	James	Canonical Melknikov Theory for Diffeomorphisms	H. Lomeli, R. Ramirez-Ros
Meiss	James	Andronov Hopf Bifurcations in Planar, Piecewise-Smooth Continuous Flows	D. Simpson
Meiss	James	Nontwist Volume-Preserving Maps	
Meiss	James	Dynamics of a Reversible System near a Symmetric Saddle-Focus Loop	L. Lerman
Meiss	James	Nilpotent Normal Forms for Divergence-Free Vector Field and Volume-Preserving Maps	H. Duillin
Morozov	Albert	Differential Equations generating nonmonotonic twist maps	J. Meiss
Muraleetharan	Murugiah	Singularity formation of Embedded Curves Evolving on Surfaces by Curvature Flow	David L. Johnson
Muraleetharan	Murugiah	Singularity Analysis of Evolving Curves using the Distance Comparison Principle	David L. Johnson
Muraleetharan	Murugiah	Real Analycity of the solutions of curve shortening flow	
Namachchivaya	Navaratnam	Stochastic Version of Lai-Sang Young's Model For Shear:	Lai-Sang Young*
Namachchivaya	Navaratnam	The Asymptotic Stability of a Weakly Perturbed Two Dimensional Non-Hamiltonian System	Kevin Lin* and Dan Wiley*
Namachchivaya	Navaratnam	A Problem in Stochastic Dimensional Reduction of Nonlinear Filters:	Jun H. Park and Richard B. Sowers
O'Reilly	Oliver	Modeling the Growth and Branching of Plants: A Simple Rod-Based Model.	Tim Tresserias
O'Reilly	Oliver	Curve Encirclement and Protein Structure	Patrick Kessler
Pavliotis	Greg	Transport optimization for the flashing ratchet	J. Lattore and P.R. Kramer
Pavliotis	Greg	Rates of Convergence in Homogenization	J. Mattingly
Pavliotis	Greg	Ballistic and diffusive motion in periodic potentials	M. Hairer
Pavliotis	Greg	Numerical methods for hypoelliptic boundary value problems	J. Lattore, P.R. Kramer
Pugh	Mary	the spin-up problem and free surfaces	Tom Witelski, Duke University
Purdom	Elizabeth	Working Title: Kernel Methods in Prediction	Susan Holmes
Purdom	Elizabeth	Working Title: Analysis of ecological data using phylogenetic information	not sure yet, many bio collaborators
Purdom	Elizabeth	Method for detection of alternative splicing from exon array data	Ken Simpson, Terry Speed, and other biology collaborators
Rink	Bob	An integrable approximation for the Fermi-Pasta-Ulam lattice	
Rink	Bob	Bifurcations of traveling waves in a reversible Hamiltonian Lattice	J. Lamb and S.-J. Guo
Rink	Bob	A second order integrable approximation for the FPU long wave approximation	
Rink	Bob	A quasi-periodic solution of Ammann-Beenker type to the planar Swift-Hohenberg equation	G. Gentile
Salur	Sema	Associative embeddings and Cartan Kahler Theory	Colleen Robles
Salur	Sema	The \Chi Flow	Selman Akbulut
Salur	Sema	Ricci Flow and Calibrations	Dan Knopf
Santoro	Bianca	On the Asymptotic Behavior of Complete Ricci-flat metrics on Quasi-Projective manifolds	
Santoro	Bianca	On Complete Ricci-flat metrics on open KÃ¤hler manifolds	
Schecter	Stephen	Stability of traveling waves in gasless combustion (working title)	Aparecido de Souza, Anna Ghazaryan, Yuri Latushkin
Schecter	Stephen	Traveling waves in a thin film with surfactant (working title)	Vahagn Manukian
Schecter	Stephen	Riemann-Dafermos solutions approximating weak shock waves of a scalar conservation law (working title)	Vahagn Manukian
Sesum	Natasa	Classification of singularities in the locally conformally flat Yamabe flow	Panagiota Daskalopoulos
Sesum	Natasa	Uniformization of conformally finite Riemann surfaces by the Ricci flow	Lizhen Ji
Sesum	Natasa	Harmonic mean curvature flow of nonconvex bodies	Panagiota Daskalopoulos
Sheng	Weimin	Local estimates for a class of conformal σ_k equations	
Song	Jian	Constructions of Kahler-Einstein metrics with negative scalar curvature	Ben Weinkove
Song	Jian	The Kahler-Ricci flow and the $\bar\partial$ operator on vector fields	D.H.Phong, Jacob Sturm, Ben Weinkove
Song	Jian	Holomorphic Kahler-Einstein metrics I.	Gang Tian
Song	Jian	Complex σ_k equations	Sophie Chen
Staffeldt	Ross	Geometrically detecting periodic brain activity in EEG data (tentative)	James Kroger, NMSU Department of Psychology
Staffeldt	Ross	The connecting homomorphism for K-theory of generalized free products	Andrew Ranicki (possibly), University of Edinburgh
Staffeldt	Ross	Geometrically detecting subprocesses of brain activity in EEG data (tentative)	Dr. James Kroger, NMSU Department of Psychology
Stuart	Andrew	Bayesian Lagrangian Data Assimilation (to be updated)	amit apte, chirs jones
Suciu	Alexandru	Quasi-Kahler Bestvina-Brady groups	Alexandru Dimca and Stefan Papadima
Suciu	Alexandru	Formality, Alexander invariants, and a question of Serre	Alexandru Dimca and Stefan Papadima
Suciu	Alexandru	Non-finiteness properties of fundamental groups of smooth projective varieties	Alexandru Dimca and Stefan Papadima
Suciu	Alexandru	On the topology of mirror complexes	Graham Denham
Suciu	Alexandru	Moment-angle complexes, monomial ideals, and Massey products	Graham Denham
Suidan	Toufic	Transition Measures for the Stochastically Forced Burgers Equation	Jonathan Mattingly
Suidan	Toufic	Random Matrices, Non-Intersecting Random Walks, and some Aspects of Universality	
Traub	Cynthia	Semidefinite Representation of k-ellipses	Jiawang Nie, Pablo Parillo, Bernd Sturmfels, Josephine Yu
Traub	Cynthia	Topology, Triangulations, and k-ellipses	
Treibergs	Andrejs	A Capture Problem in Brownian Motion and Eigenvalues of Spherical Domains	Jesse Ratzkin
Treibergs	Andrejs	On the Compression of Elastic Tubes	Feng Liu
Treibergs	Andrejs	Instability in a chemical front driven by curvature	
Treibergs	Andrejs	On hearing the area of a convex surface from a finite part of the spectrum	
Ulrich	Bernd	Row ideals and fibers of morphisms	David Eisenbud
Ulrich	Bernd	Asymtotic behavior of the regularity of powers	
Van Roessel	Henry	Homogenization Methods for Singularly Perturbed Random Dynamical Systems	N. Sri Namachchivaya
Viaclovsky	Jeff	TBA	TBA

Vrecica	Sinisa	On Knaster's conjecture	
Vrecica	Sinisa	On the general equipartition problem	
Wang	Changyou	Finte time singularity of Landau-Lifshitz-Gilbert equation in dimension 3 or 4	Ding, Shijin
Wang	Changyou	Smoothness of heat flow of harmonic maps with gradients in L^{n,\infty}	
Wanner	Thomas	Probabilistic and Numerical Validation of Homology Computations	Sarah Day, Bill Kalies, Konstantin Mischaikow
Wanner	Thomas	Rigorous Numerics for the Cahn-Hilliard Equation on the Unit Square	Stanislaus Maier-Paape, Ulrich Miller, Konstantin Mischaikow
Wanner	Thomas	Probabilistic Validation of Homology Computations for Nodal Domains	Konstantin Mischaikow
Wanner	Thomas	Numerical Validation of Homology Computations for Nodal Domains	Sarah Day, Bill Kalies
Webster	Kevin	Shift Dynamics near T-point heteroclinic cycles	Jeroen Lamb, Juergen Knobloch
Wechselberger	Martin	Stability analysis of electrical waves in the heart	Margareth Beck, Chris Jones
Wechselberger	Martin	Analysis of Mixed Mode Oscillations in HH-like neuron models	Jonathan Rubin
Wei	Guofang	Manifolds with A Lower Bound on the Bakry-Emery Ricci Tensor	Will Wylie
Wei	Guofang	A Neumann Type Maximum Principle for the Laplace Operator on Compact Riemannian Manifolds	Rugang Ye
Wei	Guofang	The Cut-off Covering Spectrum	Christina Sormani
Weinkove	Ben	Kahler-Einstein metrics and Tsuji's iteration	Jian Song
Welker	Volkmar	Complexes of injective words	Jakob Jonsson
Welker	Volkmar	Lectures on Algebraic Combinatorics	
Wickramasekera	Neshan	On the singularities of mean curvature flow of mean convex hypersurfaces	
Wickramasekera	Neshan	Some multiplicity 1 regularity theorems for minimal submanifolds	
Wickramasekera	Neshan	A frequency function and singular set bounds for immersed minimal hypersurfaces	L. Simon
Wickramasekera	Neshan	On the singularities of mean curvature flow of mean convex hypersurfaces	
Wickramasekera	Neshan	A frequency function and singular set bounds for immersed minimal hypersurfaces	L. Simon
Wiley	Daniel	A Nonlocal H-Theorem for Coupled Oscillators	
Wiley	Daniel	The Asymptotic Stabilty of a Weakly Perturbed Two-Dimensional Non-Hamiltonian System.	Sri Namachchivaya
Wiley	Daniel	The "Down-Low" Effect on the Spread of HIV Among African Americans	Evelyn K. Thomas
Wilkin	Graeme	Homotopy groups of the SL(2, C) character variety	Georgios Daskalopoulos
Wilkin	Graeme	Kirwan Surjectivity for the K-theory of quiver varieties	Megumi Harada
Wilking	Burkhard	Limit space of manifolds with lower Ricci curvature bound	Vitali Kapovitch
Wilking	Burkhard	New Ricci flow invariant curvature conditions in large dimensions	Christoph Boehm
Witte	Nikolaus	Graph Drawing with 'polymake'	Michael Joswig, Thilo Roerig, Ewgenij Gawrilow
Witte	Nikolaus	Knotted Tori	Frank Lutz, Juergen Bokowski
Wojtkowski	Maciej	Gaussian Thermostats as geodesic flows of nonsymmetric linear connections	P. Przytycki
Wojtkowski	Maciej	Geometry of Kalman filters	
Wojtkowski	Maciej	Fluctuation theorems in reversible dynamics	Lai-Sang Young
Wojtkowski	Maciej	Piecewise linear maps of T^2	Mark Demers
Worytkiewicz	Krzysztof	Towards a homotopy theory of higher-dimensional automata	Peter Bubenik
Worytkiewicz	Krzysztof	Some remarks on locally ordered spaces	
Worytkiewicz	Krzysztof	Model structures by saturation	
Wylie	William	Betti Numbers at infinty and Ricci curvature	
Wylie	William	Fundamental Group and Ricci curvature with measure	
Yang	Tonghai	CM values of HIlbert modular forms II	J. Bruinier, S. Kudla
Yang	Tonghai	An Arithmetic Intersection formula on a Hilbert modular surface	
Yang	Tonghai	An Arithmetic Intersection formula on a Hilbert modular surface II-general case	
Yang	Tonghai	Heegner points and nonvanishing of Hecke L-functions	Riad Masri
Young	Lai-Sang	Shear-induced chaos	Kevin Lin
Young	Lai-Sang	Strange attractors for PDEs	Q Wang and K Lu
Zhang	Zhou	finite time singularity of Kaehler-Ricci flow (tentative)	Gang Tian
Zhang	Zhou	modified Kaehler-Ricci flow and complex Monge-Ampere equation (tentative)	
Zheng	Yu	The ASD connection and its related flow on 4-manifolds	Min-Chun Hong
Zheng	Yu	On the flow of one mixed discriminate d curvature of hypersurface	
Ziegler	Gunter	Polytopes and surfaces via projections	Raman Sanyal, Thilo Schroeder
Ziegler	Gunter	Combinatorial Z_p-Stokes formulas	Raman Sanyal, Carsten Schultz, Bernhard Hanke, et al.
Zivaljevic	Rade	Splitting multidimensional necklaces; Consensus division in arbitrary dimension with perpendicular hyperplanes	De Longueville Mark
Zivaljevic	Rade	New directions, new ideas in topological graph theory (tentative)	
Zomorodian	Afra	On the Local Behavior of Spaces of Natural Images	Gunnar Carlsson, Tigran Ishkhanov, and Vin de Silva
Zomorodian	Afra	A new structural metric for membrane fusion: analysis of molecular dynamics data	Peter M. Kasson, Sanghyun Park, Nina Singhal, Leonidas J. Guibas, and Vijay S. Pande
Zomorodian	Afra	Localize Homology	Gunnar Carlsson
Zomorodian	Afra	Multidimensional Persistence	Gunnar Carlsson

2007 Postdoctoral Placement List

Last Name	First Name	Placement Institution	Placement Department	Placement Position	State	Country
Wiley	Daniel	University of Maryland	Department of Mathematics	Avron Douglis Assistant Professor	MD	US
Macabea	Joyce	Molecular Sciences Institute	Molecular Sciences Institute	Research Fellow	CA	US
Cao	Xiaodong	Cornell University	Department of Mathematics	Assistant Professor	NY	US
Alexakis	Spyros	Princeton University	Department of Mathematics	Instructor	NJ	US
Beck	Margaret	University of Surrey	Department of Mathematics	Research Fellow		GB
Karigiannis	Spiros	University of Oxford	Mathematical Institute	Marie Curie Incoming International Fellow		GB
Eriksson	Nicholas	University of Chicago	Department of Statistics	NSF Postdoctoral Fellow	IL	US
Traub	Cynthia	St. Mary's College	Department of Mathematics and Computer Science	Assistant Professor	MD	US
Chen	Szu-yu Sophie	Miller Institute	Miller Institute	Miller Fellow	CA	US
Lin	Christopher	Tulane University	Department of Mathematics	Postdoctoral Researcher	LA	US
Sesum	Natasa	Columbia University	Department of Mathematics	Ritt Assistant Professor	NY	US
Beheshti Zavareh	Roya	Queen's University	Department of Mathematics	Adjunct Assistant Professor		CA
Santoro	Bianca	Duke University	Department of Mathematics	Assistant Research Professor	NC	US
Liu	Fu	University of California, Davis	Department of Mathematics	Assistant Professor	CA	US
Schultz	Carsten	Technische Universität	Fachbereich Mathematik	Researcher		DE
Caputo	Maria-Cristina	University of Texas	Department of Mathematics	Instructor	TX	US
Zhang	Zhou	University of Michigan	Department of Mathematics	Post-Doc Assitant Professor	MI	US
Apte	Amit	TIFR	Center For Applicable Mathematics	Fellow		IN
Day	Sarah	College of William and Mary	Department of Mathematics	Assistant Professor	VA	US
Demers	Mark	Faifield University	Department of Mathematics and Computer Science	Assistant Professor	CT	US
Hamzi	Boumediene	Duke University	Department of Mathematics	Visiting Assistant Professor	NC	US
Hoffman	Aaron	Boston University	Department of Mathematics	NSF Postdoctoral Fellow	MA	US
Song	Jian	Rutgers University	Department of Mathematics	Assistant Professor	NJ	US
Witte	Nikolaus	Technische Universität	Fachbereich Mathematik	Researcher		DE
Chau	Albert	University of Waterloo	Department of Pure Mathematics	Assistant Professor		CA
Purdom	Elizabeth	University of California, Berkeley	Department of Mathematics and Statistics	Postdoctoral Researcher	CA	US

2007 MSRI Summer Graduate Workshops

Derived Categories in Algebraic Geometry

Date: (June 04, 2007 to June 16, 2007)
Location: University of Utah

Organizers: Aaron Bertram (University of Utah), Y.P. Lee (university of Utah), Eric Sharpe (University of Utah and Virginia Tech)

Speakers:

- Aaron Bertram (University of Utah)
- Andrei Calderaru (University of Wisconsin-Madison)
- Patrick Clarke (University of Miami)
- Alastair Craw (University of Glasgow)
- Eric Sharpe (University of Utah and Virginia Tech)

Over the last several years derived categories have emerged in a remarkable interaction between algebraic geometry and physics. Perhaps the origin of this interaction was a conjecture of Kontsevich for a new picture of mirror symmetry.

Kontsevich's proposed understanding of mirror symmetry, now known as "homological mirror symmetry," recasts mirror symmetry is as an equivalence of categories between the derived category of coherent sheaves on one Calabi-Yau and a derived Fukaya category on the mirror Calabi-Yau.

The first week of this two-week course will focus on the basics of derived categories of coherent sheaves, including the McKay correspondence and derived categories of toric varieties.

The second week will be devoted to more advanced topics, including stability conditions, applications to Landau-Ginzburg models and mirror symmetry. The course will be followed by a Summer Research Conference at Snowbird (see http://www.math.utah.edu/src2007).

Prospective participants must apply online at the website http://www.math.utah.edu/dc/app.htm. MSRI will provide funding for several students from MSRI Academic Sponsoring Institutions who are selected through the application process as participants.

IAS/PCMI Summer Conference: Statistical Mechanics

Date: July 01, 2007 to July 21, 2007
Location: IAS/Park City Mathematics Institute, Salt Lake City, UT

Organizers: Scott Sheffield, Thomas Spencer

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

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

For course titles and descriptions, please visit
http://www.admin.ias.edu/ma/current/program_gradsummer.php

Data Assimilation for the Carbon Cycle

Date: July 08, 2007 to July 13, 2007
Location: Boulder, CO.

Organizers: James Clark (Duke University), Inez Fung (University of California, Berkeley), Eugenia Kalnay (University of Maryland), Jeffrey Anderson, David Baker, Douglas Nychka, and David Schimel, (National Center for Atmospheric Research)

This workshop will expose students in the geosciences, ecology, and mathematics to multidisciplinary science through a focus on estimating the sources and sinks of carbon for the Earth system. One goal is to train the next generation of researchers to work within a multidisciplinary science team that combines geoscientists, ecologists, applied mathematicians, and statisticians. Participants will obtain an overview of this problem but also some specific skills in tackling inverse problems and working with geophysical and biogeochemical models.

Prospective participants must apply online at The Institute for Mathematics Applied to Geosciences (IMAGe). MSRI will provide funding for several students from MSRI

Academic Sponsoring Institutions who are selected through the application process as participants.

Continuous Optimization and Applications

Date: July 09, 2007 to July 20, 2007
Location: MSRI

Organizer: Henry Wolkowicz (University of Waterloo)

This workshop is intended to introduce to graduate students the main ideas of Continuous Optimization and its Applications. In particular, we emphasize the major developments in the last ten years. This includes the use of interior point methods in the solution of large scale linear and nonlinear programs. The workshop includes a hands-on approach. Numerical tests will be done using the NEOS Server for Optimization. and the large group of NEOS Solvers.. Solution interpretation and sensitivity analysis will be emphasized.

The workshop is divided into three series of lectures and hands-on labs:

- The first series includes an introduction to the modern theory of convex programming, its extensions and applications. This includes separation and support theorems, and Lagrange multiplier results. This series emphasizes that: the great watershed in optimization is not between linearity and nonlinearity, but convexity and nonconvexity (Rockafellar, 1993.)

- The main series of lectures involves numerical algorithms for general nonlinear optimization. This includes both modern interior point approaches as well as classical Lagrange multiplier methods such as sequential quadratic programming, SQP. We include applications to engineering and financial problems and emphasize the large scale case.

- The final series concentrates on specialized topics and applications. In particular, this includes optimization over convex sets described as the intersections of the set of symmetric, positive semidefinite matrices with affine spaces, i.e. Semidefinite Programming. This area has attracted a lot of interest due to the number of important applications, to e.g. Discrete Optimization and more general Engineering Problems. We will study and use several current solvers that are in the public domain.

Deformation Theory and Moduli in Algebraic Geometry

Date: July 23, 2007 to August 03, 2007
Location: MSRI

Organizers: Max Lieblich (Princeton University), Martin Olsson (University of California, Berkeley), Brian Osserman (University of California, Berkeley), Ravi Vakil (Stanford University)

This workshop is intended to introduce to graduate students the main ideas of deformation theory and moduli spaces in algebraic geometry. We hope to illuminate the general theory through extensive discussions of concrete examples and applications. The intended audience is the graduate student with a strong interest in algebraic geometry, having at least some familiarity with the language of schemes, and ideally comfortable with the content of Hartshorne's book Algebraic Geometry.

The workshop will be anchored by three lecture series on different aspects of the subject, as well as student projects aimed at furthering an understanding of the lectures and pursuing more advanced topics. The lecture series are:

- Moduli spaces: functors, algebraic spaces, stacks, algebraic stacks (Lieblich).
- Deformations (a): tangent and obstruction spaces (Olsson).
- Deformations (b): representability and Schlessinger's criterion (Osserman).

Accompanying the lectures will be a collection of tightly integrated exercises. A large portion of the workshop will be devoted to these exercises, with the students expected to work on them in the afternoon and evening. In addition, students will be expected to give short presentation on background material, which will be arranged in advance.

2007 Graduate Student Program Summary

Participants	Underrepresented Minorities	Females	Hispanic	Native American	Asian	Black	Pacific Islander	Permanent Resident	U.S. Citizens
149	32	32	0	0	3	0	0	8	11

2007 MSRI Undergraduate Program

(June 17, 2007 to July 29, 2007)

Organizers: Dr. Ricardo Cortez, Dr Ivelisse Rubio, Dr. Herbert Medina, Dr. Suzanne Weekes, Dr. Duane Cooper.

The MSRI-UP is a comprehensive program for undergraduates that aims at increasing the number of students from underrepresented groups in mathematics graduate programs. MSRI-UP includes summer research opportunities, mentoring, workshops on the graduate school application process, and follow-up support. The MSRI-UP will:

- Train undergraduates in mathematical research through a six-week summer program at MSRI in Berkeley, CA
- Provide participating students opportunities to present their research at national conferences in the year following the summer program
- Introduce participating students to a network of mentors through national societies known for their mentoring activities and professional support for students
- Guide students in the process of applying to graduate programs and fellowships

Details of the 2007 summer program:

- Twelve students will participate in research on Computational Mathematics led by Dr. Juan Meza from the Lawrence Berkeley National Laboratory and two graduate assistants
- Students who will finish their sophomore or junior year in 2007 are preferred. African American, Latino and Native American students are especially sought

- Each student will receive room and board, a $3,000 summer stipend, transportation to and from Berkeley, and funding to attend a national conference
- For further information, see our description/requirements page at http://www.msri.org/up/description2007 or contact any one of the program Directors:

Dr. Ricardo Cortez rcortez@tulane.edu, 2007 (on-site Director)
Dr. Ivelisse Rubio ive@mate.uprh.edu
Dr. Herbert Medina hmedina@lmu.edu
Dr. Suzanne Weekes sweekes@wpi.edu
Dr. Duane Cooper dcooper@morehouse.edu

2007 Undergraduate Student Participants:

Patrick Cesarz *Villanova University*, Mathematics
Luis de la Torre *University of California, Davis*, Mathemtics and Economics
Natalie Durgin *Harvey Mudd College*, Mathematics
Sean Ewing *Morehouse College*, Mathematics
Sofia Garcia *DePaul University*, Mathematics
Donavian Huskey *Harvey Mudd College*, Mathematics
Talea Mayo *Grambling State University*, Mathematics
Gina Pomann *The College of New Jersey*, Mathematics
Thomas Pulickal *University of Texas*, *Pan American*, Mathematics & Computer Science
Carmen Smith *Spelman College*, Mathematics
Greta Villarosa *The College of William and Mary*, Mathematics
Mitch Wilson *University of Arizona*, Mathematics and Mechanical Engineering

2007 MSRI Undergraduate Student Program Summary

First Name	Last Name						
Patrick	Cesarz						
Luis	de la Torre						
Natalie	Durgin						
Sofia	Garcia						
Donavion	Huskey						
Talea	Mayo						
Gina-Maria	Pomann						
Carmen	Smith						
Greta	Villarosa						
Mitch	Wilson						
Thomas	Pulickal						
Sean	Ewing						

status/ grant title	grantor	amount	date start	grant id	date end	name
Current						
The Geometry of Partial Differential Equations	NSF - National Science Foundation	$387,560.00	7/1/2006	DMS - 0604195	6/30/2008	Bryant, Robert
Coop. Agreement, 5 year renewal	NSF - National Science Foundation	$17,729,052.00	7/1/2005	DMS 0441170	6/30/2010	Bryant, Robert
Teacher Training Program for Math Circles (Collaborative Teaching)	SD Bechtel, Jr. Foundation	$150,000.00	8/26/2005	TTP 150000	12/31/2007	Eisenbud, David
Practical and Intellectual Support for Mathematical Computation	NSA - National Security Agency	$400,000.00	10/1/2007	MSPF-081C-002	9/30/2008	Bryant, Robert
S.F. Circle for Teachers	S.D. Bechtel Jr.	$50,106.00	7/10/2006	S.F. Math Teachers	12/31/2007	Sotiros, James
Critical Issues in Education: Math Knowledge for Teachers	Noyce Foundation	$25,000.00	8/1/2006	Math Knowledge	12/31/2007	Eisenbud, David
Julia Robinson Mathematics Festival & Contest	Nancy & David desJardins	$19,250.00	2/2/2007	Julia Robinson Math Fest	12/31/2007	Sotiros, James
Oakland/East Bay Math Circle & Circle for Teachers	Firedoll Foundation	$25,000.00	3/5/2007	Oakland/East Bay Math Circles Firedoll	7/31/2008	Sotiros, James
Girls Math Olympiad in China	MAA/Akamai	$43,500.00	5/1/2007	GMO in China MAA/Akamai	12/31/2007	Eisenbud, David
Girls Math Olympiad in China	IBM	$35,000.00	5/1/2007	GMO in China IBM	12/31/2007	Eisenbud, David
San Francisco Math Circle for Teachers	S.D. Bechtel, Jr.	$50,000.00	8/1/2007	SF Math Circle SDBechtel	7/31/2008	Sotiros, James
Professor Wu's Summer Math Institutes / Elementary Teachers	S.D. Bechtel, Jr.	$135,000.00	8/1/2007	Wu Summer Institutes SDBechtel	7/31/2008	Sotiros, James

Oakland/East Bay Math Circle & Teachers Circle	S.D. Bechtel, Jr.	$75,000.00	8/1/2007	O/EB Math Circle & Teacher Circle SDBechtel	7/31/2008	Sotiros, James
Girls Math Olympiad in China	Chou Foundation	$10,000.00	5/1/2008	GMO in China Chou Foundation	12/31/2008	Eisenbud, David
Critical Issues in Education: Teaching Teachers Mathematics	Noyce Foundation	$25,000.00	8/1/2007	Math Knowledge	12/31/2008	Eisenbud, David
Oakland/East Bay Math Circles	Simons Foundation	$25,000.00	7/1/2007	Oakland/East Bay Math Circles Simons Foun	7/31/2008	Eisenbud, David
Math Circles	Elwyn Berlekamp	$5,000.00	7/1/2007	Math Circles Berlekamp	7/31/2008	Eisenbud, David
Bay Area Mathematics Olympiad (BAMO) and Bay Area Mathematical Circles (BAMC)	Hilde L. Mosse Foundation	$50,000.00	8/1/2007	BAMO	7/31/2008	Eisenbud, David
Advances in Algebra & Geometry	NSA - National Security Administrati	$25,000.00	3/15/2007	H98230-07-1-0091	3/14/2008	Brend Sturmfels
Mathematical Sciences Research Institute Undergraduate Program (MSRI-UP)	NSA - National Security Administrati	$155,000.00	4/18/2007	H98230-07-1-0084	4/17/2008	Eisenbud & Cortez
10th Yr EDGE Gradate Women's Program	NSA - National Security Administrati	$61,000.00	4/25/2007	H98230-07-1-0110	4/24/2008	Bozeman, Hughes
Modern Mathematics Workshop	NSA - National Security Agency	$49,107.00	5/14/2007	H98230-07-1-0109	5/13/2008	Cortez, Ricardo
Workshop on the Mathematics of Visual Analysis	NSF - National Science Foundation	$34,980.00	8/15/2006	CCF-0639579	8/14/2008	Rossi & Hanrahan
Workshop - Lie Theory	NSA - National Security Agency	$20,000.00	10/10/2008	MSPR-07C-021	10/14/2008	Stanley & Zelmanowitz
Introductory Workshop on Combinatorial Representation Theory	NSA - National Security Agency	$15,000.00	1/21/2008	MSPR-07C-045	1/25/2008	Schilling and O'Hara
Workshop - Representation Theory of Finite Groups and Related Topics	NSA - National Security Agency	$15,000.00	1/28/2008	MSPR-07C-048/H98230-08-1-0007	2/1/2008	Alperin & Zelmanowitz
Computation and Complex Systems	NSF - National Science Foundation	$11,140.00	11/9/2007	DMS-0804070	6/30/2008	Bryant, Robert

Viterbi Endowed Post-Doctoral Scholars	The Viterbi Group	$1,440,000.00	2007	Viterbi Scholars	2008	Sotiros, Jim
Eisenbud Professorship	The Simons Fomdation	$5,000,000.00	2007	Eisenbud Professorship	2011	Bryant, Robert
Simons Colloquium on Mathematics in Biology	The Simons Foundation	$80,000.00	Fall 2007	Colloquium on Mathematics in Biology	7/31/2008	Bryant, Robert
Oakland/East Bay Math Circle and Teachers' Circle	SD Bechtel, Jr. Foundation	$50,000.00	Summer 2008	Oakland/East Bay Math Circle	Summer 2008	Sotiros, James
San Francisco Math Circle for Teachers	SD Bechtel, Jr. Foundation	$100,000.00	Summer 2008	San Francisco Math Circle	Summer 2008	Sotiros, James
Mathematics Professional Development Institute for Elementray School Teachers (Wu Summer Institute)	SD Bechtel, Jr. Foundation	$125,000.00	Summer 2008	Wu Summer Institute		Sotiros, James
Girls Math Olympiad in China	Intel Corporation	$15,000.00	4/1/2008	Intel Corporation		Bryant, Robert
Critcal Issues in Education: Teaching and Learning Algebra (First Grant)	Texas Instruments	$10,000	5/14/2008	Texas Instruments	5/16/2008	O'Hara, Kathleen
Critcal Issues in Education: Teaching and Learning Algebra (Second Grant)	Texas Instruments	$10,000	5/14/2008	Texas Instruments	5/16/2008	O'Hara, Kathleen

Pending

MSRI-UP: MSRI's Undergraduate Program	NSF- National Science Foundation	$484,151.00	1/1/2008	DMS - 0754872	1/1/2012	Bryant, Cortez
Translating, Editing, Publishing and Marketing of Extra-Curricular Books for Mathematically Sophisticated Pre-College Students	John Templeton Foundation	$122,076.00	?	Books for Mathematically Sophisticated Pre-College Students	27 months after start	Bryant, Robert
MSRI-Up MSRI's Undergraduate Program	NSA-National Security Agency	$155,000.00	Summer 2008	08IC-026	?	Bryant, Rubio, Cortez, Medina, Cooper, Weekes
National Math Circle Website	Akamai Foundation	$67,800.00	?	National Math Circle Website		Sotiros, James

Eisenbud Professorship Challenge Grant	The Simons Grant	$5,000,000.00	2007	Eisenbud Professorship Challenge Grant		Bryant, Robert
Clay Senior Scholar	Clay Mathematics Institute	?	?	Clay Senior Scholar	?	Bryant, Robert
Dicrete Rigidity Phenomena in Additive Combinatorics	NSA - National Security Agency	$15,000.00	11/3/2008	08C-024	11/9/2008	Kra & Zelmanowitz
Classic Algebraic Geometry	NSA - National Security Agency	$25,000.00	Jan-09	08C-008	Jan-09	Zelmanowitz, Julius
Combinatorial, Enumerative, and Toric Geometry	NSA - National Security Agency	$20,000.00	Mar-09	08C-007	Mar-09	Zelmanowitz, Julius
Introductory Workshop on Symplectic and Contact Geomtery and Topology	NSA - National Security Agency	$30,000.00	Aug-09	08C-020	Aug-09	Zelmanowitz, Julius
Algebraic structures associated to holomorphic curves and low-dimensional symplectic and contact topology	NSA - National Security Agency	$20,000.00	11/30/2009	08C-019	12/4/2009	Zelmanowitz, Julius
Connections for Women and Introductory Workshop in Tropical Geometry	NSA - National Security Agency	$25,000.00	8/17/2009	08C-021	8/22/2009	Zelmanowitz, Julius
Tropical Structures in Geometry and Physics	NSA - National Security Agency	$15,000.00	Nov-09	08C-023	Nov-09	Zelmanowitz, Julius
Topics in Tropical Geomtery and Physics	NSA - National Security Agency	$15,000.00	10/12/2009	08C-022	10/16/2009	Zelmanowitz, Julius
Modern Moduli Theory	NSA - National Security Agency	$20,000.00	4/1/2009	08C-009	4/1/2009	Zelmanowitz, Julius
MSRI-UP	Morgan Stanley	$50,000.00	1/1/2008	Morgan Stanley		Bryant, Cortez
Girls Math Olympiad in China	Mathematical Association of America	$45,000.00	4/1/2008	Mathematical Association of America		Bryant, Robert
Modern Mathematics	NSA - National Security Agency	$35,421.00	10/8/2008	08IC-033	10/9/2007	O'Hara, Kathleen

PASI Workshop, Mini-courses and Conference on Clsuter Algebras and Related Topics	NSF - National Science Foundation	$99,900.00	12/1/08		12/20/2008	Zelevinsky, Andrei and Zelmanowitz, Julius
Critical Issues in Mathematics Education: Teaching and Learning Algebra	Noyce Foundation	$25,000.00	5/14/2008	Noyce Foundation	5/16/2008	O'Hara, Kathleen
Mathematics of Climate Change	Google	$50,000.00		Google		Bryant, Robert
MSRI-UP	Google	$50,000.00		Google		O'Hara, Kathleen
Simons Colloquium on Mathematics in Biology	The Simons Foundation	$80,000.00	Fall 2007	Colloquium on Mathematics in Biology	7/31/2008	Bryant, Robert
Simons Visting Professors	The Simons Foundation	$120,000.00	2008-2009			Sotiros, Jim
Education Initiative	Math for America	$50,000.00		Math for America		Sotiros, Jim
Chinese Scholars Endowment	Johnson Cha	$700,000.00		Johnson Cha		Sotiros, Jim

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[1] Term of office extended when elected as chair or co-chair of a committee

- Member of the Steering Committee

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Final Report on the 2006–2007 program on

GEOMETRIC EVOLUTION EQUATIONS AND RELATED TOPICS

1 Introduction

The year-long program on Geometric Evolution Equations and Related Topics was held at the Mathematical Sciences Research Institute, Berkeley, California from August 14, 2006 to May 25, 2007. The organizing committee consisted of Bennett Chow (UCSD), Panagiota Daskalopoulos (Columbia), Gerhard Huisken (MPI), Peter Li (UCI), Lei Ni (UCSD), Gang Tian (Princeton).[1] The organizers spent substantial time in residence at MSRI, including Bennett Chow (Fall and Spring), Peter Li (Fall), Lei Ni (Fall), and Tian (2 months in the Spring).

The field of geometric flows has had a rapid recent development and connections are being developed between previously less related areas and flows. An example of this is the spectacular recent work of Perelman and earlier work of Hamilton on Ricci flow relating to the Poincaré and geometrization conjectures. For this reason the program in geometric flows was very well-suited to the resources and environment of MSRI. The workshops brought together researchers working on different geometric flows and allowed for cross-fertilization of ideas and techniques from various flows. The length of the program enabled participants to pursue deeper connections between various flows and areas of geometric analysis. Senior researchers in geometric flows, including the organizers, have been training graduate students and postdocs in the field. The participants included a cross-section of researchers including a balance of postdocs and senior mathematicians.

The year-long program focused on:

1. geometric flows of metrics and connections such as Ricci and Kähler-Ricci, Yang-Mills and Hermitian-Einstein, Calabi, and Yamabe and other conformal flows,

2. geometric flows of submanifolds such as mean, inverse mean, Gauss curvature and Willmore flows,

3. harmonic map heat flow and related topics, heat equation and function theory,

4. nonlinear parabolic equations, computational methods, discrete heat equation on graphs.

[1] On December 7, 2005 Richard Hamilton (Columbia) resigned from the organizing committee. The circumstances surrounding this resignation are too complex to discuss in this report except to say that an effort was made to keep Hamilton on the committee and Hamilton's resignation, although very regrettable, was based on issues deemed by the organizers to be unrelated to the program.

2 Participants

2.1 Long term (3 months or more)

- Bennett Chow (organizer, UC-San Diego)
- Thalia Jeffres (Wichita)
- Peter Li (Chancellor's professor, organizer, UC-Irvine)
- Jun Ling (Utah Valley)
- John Lott (Simons Professor, Michigan)
- Peng Lu (Oregon)
- Lei Ni (organizer, UC-San Diego)
- Andrejs Treibergs (Utah)
- Jiaping Wang (Minnesota)
- Neshan Wickramasekera (UC-San Diego)

2.2 Medium term (1–3 months)

- David Fisher (Indiana)
- Boris Khesin (Toronto)
- Wilhelm Klingenberg (Durham)
- Dan Knopf (Texas)
- Philippe LeFloch (Jussieu)
- Jiayu Li (ICTP)
- Sema Salur (Rochester)
- Weimin Sheng (Zhejiang)
- Knut Smoczyk (Hannover)
- Gang Tian (organizer, Princeton)
- Burkhard Wilking (Münster)
- Yuanglong Xin (Fudan)
- Yu Zheng (East China Normal)

2.3 Short term (less than 1 month)

- Sun-Yung Alice Chang (Princeton)
- Xiuxiong Chen (Wisconsin)
- Sun-Chin Chu (Chung Cheng)
- Panagiota Daskalopoulos (organizer, Columbia)
- Christine Guenther (Pacific)
- Gerhard Huisken (organizer, MPI)
- James Isenberg (Oregon)
- John Morgan (Columbia)
- Duong Phong (Columbia)
- Peter Topping (Warwick)
- Dong-Ho Tsai (Tsing Hua)
- Jeff Viaclovsky (Wisconsin)
- Changyou Wang (Kentucky)
- Guofang Wei (UC-Santa Barbara)
- Ben Weinkove (Harvard)
- Yu Yuan (Washington)
- Qi Zhang (UC-Riverside)

2.4 Yearlong postdocs

- Maria-Cristina Caputo (Columbia 2006 PhD, now at U Texas)
- Szu-yu Sophie Chen (Princeton 2006 PhD, now at UC-Berkeley (Miller Fellow))
- Spiro Karigiannis (Michigan State, now at Oxford)
- Junfang Li (Oklahoma 2006 PhD, Now at McGill)
- Christopher Chun-Peng Lin (UCI 2006 PhD, now at Tulane)
- Murugiah Muraleetharan (Lehigh 2006 PhD, now at UC-Riverside)
- Zhou Zhang (MIT 2006 PhD, now at Michigan)

2.5 Fall semester postdocs

- Vincent Bonini (UC-Santa Cruz 2006 PhD, now at McMaster)
- Qingchun Ji (Fudan)
- Qinian Jin (Rutgers 2006 PhD, now at U Texas)
- Bianca Santoro (MIT 2006 PhD, now at Duke)
- William C. Wylie (UC-Santa Barbara 2006 PhD, now at UCLA)

2.6 Spring semester postdocs

- Spyridon Alexakis (Princeton, at Toronto starting 2008)
- Xiaodong Cao (Cornell)
- Albert Chau (Waterloo)
- Natasa Sesum (Columbia, at U Penn starting 2009)
- Jian Song (Johns Hopkins, now at Rutgers)
- Graeme Peter Wilkin (Johns Hopkins)

2.7 Graduate students

- Tsz Ho Fong (CUHK 2007 Masters student, now Stanford PhD student)
- Brett Kotschwar (UC-San Diego 2007 PhD, now MIT instructor)
- Christopher Tiee (UC-San Diego PhD student)

Fresh Ph.D.s (and one graduate student) who were on the market and found instructorships or assistant professorships starting in Fall 2007 are: Vincent Bonini, Brett Kotschwar, Junfang Li, Christopher Chun-Peng Lin, Murugiah Muraleetharan.

3 Workshops

1. **Connections for Women: Geometric Analysis and Nonlinear Partial Differential Equations.** September 8, 2006 to September 9, 2006. URL: http://www.msri.org/calendar/workshops/WorkshopInfo/379/show_workshop

Organized By: Christine Guenther and Panagiota Daskalopoulos.

This intensive two-day workshop for women introduced advanced graduate students and recent PhDs to current topics in nonlinear partial differential equations related to geometric analysis. It consisted of introductory mini-courses and talks, as well as a poster session in the afternoon of the first day where all participants were encouraged to present their work. There was a panel discussion in the afternoon of the second day on issues related to women in mathematics. The workshop was very active with the relatively large number of participants for a two day workshop. This workshop was also very well attended by the postdocs at MSRI. There were 44 registered participants.

2. **Introductory Workshop on Geometric Flows and Function Theory in Real and Complex Geometry.** September 11, 2006 to September 15, 2006. URL: http://www.msri.org/calendar/workshops/WorkshopInfo/380/show_workshop

Organized By: Bennett Chow, Peter Li and Gang Tian.

The goal of the Introductory Workshop was to survey current and recent developments in geometric evolution equations and function theory in real and complex geometry. Main topics included: Geometric flows in complex geometry, Function theory on manifolds, Ricci flow and canonical metrics, Mean curvature flow and applications. These topics are tied together by the common goal of understanding the relations between the geometry, analysis, and topology of manifolds, submanifolds, vector bundles, maps, and other geometric structures. A special characteristic of the workshop was that a majority of the talks was given by (outstanding) relatively junior mathematicians (who received their Ph.D. within 3 years). In particular, speakers included Albert Chau, Andre Neves, Natasa Sesum, Jian Song, Ben Weinkove, and Zhou Zhang. One of the highlights was the concentration of talks in one of the most active areas in geometric flows: Kähler–Ricci flow. There were many positive responses from postdocs who found this an excellent introduction to a hot topic. There were 56 registered participants.

3. **Analytic and Computational Aspects of Elliptic and Parabolic Equations.** October 23, 2006 to October 27, 2006. URL: http://www.msri.org/calendar/workshops/WorkshopInfo/383/show_workshop

Organized By: Panagiota Daskalopoulos, Peter Li and Lei Ni.

The theme of the workshop was on the relation between linear and nonlinear elliptic and parabolic partial differential equations and the geometry and analysis of Riemannian and Kähler manifolds. The topics of the talks centered on eigenvalue estimates, regularity of minimal maps, isoperimetric inequalities

for minimal surfaces and surfaces flows with applications to general relativity, Yamabe equation, heat kernels on weighted manifolds, entropy and optimal transportation techniques in Ricci flow, solution to the space form problem using Ricci flow, Kähler-Ricci flow and holomorphic functions, degenerate complex Monge-Ampere equations, Kähler-Einstein metrics, and Calabi-Yau manifolds. One of the highlights was the number of well-known speakers including Christoph Böhm, Simon Brendle, Alexander Grigor'yan, Gerhard Huisken, Zhiqin Lu, Duong Phong, Richard Schoen, Leon Simon, Peter Topping. There were a large number of very positive comments by participants. There were 50 registered participants.

4. **Geometric Evolution Equations.** March 12, 2007 to March 16, 2007. URL: http://www.msri.org/calendar/workshops/WorkshopInfo/386/show_workshop

Organized By: Bennett Chow, Gerhard Huisken, Chuu-Lian Terng, and Gang Tian.

The main theme of the workshop was geometric flows, which have been applied to a variety of geometric, topological, analytical and physical problems. There were a large number of talks on Ricci flow, Kähler–Ricci flow, and mean curvature-type flows emphasizing interactions between ideas in analysis and geometry as well as applications to differential geometry, algebraic geometry, topology, and mathematical physics. Applications in geometry included uniformization-type problems where canonical geometric structures are constructed using flow techniques. Monotonicity techniques were explored which yielded applications to isoperimetric problems and estimates for heat-type flow. Well-known speakers included Simon Brendle, Robert Bryant, Xiuxiong Chen, Klaus Ecker, Dan Knopf, John Lott, Rafe Mazzeo, Natasa Sesum, Burkhard Wilking. There were also a number of junior European mathematician speakers including Jan Metzger, Reto Mueller, Todd Oliynyk, Felix Schulze. There were many well-known participants in addition to the speakers. There were a large number of very positive comments by participants. There were 90 registered participants.

5. **Recent Developments in Numerical Methods and Algorithms for Geometric Evolution Equations.** March 16, 2007 to March 17, 2007. URL: http://www.msri.org/calendar/workshops/WorkshopInfo/417/show_workshop

Organized By: Charles Elliott, Xiaobing Feng, Michael Holst, Hongkai Zhao.

The workshop emphasized the applications of geometric evolution equations to many scientific, engineering and industrial problems. Recently, significant progress has been made in computational methods and algorithms for geometric evolution equations. Powerful numerical methods, which are based on the level set and the phase field methodologies and combine well-known discretization methods such as finite difference methods, finite element methods, finite volume methods and spectral methods with efficient solution methods such as adaptive mesh methods, multilevel methods and domain decomposition methods, have greatly increased the capability of computing solutions of complicated nonlinear geometric evolution equations, in particular, in higher dimensions. The talks in this workshop discussed these recent developments. The organizers felt there was excellent interaction between mathematicians studying geometric flows from the theoretical and numerical points of view. There were 25 registered participants.

4 Postdoc and reading/learning seminar

The postdoc seminar was a very active seminar. On Fridays there was the joint postdoc seminar where postdocs from both programs gave 30 minute colloquium style talks. This benefitted especially the postdocs who were on the market (all of the postdocs in the geometric evolution equations program who did not have jobs for the following year found jobs in academic institutions). On Tuesdays was the geometric evolution equations program postdoc seminar which consisted of a 50 minute seminar style talk. In the fall the postdoc seminar was organized by Maria-Cristina Caputo and in the spring the postdoc seminar was organized by Xiaodong Cao.

Besides the postdoc seminar there was also a reading/learning seminar. In the fall the seminars main topic was Ricci flow. Many of the postdocs and some graduate students gave talks in this seminar in which they started by learning the basics of Ricci flow and quickly got to topics at the forefront of current research. This seminar was organized by Spiro Karigiannis and Andrejs Treibergs. In the spring the seminar had two main topics: (1) Kähler geometry and Kähler–Ricci flow and (2) geometric flows other than Ricci flow such as curvature flows of submanifolds and curvature flows related to special holonomy. This seminar was organized by Maria-Cristina Caputo, Spiro Karigiannis (main organizer), Christopher Lin, and Murugiah Muraleetharan.

There were also a number of informal seminars throughout the year.

5 Geometric evolution equations seminar

Speakers presented their recent original research in this seminar. Speakers included:

1. Dong-Ho Tsai (National Tsing Hua University)
2. Sun-Chin Chu (National Chung Cheng University)
3. Wilhelm Klingenberg (University of Durham)
4. Jiayu Li (The Abdus Salam ICTP)
5. Changyou Wang (University of Kentucky)
6. Lei Ni (UC San Diego)
7. Peter Li (University of California, Irvine)
8. Andrejs Treibergs (University of Utah)
9. Panagiota Daskalopoulos (Columbia University)
10. Thalia Jeffres (Wichita)
11. Dan Knopf (U Texas Austin)

12. Jeff Viaclovsky (U of Wisconsin)
13. John Morgan (Columbia University)
14. Simon Brendle (Stanford University)
15. Xiu-Xiong Chen (U of Wisconsin)
16. Boris Khesin (Toronto)
17. John Lott (U of Michigan)
18. Gang Tian (Princeton)
19. Ben Weinkove (Harvard)
20. Weimin Sheng (Zhejiang University)
21. Albert Chau (Waterloo)
22. Jun Ling (Utah Valley)
23. Yu Zheng (East China Normal University)
24. Emmanuel Hebey (Cergy-Pointoise)
25. Burkhard Wilking (Münster)
26. Philippe LeFloch (Jussieu)
27. Gerhard Huisken (MPI)
28. Jiaping Wang (U of Minnesota)
29. Guofang Wei (UC Santa Barbara)
30. Sema Salur (Rochester)
31. Neshan Wickramasekera (UC San Diego)

Highlights included the lecture series by

1. Gerhard Huisken on "Isoperimetric estimates via the inverse mean curvature flow, I, and II."
2. Peter Li on "Complete Kaehler manifolds with positive spectrum I, and II" and "Curvature, Poincaré inequality, and the structure of complete manifolds."
3. John Lott on "Ricci curvature and optimal transport I, and II."
4. John Morgan on "Finite extinction time for certain Ricci flows, I, and II."
5. Gang Tian on "Curve. Shortening and Finite Time Extinction in Ricci Flow, I, and II."

6. Jiaping Wang on "Harmonic functions and applications, I, and II" and "A splitting theorem for complete manifolds".

7. Neshan Wickramasekera on "Singularities in geometric variational problems, I, and II."

These lecture series of two or three talks on the speakers research enabled participants to gain a more in-depth understanding of some of the currently most active research topics.

6 Postdoc research originating from or influenced by the MSRI program

1. Spyridon Alexakis

   (a) (with Rafe Mazzeo) Renormalized area and properly embedded minimal surfaces in hyperbolic 3-manifolds. arXiv:0802.2250

2. Vincent Bonini

   (a) (with Jie Qing) A Positive Mass Theorem on Asymptotically Hyperbolic Manifolds with Corners Along a Hypersurface. arXiv:0711.0539

3. Xiaodong Cao

   (a) First Eigenvalues of Geometric Operators under the Ricci Flow. arXiv:0710.3947

   (b) (with Yilong Ni, Laurent Saloff-Coste) Cross Curvature Flow on Locally Homogenous Three-manifolds (I). arXiv:0708.1922

4. Albert Chau

   (a) (with Luen-Fai Tam) A survey on the Kähler-Ricci flow and Yau's uniformization conjecture. arXiv:math/0702257

   (b) (with Luen-Fai Tam, Chengjie Yu) Pseudolocality for the Ricci flow and applications. arXiv:math/0701153

5. Qinian Jin

   (a) A convergence analysis of the iteratively regularized Gauss-Newton method under Lipschitz condition. arXiv:0803.2373

   (b) (with Yanyan Li, Haoyuan Xu) Symmetry and Asymmetry: The Method of Moving Spheres. arXiv:math/0703808

6. Spiro Karigiannis

   (a) Flows of Spin(7)-structures. arXiv:0709.4594 [ps, pdf, other]

(b) (with Naichung Conan Leung) Hodge Theory for G2-manifolds: Intermediate Jacobians and Abel-Jacobi maps. arXiv:0709.2987

(c) Geometric Flows on Manifolds with G_2 Structure, I. arXiv:math/0702077

7. Brett Kotschwar

(a) (with Lei Ni) Local gradient estimates of p-harmonic functions, 1/H-flow, and an entropy formula. arXiv:0711.2291

(b) On rotationally invariant shrinking gradient Ricci solitons. arXiv:math/0702597

(c) Hamilton's gradient estimate for the heat kernel on complete manifolds. arXiv:math/0701335

8. Junfang Li

(a) First variation of the Log Entropy functional along the Ricci flow. arXiv:0712.0832

(b) (with Pengfei Guan) The quermassintegral inequalities for starshaped domains. arXiv:0710.4307

(c) Eigenvalues and energy functionals with monotonicity formulae under Ricci flow. arXiv:math/0701548

9. Christopher Lin

(a) (with Zhiqin Lu) Quantum Layers over Surfaces Ruled Outside a Compact Set. arXiv:math/0701349

10. Natasa Sesum

(a) Compactness results for the Kähler-Ricci flow. arXiv:0707.2974 [ps, pdf, other]

(b) (with Panagiota Daskalopoulos) Classification of singularities in the complete conformally flat Yamabe flow. arXiv:0705.3667

(c) (with Lizhen Ji, Rafe Mazzeo) Ricci flow on surfaces with cusps. arXiv:math/0703357

11. Jian Song

(a) (with Gang Tian) Canonical measures and Kahler-Ricci flow. arXiv:0802.2570

(b) (with Steve Zelditch) Test configurations, large deviations and geodesic rays on toric varieties. arXiv:0712.3599

(c) (with Steve Zelditch) Bergman metrics and geodesics in the space of Kähler metrics on toric varieties. arXiv:0707.3082

(d) (with D.H. Phong, Jacob Sturm, Ben Weinkove) The Kähler-Ricci flow with positive bisectional curvature. arXiv:0706.2852

(e) (with D.H. Phong, Jacob Sturm, Ben Weinkove) The Kähler-Ricci flow and the $\bar\partial$ operator on vector fields. arXiv:0705.4048 [ps, pdf, other]

(f) (with Ben Weinkove) Constructions of Kahler-Einstein metrics with negative scalar curvature. arXiv:0704.1005

(g) (with Steve Zelditch) Convergence of Bergman geodesics on CPˆ1. arXiv:math/0703517

12. Graeme Wilkin

13. (with Georgios Daskalopoulos, Jonathan Weitsman) Morse Theory and Hyperkahler Kirwan Surjectivity for Higgs Bundles. arXiv:math/0701560

14. William Wylie

(a) (with Peter Petersen) On the classification of gradient Ricci solitons. arXiv:0712.1298

(b) (with Peter Petersen) On gradient Ricci solitons with Symmetry. arXiv:0710.3595

(c) (with Peter Petersen) Rigidity of gradient Ricci Solitons. arXiv:0710.3174

(d) (with Guofang Wei) Comparison Geometry for the Bakry-Emery Ricci Tensor. arXiv:0706.1120

(e) Complete Shrinking Ricci Solitons have Finite Fundamental Group. arXiv:0704.0317

15. Zhou Zhang

(a) (with X. X. Chen, G. Tian) On the weak Kähler-Ricci flow

(b) A Modified Kähler-Ricci Flow. arXiv:0801.3473

(c) Scalar Curvature Bound for Kähler-Ricci Flows over Minimal Manifolds of General Type. arXiv:0801.3248

(d) (with Sławomir Dinew) Stability of Bounded Solutions for Degenerate Complex Monge-Ampère equations. arXiv:0711.3643

(e) On Degenerated Monge-Ampere Equations over Closed Kähler Manifolds. arXiv:math/0603465

Topics in which postdocs made original research contributions centered on:

1. Canonical structures (including Kähler–Einstein and constant scalar curvature metrics) in complex geometry and Kähler–Ricci flow

2. Energy, entropy and eigenvalues under Ricci flow

3. Special holonomy metrics via geometric flow techniques

4. Pseudolocality for Ricci flow

5. Structure of Ricci solitons
6. Estimates for heat equations with respect to evolving metrics
7. Yamabe flow
8. Degenerate complex Monge-Ampere equation

7 Research of participants

The year-long program had a very positive impact on the research of the participants including organizers, research professors, key senior scientists, and general members. Some of leaders in research who made substantial research progress during their MSRI visit included: Sun-Yung Alice Chang, Panagiota Daskalopoulos, Gerhard Huisken, James Isenberg, Boris Khesin, Peter Li, John Lott, Peng Lu, John Morgan, Lei Ni, Duong Phong, Gang Tian, Peter Topping, Andrejs Treibergs, Jeff Viaclovsky, Jiaping Wang, Guofang Wei, Ben Weinkove, Neshan Wickramasekera, Burkhard Wilking, Yu Yuan.

A couple of examples of research of participants are:

1. Peter Li, Jiaping Wang.
   (a) Connectedness at infinity of complete Kähler manifolds and locally symmetric spaces. arXiv:math/0701865
   (b) Weighted Poincaré inequality and rigidity of complete manifolds. arXiv:math/0701693
2. John Lott
   (a) Optimal transport and Perelman's reduced volume. arXiv:0804.0343
   (b) Dimensional reduction and the long-time behavior of Ricci flow. arXiv:0711.4063

Books and research-expository projects on Ricci flow which were worked on during the MSRI year included:

1. Morgan, John; Tian, Gang. *Ricci flow and the Poincaré conjecture.* Clay Mathematics Monographs, **3**, AMS, Providence, RI, 2007.
2. AMS books on Ricci flow (GSM vol. 77, MSM vols. 135 and 144) coauthored by MSRI participants Sun-Chin Chu, David Glickenstein, Christine Guenther, James Isenberg, Dan Knopf, Peng Lu, Lei Ni and others.

9 Miscellaneous

Of special note was the exceptional contribution of Andrejs Treibergs during the fall semester in terms of organizing seminars, mentoring postdocs, and contributing to the excellent learning and research atmosphere.

REPORT ON COMPUTATIONAL APPLICATIONS OF ALGEBRAIC TOPOLOGY PROGRAM

MSRI Fall 2006

1 Introduction

The semester-long research program in computational applications of algebraic topology was held at MSRI from August 14, 2006 to December 15, 2006. The organizing committee consisted of Gunnar Carlsson (Mathematics Department, Stanford University), Persi Diaconis (Departments of Mathematic and Statistics, Stanford University), Susan Holmes (Department of Statistics, Stanford University), Rick Jardine (Department of Mathematics, University of Western Ontario), and Günther Ziegler (Institut für Mathematik, Technische Universität Berlin). Among this group, Carlsson and Jardine were in residence throughout the program, and Diaconis, Holmes, and Ziegler participated between September 1 and October 15. Although the applications of algebraic topology cover a broad range of different ideas, the emphasis of the program was usefully divided into two separate themes, one consisting of applications in science and engineering, and the other consisting of work on combinatorics, algorithms, and computational geometry. Carlsson, Diaconis, and Holmes were involved in the first portion, and Carlsson, Diaconis, Jardine, and Ziegler in the second.

The organizers found that because of participants's time constraints, the amount of activity in the first two months was higher than in the period November-December. In particular, there were particular working groups in dynamical systems (within the applications to science and engineering subfield) and in computational geometric algorithms (within the combinatorics subfield) who were in residence only until October 15. In view of this situation, it was decided to schedule all workshops (there were four, including the connections for women workshop) during this period. The decision to run four workshops (higher than usual) was that in view of the fact that computational topology is an emerging discipline, it is important to expose it in public forums as much as possible, with the hope and expectation that it will attract the interest of investigators who might be outside the field. The introductory workshop included high level talks from both the subfields, and covered the main intellectual directions in the area.

2 Personnel

1. Participants in residence for the entire program:
    - Eric Babson (University of California, Davis)
    - Gunnar Carlsson (Stanford University)
    - Peter Csorba (University of Western Ontario)
    - Andre Diatta (Universit of Liverpool)
    - Joel Hass (University of California, Davis)
    - Rick Jardine (University of Western Ontario)
    - Kevin Knudson (Mississippi State University)
    - Ross Staffeldt (New Mexico State University)
    - Krzysztof Worytkiewicz (University of Western Ontario)
    - Afra Zomorodian (Dartmouth College)

2. Long term visitors (one month or more):

    - Pavel Blagojevich ((Serbian Academy, Belgrade))
    - Ken Brown (Cornell University)
    - Peter Bubenik (Cleveland State University)
    - Mark de Longueville (Freie Universität Berlin)
    - Graham Denham (University of Western Ontario)
    - Persi Diaconis (Stanford University)
    - Dmitry Feichtner-Kozlov (Universität Bremen)
    - Eva Feichtner-Kozlov (ETH Zürich)
    - Rocio Gonzalez-Diaz (Universidad de Sevilla)
    - Susan Holmes (Stanford University)
    - Michael Joswig (Technische Universität Darmstadt)
    - Frank Lutz (Technische Unversitä Berlin)
    - John McCleary (Vassar College)
    - Alex Suciu (Northeastern University)
    - Shmuel Weinberger (University of Chicago)
    - Günter Ziegler (Technische Uinversität Berlin)
    - Rade Zivaljevic (Serbian Academy, Belgrade)

3. Short term visitors (one week or more):

    - Jorge Aarao (Claremont McKenna College)
    - William Dwyer (University of Notre Dame)
    - Herbert Edelsbrunner (Duke University)
    - John Harer (Duke University)
    - Chris Hoffman (University of Washington)
    - William Kalies (Florida Atlantic University)
    - Konstantin Mischaikow (Rutgers University)
    - Pedro Real Jurado (Universidad de Sevilla)
    - Martin Raussen (Aalborg University)
    - Mehrdad Shahshahani (IPM, Teheran)
    - Steve Smale (Toyota Institute, University of Chicago)
    - Thomas Wanner (George Mason University)
    - Volkmar Welker (Universität Marburg)

4. Postdoctoral fellows:

    - Sarah Day (William and Mary)
    - Nicholas Eriksson (University of Chicago)
    - Fu Liu (University of California, Davis)
    - Carsten Schultz (Technische Universität Berlin)
    - Cynthia Traub (St. Mary's college, Maryland)
    - Nikolaus Witte (Technische Universität Berlin)

3 Workshops

1. **Connections for Women: Computational Applications of Algebraic Topology**. *Organized by Susan Holmes.* This meeting was held on August 31 and September 1, 2006, and immediately preceded the Kick-off workshop. Its purpose was to provide an introduction to various components of the subject, and consisted of minicourses run by Susan Holmes, Sarah Day, and Anne Collins on spectral methods in data, dynamical systems, and persistent homology, as well as hands on sessions for working with existing tools. It served as a useful introduction to the introductory workshop. Details are available at http:// www.msri.org/calendar/workshops/Workshopinfo/378/show_workshop.

2. **Introductory Workshop on Computational Application of Algebraic Topology**. *Organized by Gunnar Carlsson, Persi Diaconis, and Günther Ziegler.* This workshop served both as an introduction to the area for the participants in the program as well as the mathematical community at large. In order to allow for the presentation of the material in depth, some invited speakers gave two talks. Some areas which were covered, and associated speakers:

   - Topological methods for sensor nets (R. Ghrist)
   - Concurrency and distributed computing (S. Rajsbaum)
   - Algebraic topology for data analysis (G.Carlsson, S. Holmes, P Diaconis)
   - Topological methods combinatorial problems (E. Babson, G. Ziegler, R.Zivaljevic)
   - The geometry of grains (R. MacPherson)
   - Computational topology and dynamical systems (K. Mischaikow)

   In addition, some contributed talks were given. A complete list is available at

   http://www.msri.org/calendar/workshops/WorkshopInfo/378/show_workshop

3. **Workshop on Application of Topology in Science and Engineering** . *Organized by Gunnar Carlsson, Persi Diaconis, and Susan Holmes.* In this workshop, various application domains within science and engineering were examined in more detail. In particular, there were talks on sensor networks, algebraic topology of image patch data, neuroscience data, applications to protein docking, the general study of dynamical systems using algebraic topological tools, gene periodicity, and theorems about the reconstructibility of submanifolds from point cloud data. There were also a number of contributed talks. Details are available at http://www.msri.org/calendar/workshops/WorkshopInfo/381/show_workshop.

4. **Workshop on Topological Methods in Combinatorics, Computational Geometry, and the Study of Algorithms**. *Organized by Gunnar Carlsson, Persi Diaconis, Rick Jardine, and Günther Ziegler.* This workshop focused on the second main area, applications to combinatorics, algorithms, and computer science. Main topics included:

   - Applications to graph coloring
   - Explicit computations of topological invariants
   - Equivariant methods in computational geometry
   - Persistent homology
   - Discrete Morse theory
   - Applications to concurrent computing

   There were a number of contributed talks. Details are available at

   http://www.msri.org/calendar/workshops/WorkshopInfo/382/show_workshop

   .

4 Other Events

1. **MSRI-Evans Lectures:** Gunnar Carlsson and Günter Ziegler participate in the MSRI-Evans lecture series, giving talks on point cloud data and on extremal surfaces and polytopes, respectively. Robert Ghrist had been scheduled to speak on sensor networks but was forced to cancel.
2. **Other Lectures:** Herbert Edelsbrunner spoke in the U.C.Berkeley colloquium, on "Global methods for high-dimensional data sets".
3. **Other Workshops:** During the period of the program, there was an additional workshop entitled "Mathematics of Visual Analysis", which was quite relevant to many of the participants. It included a presentation by Vin de Silva, who works in the area of computational topology
4. **Seminar series:**
   - General seminar: This series met weekly and dealt with topics of general interest. Topics included multidimensional persistence, discrete Morse theory, spaces of graph homomorphisms, particular constructions on polytopes, geometric random graphs, and more. This seminar also had an introductory component, when Kevin Knudson gave two introductory talks on discrete Morse theory.
   - Combinatorics seminar: This series met during the first couple of months of the program, while a substantial group in this area was in residence. It dealt specifically with questions in combinatorics and computational geometry.
   - Concurrency seminar: This series met weekly, and dealt with questions concerning the possibilities for concurrent execution of components of algorithms, and distributed computing.
   - Dynamical systems: This seminar met briefly in the earlier part of the program, when the dynamical systems personnel were in residence. It focused on computational problems within the algebraic topology of attractors in dynamical systems, particularly in Conley index theory. It also had an introductory component, when Sarah Day gave introductory lectures on this theory.
   - Postdoc seminar: This seminar met throughout the quarter, and afforded each of the postdoctoral fellows the opportunity to speak.

5 Diversity

The organizers consulted existing databases of women and underrepresented minority mathematicians in order to encourage candidates whose work might have some relevance to the program. In spite of this, the participant list includes 6 women, and none from underrepresented minorities. The lists of participants in the workshops includes some more women, and some members of underrepresented minorities. Nevertheless, we are disappointed in this aspect of the turnout. It is encouraging to note, though, that three of the six postdoctoral fellows are women.

6 Connections

One of the stated goals of the program was to generate interest among mainstream topologists and geometers in the area of computational topology. We feel that a great deal of progress was made in this direction. Four mainstream topologists (Ken Brown (Cornell), Kevin Knudson (Mississippi State), John McCleary (Vassar), and Ross Staffeldt (New Mexico State)) were long term visitors and a fifth (Bill Dwyer (Notre Dame)) was a short term visitor. Their engagement in the program was as follows.

- Knudson, who had worked on algorithmic aspects of discrete Morse theory, has now written a paper on multidimensional persistence, and is beginning to work with applications to actual data sets.
- Staffeldt is now applying computational topological techniques to neural recording data from the surface of the skull. He is collaborating with a neuroscientist at New Mexico State.
- Dwyer has developed in interest in geometric random graph theory, as described in M. Penrose's book *Random Geometric Graphs*. He is beginning to work in the area. Dwyer is one of the leaders within the subfield of homotopy theory within algebraic topology.
- Brown and McCleary contributed useful insights and suggestions during their stays, and since they are now aware of the range of ideas involved in the computational efforts. They are both enthusiastic about the research agenda, and may ultimately get more seriously involved.

Bob MacPherson (IAS) gave a lecture in one of the workshops on recent work he has been doing related to materials science. This talk was very well received and suggests new possible research directions for the subject. MacPherson-Goresky-Diaconis-Holmes and Shahshahani teamed up on a project of designing algorithms for sampling from the area measure of an embedded manifold. This is being used to generate test problems for the PLEX software developed at Stanford. Matt Kaehle spoke in one of the seminars on his joint work with Chris Hoffman and Eric Babson on the higher homology of geometric random graphs. This work, suitably generalized and refined, will be very important in understanding the degree to which topological invariants computed via Rips complexes represent real geometric information instead of noise. Kaehle is now a Samelson fellow at Stanford, and we expect that there will be collaboration between him and Carlsson and Diaconis on this precise question. Hoffman is a probabilist who is working on algebraic topological questions. Finally, a collaboration between Nicholas Eriksson and Yuan Yao on the study of phylogenetic trees developed at the program, and is the basis for an ongoing collaboration.

7 Postdoctoral Fellows

The postdocs were assigned a mentor, to whom they were encouraged to bring any issues, or to ask for advice. Several of them spoke in the workshops, and all spoke in the postdoc seminar as well as in the regular seminar. Some were also involved in organizing the seminars. Carsten Schultz was instrumental in the combinatorics seminar, and NIko Witte worked on the postdoc seminar series. Their achievements and current positions are described below.

Sarah Day: Sarah has taken a position in the Mathematics Department at the College of William and Mary. She has been continuing her excellent work on the computational topology. Since the end of the program at MSRI, she has produced three manuscripts, with another one in preparation. The work includes the analysis of bounds for entropy using symbolic dynamics, the probabilistic and numerical verification of homology computations, and also an application to the validation of certain continuation formulae for equilibria. This is fundamental work, which one expects will have application to scientific problems.

Nicholas Eriksson: Nick is now an NSF postdoctoral fellow at the University of Chicago. While at MSRI, he initiated work with Yuan Yao on metric learning for phylogenetic tree reconstruction. He is working on several directions under the general heading of applying and developing sophisticated statistical techniques for the study of various problems in biology, including phylogenetic tree reconstruction, viral population sequencing, and epidemiological studies of HIV drug resistance.

Fu Liu: Fu has taken a position in the Mathematics Department at the University of California, Davis. She has been continuing her work in combinatorial geometry. Specifically, she has produced the manuscript "Formulas for the volumes of the polytope of doubly-stochastic matrices and its faces", jointly with Jesus

A. De Loera and Ruriko Yoshida. It provides an explicit combinatorial formula for the volume of the polytope of $n \times n$ doubly-stochastic matrices, also known as the Birkhoff polytope. This is done by finding the multivariate generating function for the lattice points of the polytope. Liu also completed work with Diaconis on random generation for conditional distributions arising in logistic regression.

Carsten Schultz: Carsten has taken up a position in the Mathematics Institute of the Technische Universität Berlin. While at MSRI, he developed a combinatorial approach to problems which had previously been attacked using equivariant topological methods, thereby deepening our understanding of the problems in question. Specifically, the problems in question include the Borsuk-Ulam theorem, Fan's rainbow coloring theorem for pseudomanifolds as interpreted by Meunier, and the Kneser conjecture. He has also been doing work on graph coloring, using topological methods.

Cynthia Traub: Cindy has taken a faculty position in the Department of Mathematics and Computer Science at St. Mary's College of Maryland.

Nikolaus Witte: Niko is in the Mathematics Institute of the Technische Universität Berlin. HIs main result shows that every 4-manifold can be obtained by a process known as "unfolding". While at MSRI, he found an alternate proof of this theorem, which gives even stronger results. This work appears in his manuscript "Constructing simplicial branched covers", arXiv:0707.1411v1. He has also been studying how his constructions behave under products, and has constructed a number of interesting examples in low dimensional combinatorial geometry and topology.

8 Nuggets

A number interesting developments occurred during and as a consequence of the MSRI program. Some of them are listed below.

- A generalization of Alon's "splitting necklace theorem" was proved by de Longueville and Zivaljevic. This theorem is one of many theorems in computational geometry which attempt to estalbish the existence of partitions of sets into parts which are equal according to some measure, or family of measures. The earliest version is the so-called "Ham Sandwich Theorem". The proof uses equivariant cohomological methods, and uses a notion of topological shellability. The paper is arXiv:math.CO/0610800 v1.
- The theory of multidimensional persistence, which is an extension of ordinary persistent homology which permits the study of multiparameter filtrations on a space, was developed by Carlsson and Zomorodian during the program. The work has appeared in SOCG 2007, one of the main conferences in computer science. The implementation of the ideas into code is now in its final stages at Stanford.
- Volkmar Welker and Persi Diaconis began a collaboration on statistical applications of multivariate orthogonal polynomials. This has morphed into a substantial project which is a main part of the Ph.D. dissertations of two students in the Stanford Statistics department.
- The dissertation of Stanford Statistics student Julia Saltzman was begun and essentially completed during the program. She was a speaker at the Connections for Women workshop. She spoke on projection pursuit for discrete data, which was the subject of her thesis. Methods for displaying and analyzing discrete data were actively discussed between Julia, Diaconis, and Holmes, and the finished thesis is a direct result of her participation in the program.
- The work on the Klein bottle structure of the space of 3×3 image patches in natural images was completed and submitted for publication during the period of the program. The joint effort of Carlsson,

de Silva, Ishkanov, and Zomorodian will appear in the International Journal of Computer Science, and an expository paper on the work by Rob Ghrist will appear shortly in the Bulletin of the AMS.

REPORT ON DYNAMICAL SYSTEMS PROGRAM

MSRI Spring 2007

1 Introduction

The semester-long research program on Dynamical Systems was held at MSRI from Jan 8, 2007 until May 25, 2007. It was based on a proposal accepted by the SAC of MSRI in 2003 and led by Christopher Jones (University of North Carolina at Chapel Hill) and Jonathan Mattingly (Duke University). The original proposal was coauthored by Igor Mezić (UC Santa Barbara), Andrew Stuart (University of Warwick, UK) and Lai-Sang Young (Courant Institute, New York University). Each of the original proposers played a critical role in the execution of the program. Jones and Mattingly were in residence for the entire program, Young led the latter part of the program and was in residence at that time. Stuart taught a mini-course at the half-way point of the program and Mezić was part of the second workshop.

The program was envisioned to be in two parts: the first half, roughly from the beginning until mid-March, during which the focus was on large-dimensional dynamical systems. Such so-called extended systems arise from discretizations of partial differential equations, lattice models or looking at pde's themselves. The second part of the program emphasized problems at the boundary of dynamical systems and stochastic equations.

The program was punctuated by workshops. The opening workshop, held in January, kicked off the program with a high-level meeting featuring some of the leading figures of dynamical systems. A particular emphasis was put on issues of current and future interest that challenge dynamicists, both theoretical and applied.

2 Personnel

1. Participants in residence for entire program:
   - Ethan Coven (Wesleyan University)
   - Christopher Jones (University of North Carolina at Chapel Hill)
   - Jeroen Lamb (Imperial College)
   - Jonathan Mattingly (Duke University)
   - James Meiss (University of Colorado)
   - Sri Namachchivaya (University of Illinois)
   - Oliver O'Reilly (University of California at Berkeley)
   - Bob Rink (Imperial College)
   - Maciej Wojtkowski (University of Arizona)
2. Long-term visitors (month or more):
   - Bjorn Birnir (University of California at Santa Barbara)
   - Holger Dullin (Loughborough University)
   - Angela Grant (Northwestern University)
   - Art Krener (University of California at Davis and the Naval Postgraduate School)
   - Oscar Lanford (ETH)
   - Yuri Latushkin (University of Missouri)
   - Debra Lewis (University of California at Santa Cruz)

- Mary Pugh (University of Toronto)
- Steven Schecter (North Carolina State University)
- Toufic Suidan (University of California at Santa Cruz)
- Lai-Sang Young (Courant Institute, New York University)

3. Short-term visitors (more than one week):

- Claude Baesens (University of Warwick)
- Peter Bates (Michigan State University)
- Martin Hairer (University of Warwick)
- Alice Jukes (Imperial College)
- Tasso Kaper (Boston University)
- Panos Kevrekidis (University of Massachusetts)
- Lev Lerman (Nizhny Novgorod)
- Robert MacKay (University of Warwick)
- Albert Mozhorov (Nizhny Novgorod)
- Greg Pavliotis (Imperial College)
- Richard Sowers (UIUC)
- Andrew Stuart (University of Warwick)
- Martin Wechselberger (University of Sydney)

4. Postdoctoral Fellows:

- Amit Apte (University of North Carolina; PhD, University of Texas at Austin)
- Margaret Beck (University of Surrey; PhD, Boston University)
- Mark Demers (Georgia Tech University; PhD, New York University)
- Boumediene Hamzi (University of California at Davis; PhD, University of Paris)
- Aaron Hoffman (Boston University; PhD, Brown University)
- Joyce Macabea (Biomolecular Sciences Institute; PhD, Boston University)
- Daniel Wiley (University of Maryland; PhD, Cornell University)

5. Other visitors (funded by other sources)

- Takeo Fujihira (Imperial College)
- Hector Lomeli (ITAM-Mexico)
- Scott McKinley (Duke University)
- Kristjan Onu (UIUC)
- Jun H. Park (UIUC)
- Natesh Pilar (Duke University)
- Henry Van Roessel (Alberta)
- David Simpson (Colorado)
- Kevin Webster (Imperial College)
- Andrea Watkins (Duke Unversity)

3 Workshops

1. **Connections for Women: Dynamical Systems.** *Organized by Debra Lewis, Mary Silber and Mary-Lou Zeeman.* This meeting preceded the opening workshop and served to bring together a number of women mathematicians with interests in dynamical systems. It featured main talks by leaders in the area, a poster session and a networking dinner. For details, see:
http://www.msri.org/calendar/workshops/WorkshopInfo/384/show_workshop

2. **Introductory Workshop on Dynamical Systems with an Emphasis on Extended Systems.** *Organized by Chris Jones, Edgar Knobloch, Nancy Kopell and Lai-Sang Young.* The opening workshop served to introduce the participants to the themes of the program as well as display the state-of-the-art in the area to all attendees. A particularly interesting aspect is that the workshop combined presentations of both pure and applied areas in dynamical systems. The first two days featured speakers addressing issues that arise in theoretical considerations of dynamical systems, including a number of talks on Arnol'd Diffusion, networks and chaotic attractors. A shift occurred on Wednesday when many of the talks addressed problems arising from nonlinear waves. Thursday focussed on fluids problems, including talks on data assimilation and ocean dynamics. The talks on Friday emphasized biological applications, particularly neurobiology.

   A poster session was held at which graduate students were able to display their work and discuss it with the many senior people in attendance. A new idea was tried on Wednesday afternoon that proved very successful. Each of those present who was, at the time, a postdoc (not just at MSRI), was given seven minutes to present their work and were allowed one transparency. This allowed them the opportunity to expose their research and practice their ability to communicate their work succinctly. the speakers in this session were: Jorge de Freitas (Porto), Mason Porter (Caltech), Maria Leite (Purdue), Joyce Macabea (MSRI and MSI), Nikola Popovic (Boston), Amit Apte (MSRI), Aaron Hoffman (MSRI and Boston), Zoi Rapti (UIUC), Abdul Kane (Toronto), Alice Jukes (Imperial), Claire Postlethwaite (Northwestern), Vahagn Manukian (NCState), Emily Burkhead (Santa Fe), Margaret Beck (MSRI), Boumediene Hamzi (MSRI), Dan Wiley (MSRI) and Mark Demers (MSRI). For details, see:
http://www.msri.org/calendar/workshops/WorkshopInfo/385/show_workshop

3. **Stochastic Dynamics and Control.** *Organized by Jonathan Mattingly, Igor Mezić and Andrew Stuart.* This workshop marked the transition in the program. Whereas the first part emphasized extended systems, the focus shifted with this meeting to random dynamical systems. Of particular interest was the relationship between random systems and control theory. For details, see:
http://www.msri.org/calendar/workshops/WorkshopInfo/387/show_workshop

   The workshop was followed by a short course on methods for multiscale systems given by Andrew Stuart and Greg Pavliotis, see:
http://www.msri.org/calendar/workshops/WorkshopInfo/426/show_workshop

4. **Mathematical Issues in Stochastic Approaches for Multiscale Modeling.** *Organized by Roberto Camassa, Jinqiao Duan, Peter Kloeden, Jonathan Mattingly and Richard McLaughlin.* Although not part of the original proposal, this workshop fit well the focus of the program and marked its conclusion. For details, see:
http://www.msri.org/calendar/workshops/WorkshopInfo/398/show_workshop

4 Other Events

1. **Evans/MSRI Lectures:** These lectures were spread throughout the program and, except for the special one by Smale, were given by the main organizers of the program. They served to expose the main themes of the program to the mathematics faculty at UC Berkeley.

   - *Stephen Smale (UC, Berkeley)* "Some Mathematics of Vision," Monday, January 22.

- *Chris Jones (UNC-CH)* "Going with the Flow and Updating Ocean Models," Monday, February 26
- *Lai-Sang Young (Courant Institute, NYU)* "Probabilistic Limit Laws for Chaotic Dynamical Systems," Monday, April 30.
- *Jonathan Mattingly (Duke University)* "The Spread of Randomness: Stochastic Fluids and Ergodicity," Monday, May 8.

2. **Weekly Organizational Meeting:** A meeting of all resident participants was held over lunch (brown-box) each Thursday. The purpose was to plan the activities of the following week and discuss any issues arising of interest to the entire group, including social events and outings.

3. **Opening Lectures:** In order to familiarize each other with the research of all the participants, we held a week-long series of short talks (half-hour each) by the senior participants. Lectures were given by Amit Apte, Bob Rink, Maciej Wojtkowski, Jeoren Lamb, Debra Lewis, Jonathan Mattingly, Martin Wechselberger, Steve Schecter, Yuri Latushkin, Chris Jones, Mary Pugh, Ethan Coven, Holger Dullin, Sri Namachchivaya and Margaret Beck. This series of talks were spread across the first week of the program after the opening workshop.

4. **Tutorial Lectures:** "Introduction to Random Dynamics." Jonathan Mattingly and Sri Namachchivaya gave a series of five lectures introducing the field of random dynamical systems to those trained in deterministic dynamical systems.

5. **Dynamical Systems Seminar:** A formal one-hour seminar was held each Tuesday afternoon at 4p. Talks were of interest to the entire group and covered the spectrum of research in dynamical systems. Speakers were: Oliver O'Reilly (UC Berkeley), Maciej Wojtkowski (Arizona), Mary Pugh (Toronto), Peter Bates (Michigan State), L. Mahadevan (Harvard and UC Berkeley), Jonathan Weare (UC Berkeley), Claude Baesens (Warwick), Robert MacKay (Warwick), Richard Montgomery (UC Santa Cruz), Lev Lerman (Nizhny Novgorod).

6. **Short Course:** "An Introduction to Multiscale Methods" was organized by Andrew Stuart (Warwick) and Greg Pavliotis (Imperial). It involved a total of ten lectures aimed primarily at graduate students. It attracted a good number of students from the Bay Area and beyond. Each lectured multiple times each day with Pavliotis emphasizing PDEs and Stuart lecturing mostly on SDEs. The entire course amounted to a comprehensive treatment of the subject that is encapsulated in a set of notes available through the website. It also featured guest lectures by Tom Hou (Caltech), Bjorn Birnir (UCSB), and Alexandre Chorin (UC Berkeley). For details, see:
http://www.msri.org/calendar/workshops/WorkshopInfo/426/show_workshop

7. **Postdoc Seminar:** A joint seminar with the program on Geometric Evolution Equations was run each week by the postdocs. It featured a half-hour talk each week by one of our postdocs (and a complementary one by their postdocs.) This was organized through our program by Margaret Beck.

8. **Special Lecture:** Jeroen Lamb delivered a public lecture on Penrose Tilings. The talk was entitled "The Geometry of Penrose Tilings: Projection, Substitution and Matching Rules," and was an accessible lecture of popular interest. The tiling on the outside of the MSRI building is an example of this interesting effect. For details, see:
http://www.msri.org/calendar/specialtalks/SpecialTalkInfo/3236/show_specialtalk

9. **Monday Night Playground:** Berkeley Repertory Theater, February 19. In a special meeting with the prospective playwrights, participants in the program (Jonathan Mattingly, Yuri Latushkin and Maciej Wojtkowski) discussed topics of current interest on the theme: "Controversy and Proof." This impacted a number of the short plays during the Playground evening. In addition, Jonathan Mattingly gave a short introductory talk in the pre-show discussion.

10. **Presentation at Academic Sponsors Meeting:** An original presentation was formulated by the organizers, the postdocs and the group of visitors for the Academic Sponsors Meeting on March 2. We developed and enacted a "skit" that exposed the process through which the proposal was put together. It enabled us to give an overview of the program and expose the breadth of topics being covered. This was followed by short presentations on behalf of each of the postdocs.

11. **Symposium on Climate Change:** The idea for this symposium arose while the dynamical systems program was in full swing. It was initiated by David Eisenbud and Inez Fung (UC Berkeley). Because of the natural connections to dynamical systems in terms of modeling and prediction issues, the program organizers and other visitors became deeply involved. In particular, Chris Jones joined the organizing committee and played a key role in formulating the program, inviting the speakers and conducting the meeting itself. A number of speakers in dynamical systems presented, including Lenny Smith (LSE and Oxford) and Jim McWilliams (UCLA). For details, see: http://www.msri.org/specials/climatechange/workshop

5 Working Groups

The collaborative research of the program was organized largely through a system of ongoing working groups. These groups met weekly. Some extended through the entire program, while others met mainly during the first or second part of the program, depending on their emphasis. The group meetings served to introduce the participants, particularly the postdoctoral fellows, to the basics of the topic under consideration, to set a common language and understanding and to define key problems. Many of them spawned smaller informal groups that would work on specific problems.

1. **Lattice Dynamics:** The emphasis of the activities in the lattice dynamical systems working group has been on the development of functional analytic methods for the study of spatially localized and periodic traveling waves in lattice dynamical systems, with and without Hamiltonian structure. The main activity of this group was in the first half of the program, when most of the participants were in residence. As background for the study of localized traveling waves the paper by Sandstede and Scheel "Defects in oscillatory media: toward a classification." was read in some detail with a view towards seeing how these results could be adapted for lattice dynamical systems. This project is ongoing, most likely leading to collaborative papers between a number of the working group participants. We anticipate substantial progress by the end of the year, which will be reported in a workshop on Hamiltonian Lattice Dynamical Systems at the Lorentz Center of the University of Leiden (Netherlands) 15-19 Oct 2007, organized by J. Lamb and B. Rink.

   Furthermore, the following issues were discussed extensively: functional analytic entry into KAM theory and functional analytic methods for the detection of small homoclinic solutions (as in the Bogdanov-Takens bifurcation), all with a view to applications in lattice dynamical systems. These discussions have led to increased insight into obstructions for the developments of such techniques, without (yet) any decisive breakthrough. The discussion yielded an important transfer of knowledge and ideas. Lamb and Rink (in collaboration with Guo) worked on the problem of bifurcations of resonant traveling waves in Hamiltonian lattices, and a paper on this will be submitted soon.

2. **Stability and Spectral Theory:** The Stability and Spectral Theory working group met weekly, during the first half of the program. Two main topics were discussed: Pruss's Lemma, a result extending the spectral mapping theorem to a certain class of strongly continuous semigroups, and Palmer's Theorem, which relates the Fredholm properties of a dynamical system to the existence of exponential dichotomies. The discussion of Pruss's Lemma was lead by Yuri Latushkin. Yuri presented a proof of the lemma, which demonstrates that a certain uniform bound on the resolvent of a linear operator is sufficient to guarantee that the associated strongly continuous semigroup satisfies a spectral mapping theorem. In addition, Yuri presented a result that he, in collaboration with Anna Ghazaryan

and Steve Schecter, had proved while at MSRI. They proved that the linearization about the traveling wave in a certain combustion model satisfies the the hypothesis of Pruss's lemma, and, as a result, the spectral mapping theorem can be used to conclude that spectral stability implies stability of the wave in the linearized system.

In addition, Margaret Beck presented a paper by Sandstede and Scheel, in which the authors developed a technique for extending Palmer's Theorem to a class of ill-posed dynamical systems. For well-posed dynamical systems, Palmer's Theorem relies heavily on being able to count the dimension of the stable and unstable subspaces, or Morse indices, and compare their sizes. For ill-posed systems, these dimensions are infinite. Sandstede and Scheel found a way to relate the system of interest to a certain reference equation and compute the Morse indices relative to those of the reference equation. They then demonstrate how this technique can be used to study the stability of modulated traveling waves.

3. **Control Theory:** We discussed the extension of tools from dynamical systems theory to control theory. The focus was on a discussion of the stabilizability and the stabilization problems for controlled dynamical systems. For instance, consider the controlled dynamical system

$$\Sigma: \ \dot{x} = f(x,u), \ y = h(x)$$

Where $x \in R^n$ is the state and $u \in R^p$ is the input. Assume that $f(0,0) = 0$ then two central problems in control theory are:

- Is there a function $u = varphi(x)$ such that the origin is a (locally)-asymptotically stable equilibrium point of the system $\dot{x} = f(x, \varphi)$?
- If this is possible, how can $\varphi(x)$ be found?

The following problems were considered. First, can another method to derive normal forms for nonlinear control systems be developed? A new approach might allow one to find normal forms for nonlinear control systems with time-delays and to solve both of the above problems. Given a Hamiltonian control system Σ_H defined by

$$H(x,u) = H_0(x) + uH_1(x,u),$$

use a change of coordinates and feedback to derive the Poincaré normal form within the class of Hamiltonian systems and then study the stabilizability and design a controller. Find the Hamiltonian analogue of the Brunovský normal form, i.e., a linear Hamiltonian control system is controllable iff there exist a change of coordinates and feedback that puts Σ_H in Brunovský normal form. A future direction would be an extension to the nonlinear case and to use the normal form to solve the above problems. Another issue considered was the stabilization of nonlinear control systems around relative equilibria.

There were also interactions with other working groups. For instance, in considering data assimilation approaches to design observers for nonlinear control systems (estimate the state from the data) and then design controllers. The idea would be to excite an infinite-dimensional control system with a noise from the input and find the "controllability Gramian". Then, consider the case of stochastic initial conditions and define an "observability Gramian ". Finally, find (if possible) a change of coordinates where the two Gramians are the same and deduce a reduced order model having the same input-output behavior as the full order system. Three papers on these topics are in preparation.

4. **Nonlinear Filtering and Data Assimilation:** The Ensemble Kalman filter, (EnKF) which approximates an error covariance matrix by ensemble of states, was studied. Replacing the linearized state evaluation in Extended Kalman Filter with integration of each member of the ensemble forward in time using Markov Chain Monte Carlo method made EnKF possible to handle nonlinear problems and succeed in many areas of application. However, EnKF has never been proved rigorously and failed to be

applied to a fully nonlinear problems with a multi-modal distributions. We examined mathematically the method of EnKF. These discussions are still in the embryonic stage.

Wojtkowski introduced the Hamiltonian view of the Kalman Filter to the group. The idea is that the covraiance matrix is positive definite and symmetric and hence its graph is a Lagrangian plane that remains in a certain positive cone. This can be used to show that controllability and observability together imply the convergence of the Kalman Filter.

5. **Random Dynamical Systems:** One focus emerged that related to how positive Lyapounov exponents can arise in random systems. Specific two degree of freedom Hamiltonian systems were considered with small noise $O(\varepsilon)$. It was shown that a positive Lyapounov exponent can be excited of order $\varepsilon^{\frac{1}{3}}$. The group studied a number of classical papers on the Lyapounov exponents of random matrices and linear stochastic differential equations. The linear stochastic systems and the twists maps studied by Lai-Sang Young were also considered in terms of their Lyapounov exponents.

6. **Hamiltonian Systems:** During the program, a number of visitors came to interact with Research Professor Meiss.These include Holger Dullin of Loughborough University visited Jan 22-Feb 8. He presented a short seminar for the group. Primarily his research was in collaboration with James Meiss, and they discovered a new normal form for volume preserving mappings. During this work, interaction with Lamb was very helpful. Professor Hector Lomeli of the Instituto Tecnolgico Autnomo De Mxico who visited on his own funds from March 29-April 3. His work, with Meiss lead to the construction of a measure of transport in three-dimensional systems that model mixing of fluids. They also completed work on a canonical formulation of the Melnikov function for mappings. Professors Albert Morozov and Lev Lerman from Nizhny Novgorod University in Russia visited from April 30-May 11, supported by their home university. Morozov interacted with Meiss and Apte on degenerate resonances in dynamical systems, and Lerman and Meiss nearly finished a paper on the structure of homoclinic tangles in four dimensional reversible systems. For this work, essential interaction with Lamb lead to a reformulation of the techniques of proof.

7 Connections

A number of connections were made between the group at MSRI and faculty at UC Berkeley

1. Through the Simons Biology Colloquium delivered by Mimi Koehl (Integrative Biology, UC Berkeley), a connection was made between her group and a number of the dynamicists in residence at MSRI. A follow-up visit was organized at which Koehl and her postdoc presented more specifics of dynamic relevance. This was held during a lunch meeting on March 22. Rob Full (Integrative Biology, UC Berkeley) also came up and discussed stochastic issues arising in his work. A further follow-up meeting, attended by Jim Meiss, Chris Jones and Amit Apte, was held in Mimi Koehl's lab on April 9. The focus of that meeting was to delineate chaotic mixing from turbluent effects in her models.

2. Bernd Sturmfels (Mathematics) and his student, Anna Shiu, presented a dynamical systems problem at a lunch meeting on April 25. The idea was to discuss what might be known and what might be done in studying a class of chemical reaction networks with toric phase spaces. Issues discussed included whether trivial dynamics could be established by preventing trajectories from going to the "boundary."

3. Amala Mahadevan (Boston University, visiting Integrative Biology at UC Berkeley) and her postdoc, Bror Johnson, came to a lunch meeting at MSRI with the dynamics group on April 30 and delivered a presentation on their models of carbon take-up. The connection here was through their interest in data assimilation and the possibility of implementing an assimilation scheme in their model.

4. A visit was arranged to the Molecular Sciences Institute in Berkeley on March 9. This was a follow-up to an earlier visit at the end of the opening workshop. Joyce Macabéa, a postdoc in the program, works at MSI and arranged the visit. It was graciously hosted by a number of the scientists there who gave a tour to the group and explained the research, funding and history of the institute. Ethan Coven visited again afterwards to consider a collaboration with Anna Song (MSI) on using dynamical systems coding techniques in gene sequencing.

8 Postdoctoral Fellows

Each of the postdocs in the program were assigned a mentor who ensured their participation in programs, working groups, workshops and suggested collaborations for them. Some of their achievements are documented below. There were two occasions at which the postdocs were able to discuss their work in front of a large audience. Once at the opening workshop in seven-minute presentations, and again at the Academic Sponsors Meeting in March. Their improvement was extraordinary and led, for a number of them, to discussions with department chairs and further potential employment opportunities.

Margaret Beck Margaret worked on three distinct projects and also had the opportunity to present aspects of her research in the introductory workshop and postdoctoral seminar. She began one project with three new collaborators, Dave Schaeffer, Chris Jones and Martin Wechselberger, the last two of which were participants in the program at MSRI. Entitled "Electrical Waves in the Heart,"this project involved using geometric singular perturbation theory to analyze both the existence and stability of traveling pulses in a model of the human heart. This problem presented an interesting technical difficultly, due to the lack of hyperbolicity in the underlying geometric structure, as well as provided a real-world example of an interesting mathematical phenomenon: "gluing "a stable front with an only marginally stable back, to produce a stable pulse. As future work, the authors intend to analyze the period doubling bifurcation of this wave.

Beck also continued work on "The Stability of Time-periodic Waves in Viscous Conservation Laws"with Björn Sandstede, from the University of Surrey, who was a short term visitor at MSRI during the introductory workshop. The focus of this project is to analyze the nonlinear stability of waves that appear when viscous shock waves undergo a Hopf bifurcation. The associated linearized operator is not

only time-periodic, but also lacks a spectral gap, which prevents the application of standard techniques in stability analysis.

Finally, Beck worked on "A Geometric View of Metastability in the Viscous Burgers Equation "with C. Eugene Wayne, from Boston University. For small viscosity, solutions to Burgers equation are known to exhibit "metastable "behavior, in which they remain close to the inviscid N-wave solutions for long times, before approaching the diffusive waves and decaying to zero. The goal of this project is to explain this behavior geometrically by constructing invariant manifolds, despite the absence of a gap in the spectrum of the linear operator.

Joyce Macabéa During the Stochastic Dynamical Systems and Control workshop (March 26, 2007 to March 30, 2007), there was a talk given by Igor Mezić entitled "Controllability, Integrability and Ergodicity" which led to a discussion about control of genetic transcription. The conversation inspired Macabéa to use a different approach for modeling molecular interactions. Genes and certain other proteins have energy conserving properties and can therefore be modeled as Hamiltonian systems. Macabéa attended the working group on random dynamical systems and received an introduction to stochastic differential equations, and was presented with a interesting problem on developing a hybrid model (stochastic, discrete, continuous) of molecular motors. Joyce Macabéa presented a poster at the Connections for Women: Dynamical Systems (January 18, 2007 to January 19, 2007) and the Introductory Workshop on Dynamical Systems with Emphasis on Extended Systems (January 22, 2007 to January 26, 2007). She also gave five minute minitalks during the aforementioned Introductory Workshop, the Stochastic Dynamical Systems and Control Workshop (March 26, 2007 to March 30,2007) and the MSRI academic sponsors meeting (March 2, 2007). She presented her research on modeling molecular signal transduction at the weekly postdoc seminar. As a result of these presentations she was invited to speak at the University of Washington, UC Santa Barbara and the University of New Mexico. Joyce Macab éa had conversations with senior mathematicians about career opportunities at NIH, NSF, NSA, Genentec and two universities during the informal meetings during conference breaks and at the dinner in honor of the William Massey. Macabéa organized a meeting between two undergraduate students working at MSI who are aspiring science writers and MSRI member and science writer Dana Mackenzie. Macabéa also worked with Dana Mackenzie on a possible write up about the pheromone signaling pathway in yeast to appear in the AMS Notices.

Mark Demers Systems with holes are examples of dynamical systems on domains which are not invariant under the dynamics. They have mainly been studied for uniformly hyperbolic systems which admit finite Markov partitions, with the only exceptions being certain 1-dimensional systems: specifically, piecewise expanding maps and Misiurewicz maps. During the opening workshop in January, MSRI Demers met with Paul Wright (grad student at NYU) and Lai-Sang Young (NYU) to begin discussing how to study mathematical billiards with holes. Billiards with convex boundaries are examples of nonuniformly hyperbolic systems which do not admit finite Markov partitions. They are widely used as models in mathematical physics. The two primary techniques being used by Demers, Wright and Young are Young towers with holes and the spectral decomposition of the transfer operator associated with the open system via Lasota-Yorke type inequalities. At this point, preliminary results include: (1) tower constructions for Sinai billiard tables (without infinite cusps) with holes either in the interior or along the boundary; (2) convergence of a class of measures with smooth densities on unstable leaves to a conditionally invariant measure under the normalized push forward action of the map (conditioned on not having fallen into the hole). This implies in particular an exponential rate of escape for the open billiard system and the existence of a physically observable metastable state for the system. Continuing efforts will attempt to establish: regularity properties of the conditionally invariant measure, rates of convergence, and the existence of a singular physical invariant measure on the Cantor set of points which never escape from the system which has been conjectured to be ergodic, enjoy exponential decay of correlations and be an equilibrium state for the potential $\det(DT|E^u)$.

On April 10, Robert MacKay (University of Warwick) gave a talk in the weekly Dynamical Systems

seminar discussing the properties of a homeomorphism of the two-torus that had been proposed by two chemists (Cerbelli and Giona) as a prototype for a certain type of mixing involving nonuniform sheer. MacKay showed that in fact the map is pseudo-Anosov and that many useful properties can be derived from this: explicit calculations of metric and topological entropies, rate of mixing, the measure of maximal entropy, singularity of this measure and fractal distribution of stable and unstable foliations, to name just a few. As a result of this talk, Demers and Wojtkowski began exploring how to explicitly construct a broader class of maps satisfying the basic elements of this prototypical example and what were the essential components of the construction to be generalized.

Preliminary results include the fact that Cerbelli and Giona's map belongs to a 1-parameter family of maps with increasing shear satisfying the same basic properties and possessing a high degree of symmetry. It is possible to give a general recipe for how to construct Markov partitions for this class of maps and to show that they are in fact pseudo-Anosov. The analysis of MacKay can be extended to this class of maps.

Dan Wiley Dan worked on a project with Sri Namachchivaya on the asymptotic stability of a weakly perturbed two dimensional non-Hamiltonian system. The purpose of this work is to obtain the top Lyapunov exponent, the exponential growth rate, of the response of a two dimensional non-Hamiltonian system driven by an additive white noise process. This work is still in progress.

Amit Apte There were two parts to Apte's involvement in the program. First, he worked with Jones and Andrew Stuart on implementing Langevin sampling techniques in Lagrangian data assimilation. Significant progress was made during the MSRI program in developing the underlying philosophy of these ideas and working them out in the framework of the linearized shallow water problem.

He was also involved in work with Jim Meiss and others on mixing and bifurcations in Hamiltonian systems.

Boumediene Hamzi Hamzi was the key figure in the control theory working group and much of his work is described there (see above).

Aaron Hoffman He was in the program for the first half, until mid-March. During the time, he was very active in the Lattice Models working group and interacted extensively with Jeroen Lamb and Bob Rink, among others. Hoffman also work on a stochastic lattice model which was inspired by shell models from turbulence theory with Jonathan Mattingly and Scott Mckinley.

9 Nuggets and Future Events

Three nuggets are being prepared in collaboration with Dana Mackenzie. the subjects are:

1. Kalman Filter and Lagrangian Dynamics. This features the work of Wojtkowski on using the structure of positive cones and contraction operators on such cones to show the convergence of the Kalman Filter

2. Lagrangian Data Assimilation. Jones, together with Ide (UCLA) have developed techniques of assimilating data coming from instruments in the ocean that move with the flow.

3. Heart Wave Dynamics. Margaret Beck, with Jones and Wecheslberger have collaborated with David Schaeffer (Duke) on studying the dynamics of heart waves and their contrast with nerve impulses.

A "White Paper "has been prepared merging from the Symposium on Climate Change, held at MSRI, April 11-13. This has been circulated, including to NSF. Furthermore a full "glossy "report has been prepared by Dana Mackenzie. The initiative on climate change is leading to a summer program in 2008 at MSRI and further events are also being planned.

Connections for Women : Computational Topology and Applications

Susan Holmes

September 2, 2007

1 Connections for Women

MSRI held an introductory workshop for women in preparation for the program on Computational Applications of Topology on August 31st and September 1, 2006. Its main purpose was to familiarize our participants with the mix of different types of mathematics to be presented at the workshop. All the participants came from different backgrounds, with representatives from Algebraic topology, Dynamical Systems, Combinatorics, Probability, Statistics and Geometry.

Our workshop was the first for the academic year 2006-2007 and many participants were eager to get to know each other and the problems, so much so that often the audience for the scientific talks contained more men than women.

It was a good opportunity for us to get to know the new auditorium, the technical challenges of giving mixed blackboard/computer talks and using the technology effectively. The scientific focus of the workshop already prepared us for an original mixture of computer based tools as well as advanced mathematical concepts.

Most of all the workshop was useful in providing the participants in the program an opportunity to get to know each other and exchange views on our specific problems.

1.1 Scientific Program

Our scientific program included lectures on dynamical systems from the ground up with very clear expository lectures by Sarah Day, with very well tailored animations of the Henon map. We had some lectures on statistics with Julia Salzmann, Elizabeth Purdom and Susan Holmes. An introduction to a central topic of the program: persistence was provided by Ann Collins.

1.2 Social Program

The social calendar was highlighted by a wonderful meal in a top Chinese restaurant in Berkeley recommended to us by David Eisenbud. Happily the new associate director of

MSRI, Kathy O'Hara was able to join us, a mathematician herself she fulfils her role as animator and representative component in many commitees at MSRI.

2 Women's issues in Academia

2.1 Career Development and Two Body Problems

We had a panel on dual career problems which plague women mathematicians. If a majority of women academics are married to other academics this is even more true in the field of mathematicians, where more than 75% of women mathematicians have academic partners. We discussed all the aspects of looking for jobs and the interviewing process and the difficulties involved in the particular case of looking for two jobs in the same department.

We were able to share our private horror stories and laugh about the fact that so many mathematicians still live in another century as far as women are concerned. How women are still expected to dress especially well to be worthy of populating the man's world, power suits being often expected. We compared notes on the conditions in Europe and in the US, and agreed that in family matters the US lagged far behind, although in this country we are so often reminded that it is supposed to be easier for us to get jobs since all the universities are supposed to be agressively hiring women. However the equal opportunity laws seem never to be able to give women extra help for raising a family.

One of the topics we exchanged notes on was the question of when to bring up 'the partner/family' problem with future employers. Strictly speaking, in the US it is against the law for potential employers to ask candidates about their personal life. However the departments who cater to such problems often retain women candidates. An unofficial study is now underway, in which university administrations and faculty have participated on a voluntary basis in an evaluation of practices across research universities in the US, the results are being analyzed and should appear in 2008.

The social calendar was highlighted by a wonderful meal in a top Chinese restaurant in Berkeley recommended to us by David Eisenbud. Happily the new associate director of MSRI, Kathy O'Hara was able to join us, a mathematician herself she fulfils her role as animator and representative component in many commitees at MSRI.

This short workshop completely fulfilled its role in making us more comfortable with each other and the new material underlying this workshop so full of interdisciplinary challenges and sharing resources for our future career plans.

Resources for the Dual Career/ Two Body Problem

Books:

The Two-Body Problem: Dual-Career-Couple Hiring Practices in Higher Education, by Lisa Wolf-Wendel, Susan B. Twombly and Suzanne Rice

Academic Couples: PROBLEMS AND PROMISES, by Marianne A Ferber and Jane W Loeb (Editors) University of Illinois Press
http://www.phds.org/jobs/the-two-body-problem/

Some articles:
http://sciencecareers.sciencemag.org/career_development/previous_issues/articleS/2240/solving_the_two_body_problem
http://chronicle.com/jobs/news/2006/10/2006100501c/careers.html

3 Scientific Results and Perspectives

From a scientific viewpoint, the successes of the workshop were an initiation for all of the participants in areas of research which were unfamiliar to us. Statisticians do not use topology in their day to day work and the language and theory involved can be daunting, it was very useful to have an unthreatening platform where to sort out the foundations. In particular, we exchanged effective software tools, R and ggobi for statistics, plex, CHomp and gaia for computing homologies. These were all illustrated by specific examples of applications.

Some of the main products of our scientific discussions came from the realization that we are often tackling similar problems from different viewpoints, nodal domains are important in statistics for spectral clustering problems, whereas in dynamical systems they produce metastable subspaces. In dynamical systems perturbation methods are used to test stability and metastability, whereas in statistics methods such as the bootstrap are used for similar purposes.

3.1 Personal Success Stories

Julia Salzman's PhD thesis topic was completely defined and developed during her stay at MSRI that served to jog her into a research perspective. Julia is now going to Columbia University statistics department as an assistant professor in Statistics. Elizabeth Purdom is an NSF postdoctoral fellow at Berkeley statistics department and has continued her research project as well as furthering her family project by having a baby. Sarah Day is preparing work on nodal domains and gave followup lectures at the two other workshops that were extremely well received.

Scientific Resources Linked to the Workshop

The Bootstrap

http://www-stat.stanford.edu/~susan/courses/s208

Dynamical Systems

The 2-dimensional Hnon example: Towards automated chaos verification Proc. Equadiff 2003, World Scientific, Singapore, 157–162, 2005. S. Day, O. Junge, K. Mischaikow

Code for the Hnon example:
http://www.math.wm.edu/~sday/henon_comp.html

The infinite-dimensional Kot-Schaffer model:
A rigorous numerical method for the global analysis of infinite-dimensional discrete dynamical systems SIAM Journal on Applied Dynamical Systems, 3 (2004), no. 2, 117–160. S. Day, O. Junge, K. Mischaikow

Software Used during the Workshop

ChoMP : http://chomp.rutgers.edu/software/
plex: http://comptop.stanford.edu/programs/plex/
ggobi : http://www.ggobi.org/
R: http://www.r-project.org/

See also the summary in the SpringFall2006 Emissary.

Name of the workshop: Connections for Women: Dynamical Systems
Date: January 18 to January 19, 2007
Location: MSRI

Organizers and their Institutional Affiliation:
Debra Lewis, UC Santa Cruz
Mary Pugh, U Toronto
Mary Lou Zeeman, Bowdoin College

Schedule of Talks:

January 18:
09:00 AM - 10:00 AM ***Gerda de Vries***,
Modelling the Spatio-Temporal Dynamics of Nuclear Proteins
10:30 AM - 11:00 AM ***Kathleen Hoffman***,
Stability Results for Elastic Rods with Electrostatic Self-Repulsion.
11:00 AM - 12:00 PM ***Alice Jukes***,
Symmetric Homoclinic Bifurcation.
11:30 AM - 12:00 PM ***Aimee Johnson***,
The Relative Growth of Information in Two-Dimensional Partitions.
01:30 PM - 02:30 PM ***Jenny Harrison***,
ChainletTheory and Dynamics.
02:30 PM - 03:30 PM ***Ana Dias***,
Coupled Cell Networks: ODE-Equivalence, Minimality and Quotients.

January 19:
09:00 AM - 10:00 AM ***Mary Silber***,
Controlling Pattern Formation.
10:30 AM - 11:00 AM ***Claire Postlethwaite***,
Controlling Travelling Waves of the Complex Ginzburg-Landau Equation with Spatial Feedback.
11:00 AM - 11:30 AM ***Anna Ghazaryan***,
Traveling Waves in Porous Media Combustion: Uniqueness of Waves fro Small Thernal Diffusivity.
11:30 AM - 12:00 PM ***Mary Lou Zeeman***,
Mathematical modeling of the menstrual cycle
01:30 PM - 02:30 PM ***Rachel Kuske***,
Multi-Scle Dynamics and Noise Sensitivity
03:45 PM - 04:15 PM ***Lea Popovic***,
Degenerate Diffusion Limits in Gene Duplication.
04:15 PM - 05:30 PM ***Hans Kaper***,
What Goes Into a Good Proposal, Where Do I Send It, and What Happens to It?

Participant List

Including diversity data: gender and ethnicity.
We hope MSRI can do this bit. Thank you!

Short Summary of the Workshop Goals

This intensive two-day workshop spotlit several innovative applications of dynamical systems theory, offering advanced graduate students and recent PhDs an insider's tour of recent developments in the field and setting the stage for the semester-long program Dynamical Systems. The program included invited lectures, contributed talks, a poster session, and a workshop dinner.

The primary workshop goals were to bring together a diverse group of women at all career levels in dynamical systems, to stimulate the formation of new research collaborations, to encourage the continued growth of an active, effective network of women researchers in dynamical systems, and to increase the visibility of these researchers within the mathematical community. Men were also actively encouraged to participate.

While all career levels were present, the workshop was designed particularly for women in the early stages of their research careers: graduate students and postdocs. The underlying principle was that an effective way to optimize networking opportunities is to showcase the research of the junior women to a broad audience, and then provide ample time for breaks and social events with both women and men at which plenty of science, informal advising and networking occur. Thus, with the notable exception of one presentation on the NSF's grant proposal submission and review process, the focus of the presentations was on mathematics and science, and all the participants were invited to present a poster on their research.

Concrete outcomes of the workshop

To illustrate the breadth of research encompassed by dynamical systems, and to showcase the achievements of a representative sampling of women working in the field, there were one-hour talks, half-hour talks, and poster presentations. The four one-hour talks were given by outstanding expositors: Gerda de Vries (University of Alberta), Jenny Harrison (UC Berkeley), Rachel Kuske (University of British Columbia), and Mary Silber (Northwestern). There were nine half-hour talks (Ana Dias, Anna Ghazaryan, Kathleen Hoffman, Aimee Johnson, Alice Jukes, Lea Popovic, Claire Postletwhaite, Ami Radunskaya, and Mary Lou Zeeman). Both pure and applied dynamical systems were represented. Several novel applications were presented, with an emphasis on the challenges involved in the development of new mathematical models.

The final talk of the workshop was an extremely informative presentation by Hans Kaper (NSF) entitled *What goes into a good proposal, where do I send it, and what happens to it?* Dr. Kaper demystified the proposal review process, giving an overview, providing invaluable tips, and answering many questions. He convincingly demonstrated that program directors are wise individuals who are genuinely enthusiastic about the research they manage, so that all members of the audience can be more confident about contacting program directors for guidance and assistance in the future.

Networking opportunities included regular coffee and tea breaks, a workshop dinner, and a joint reception and poster session. All workshop participants were encouraged to present their research in poster form; seventeen posters were presented. Presenters included graduate students (both female and male), post-docs, and faculty. The poster session/reception format facilitated informal discussions in small groups, providing opportunities for the graduate students and postdocs both to get acquainted with the more senior participants, and to appreciate the research accomplishments of their peers. Biological applications were strongly represented,

including fish migration, bioremediation, macrophage activation, gypsy moth populatioin dynamics, nuclear transcription autoregulation, and neural oscillators. More traditional applications included the Navier Stokes equations, ocean models, and wave equations.

All MSRI visitors were encouraged to participate in the workshop, as were participants from several departments at UC Berkeley. There were a significant number of men in the audience during the entire workshop, and also at the posters and the workshop dinner. There were several benefits to this breadth of audience. The junior participants were able to maximize their networking opportunities: the more mid-career and senior researchers in their area they know, the better their chances when applying for positions and grants. Similarly, the senior participants learned about the work of promising junior women in the field. A less tangible but nevertheless extremely important result of the workshop for increasing diversity in the field, is that the increased visibility of so many excellent women speakers (junior and mid-career) can help to dispel the unfortunate notion that there are very few women to suggest for jobs, talks, or organizing committees related to dynamical systems. In fact there are excellent active and energetic women at every level.

Advertising

Although MSRI distributed a flyer announcing the workshop, and the workshop was advertised on the MSRI web space, broader advertising was necessary to reach the target audience: junior women researchers who may not yet have the experience or confidence to apply to a MSRI workshop. Announcements were therefore posted in the Association for Women in Mathematics (AWM) newsletter, and on various dynamical systems networks. Announcements were also sent to women in the AIM database identified as working in areas relevant to dynamical systems, the chairs of mathematics departments known to be strong in dynamical systems and those of all UC campuses, the directors of the American and Canadian mathematics research institutes and other individuals the workshop organizers knew to work with women graduate students and postocs. The announcements also encouraged applicants to consider participation in the other workshops in the Dynamical Systems program, particularly the Introductory Workshop following the Connections for Women workshop.

There were 53 applications: 31 from graduate students, 9 from postdocs, 12 from faculty in tenured or tenure track positions. Applications came from students and postdocs in top mathematics departments across the country and abroad, including Brown, Cornell, the Czech Academy of Sciences, Imperial College, Indiana, MIT, NYU, Northwestern, Queens College, Universidade do Porto, University of British Columbia, and University of Virginia. Nine applicants came from the University of California campuses (Santa Barbara, Berkeley, Irvine, Riverside, and Santa Cruz); and three from CSU San Diego, Stanford, and USC. (MSRI residents and most Bay Area participants registered on site.)

MSRI provided full or partial financial support to 24 participants. 12 graduate students, 5 postdocs, and 7 faculty received full or partial financial support. To maximize participation, funding was split between MSRI and the participant's home institution or advisor whenever possible. Funding priority was given to applicants who intended to participate in the Introductory Workshop of the MSRI Dynamical Systems program the following week, and to applicants who intended to present their work in a short talk or poster. Invited speakers, with the exception of the local speaker, were offered full support, but informally encouraged to use their own funds if possible, to increase the funds available to junior participants. At the end of the Connections Workshop, several of the junior women applied to MSRI for additional funds to stay on for the workshop the following week, and those funds were granted.

Dissemination

The talks are disseminated by streaming videos on MSRI's website. Results were also disseminated by poster presentations at the workshop.

MSRI Short Course: “An Introduction to Multiscale Methods".

April 2nd to April 5th 2007
MSRI Berkeley

Organizers: Greg Pavliotis (Imperial College) and Andrew Stuart (Warwick)

Schedule of Talks:
See http://www.msri.org/calendar/workshops/WorkshopInfo/426/show_workshop

Participant List:

Full Name	Role	Institution
Pavliotis, Greg	Organizer	Imperial College, London
Stuart, Andrew	Organizer	University of Warwick
Hou, Thomas Y.	Speaker	California Institute of Technology
Birnir, Björn	Speaker	University of California, Santa Barbara
Chorin, Alexandre J.	Speaker	University of California, Berkeley
Jahnke, Tobias	Participant	Free University Berlin
Yan, Pengchong	Participant	University of California, Davis
Onu, Kristjan	Participant	University of Illinois at Urbana-Champaign
Latorre, Juan Cristobal	Participant	Rensselaer Polytechnic Institute
Rhodes, Rémi	Participant	Centre de Mathématiques et Informatique, LATP
Ghosh, Debraj	Participant	Stanford University
Venturini, Gabriela Natalia	Participant	California Institute of Technology
Baydil, Banu	Participant	Rensselaer Polytechnic Institute
Zhou, Hui	Participant	Stanford University
Hesse, Marc	Participant	Stanford University
Simpson, Gideon	Participant	Columbia University
Moreno, Sergio	Participant	Stanford University
Kwok, Felix	Participant	Stanford University
Rorro, Marco	Participant	University of Rome "La Sapienza"
Diaz, Aaron	Participant	Santa Clara University
Ulrich, Bruce T.	Participant	Technische Universität München
Vanden-Eijnden, Eric	Participant	Courant Institute of Mathematical Sciences
Park, Jun Hyun	Participant	University of illinois at Urbana-Champaign
Doostan, Alireza	Participant	Center for Turbulence Research
Constantine, Paul	Participant	Stanford University
Dobson, Matthew	Participant	University of Minnesota
Jaramillo, Andres	Participant	California Institute of Technology
Schaefer, Tobias Bodo	Participant	College of Staten Island
Horne, Rudy Lee	Participant	Florida State University
Williams, Sarah A	Participant	University of California, Davis
Hunt, Fern Y.	Participant	National Institute of Standards & Technology
Jiang, Ning	Participant	Courant Institute of Mathematical Sciences
Zemlyanova, Anna	Participant	Louisiana State University
Meza, Juan C.	Participant	LBNL
Lin, En-Bing	Participant	Central Michigan University
Musslimani, Ziad H	Participant	Florida state University

Enakoutsa, Koffi	Participant	Institut Jean Le Rond d'Alembert
Armstrong, Scott N.	Participant	
Ryu, Jaiyoung	Participant	Stanford University
Tezaur, Radek	Participant	Stanford University
Warnock, Robert Lee	Participant	Stanford Linear Accelerator Center
Callaghan, Thomas	Participant	
Weare, Jonathane	Participant	University of California, Berkeley
Shaw-Krauss, Abby Moshe	Participant	Columbia University
Nolen, James	Participant	Stanford University
Ide, Kayo	Participant	University of California, Berkeley
Spiller, Elaine	Participant	SAMSI
Kaplan, Jonathan Robert	Participant	Stanford University
Krener, Arthur J.	Participant	Naval Postgraduate School

The aim of this workshop is to deliver a set of lectures in the area of multiscale methods, aimed at graduate students. Whilst many of the methods described have been in the literature for several decades, there is a need for a modern treatment of the subject, reflecting two facts, the first application-driven, the second mathematics-driven: (i) there are a range of emerging new applications in areas such as systems biology, finance, turbulent diffusion, chemistry and solid state physics all of which can benefit from application of the tools of multiscale methods; (ii) existing treatments of the subject fail to expose the unity of the mathematics of multiscale methods, linking its use in PDEs, ODEs, SDEs and Markov chains. The treatment in the lectures primarily highlighted the second point, but the high turn out of students was very much related to the first point. Because no funding was available for students, the majority were from the Bay Area. However students from other parts of the USA, and from Europe, were also present.

Pavliotis and Stuart delivered 5 lectures each, over four days. In addition there were 4 guest lectures, to give students in indication of the research frontiers in this area. These guest lectures were given by A. Chorin (Berkleey), T. Hou (CalTech), B. Birnir (UCSB) and E. Vanden Eijnden (Courant).

Concrete Outcomes of the Workshop:
Pavliotis and Stuart delivered the same course in the UK, to a range of graduate students from Europe. On the basis of experience gained from offering the course at MSRI and in the UK, Pavliotis and Stuart converted their lectures notes for the course into a book, published by Springer in February 2008. See:
http://www.warwick.ac.uk/~masdr/mult.html for links to the Springer web-page for the book.

Connections for Women:
Geometric Analysis and Nonlinear Partial Differential Equations
(9/08/2006 to 9/09/2006)

We had about 20 women participating, about 15 postdocs and graduate students and about 5 at a more senior level. The talks were at an introductory level and all participants seemed to enjoy them. We left plenty of time for discussion/socializing and younger women liked the informal interaction with the more senior professors and with each other. I found important to choose good and inspiring speakers.

Most of the women that we invited to participate accepted our offer (about 70%). We also included some women from Europe and Asia who gave us their thoughts on women issues in mathematics. During the panel discussion special issues were raised and women liked to share their experiences.

We were planning to have a poster session which at the end did not happen. I thought that this would have been a good opportunity for the younger ladies to show their work and I would recommend it for future meetings.

Overall, I thought that the Connections for Women meeting was a successful event and I encourage MSRI to continue having it.

Report on MSRI Workshop " Recent Developments in Numerical Methods and Algorithms for Geometric Evolution Equations"

C. Elliott (University of Sussex, UK)
X. Feng (University of Tennessee)
M. Holst (UCSD)
H. Zhao (UCI)

1 summary

The two-day workshop was held on March 16–17, 2007. It was embedded in the one-year long program on *Geometric Evolution Equations and Related Topics*, and was arranged in conjunction with and followed immediately after a companion MSRI workshop on "Geometric Evolution Equations". This is a focused meeting in the rapidly developing area of numerical methods and algorithms for geometric evolution equations. The workshop presents a unique and timely opportunity for stimulating discussions and communications on recent developments in the area. In addition, arranging the workshop immediately following its companion workshop encourages and facilitates communications and collaborations between pure and applied mathematicians on geometric evolution equations so that two groups of researchers can benefit from each other.

There are about twenty five participants for the workshop, they consist of mathematicians from Canada, China, Germany, United Kingdom, and United States. The participants of the workshop includes some of the most distinguished numerical mathematicians in the world and some of top young researchers (including two female mathematician and four Ph.D students) in the field. That's a good mixture of both senior and junior researchers. There were six invited talks in the workshop. The six speakers are:

C. Elliott (University of Sussex, UK),
D. Chopp (Northwestern University),
Q. Du (Penn State University),
G. Dziuk (University of Freiburg, Germany),
R. Nochetto (University of Maryland),
A. Oberman (Simon Fraser University).

There were great interactions among workshop participants, in particular, between senior and junior researchers, and between pure and applied researchers. This kind of interactions at research level is crucial to the continuing high level of advancement of the field. The workshop facilitated and fostered such high level interactions. The workshop

also provided a wonderful educational opportunity for the participated junior researchers and graduate students in the field. The combination of talks, informal discussions, and the special environment of MSRI provided this opportunity.

2 Mathematical activities

Besides their rich and interesting mathematical features and challenges, geometric evolution equations appear in many scientific, engineering and industrial applications such as moving interface and phase transition in material sciences, image processing, and etc. Numerical computation of geometric evolution equations is quite challenging due to dynamic deformation of geometry, nonlinearity and possible development of singularities, especially topological changes such as self-intersection, merging, pinching, splitting, and fattening. Recently, significant progress has been made in computational methods and algorithms for geometric evolution equations. Powerful numerical methods, which are based on the level set and the phase field methodologies and combine well-known discretization methods such as finite difference methods, finite element methods, finite volume methods and spectral methods with efficient solution methods such as adaptive mesh methods, multilevel methods and domain decomposition methods, have greatly increased the capability of computing solutions of complicated nonlinear geometric evolution equations, in particular, in higher dimensions.

During the workshop the following topics were covered.

- Surface partial differential equations and applications (by C. Elliott). In particular finite element formulation and adaptive mesh for solving surface diffusion equation was presented.

- Phase field models for curvature related interface energies (by Q. Du). Phase field model of interfacial energies involving curvature terms was the theme of the presentation. Particular examples include the elastic bending energy (the Willmore energy) for vesicle membranes. Analysis on the sharp interface limit and the convergence of numerical simulation methods was shown.

- Numerical schemes and their convergence to viscosity solution for degenerate elliptic partial differential equations (by A. Oberman). Convergent schemes for genuinely nonlinear or degenerate second order equations, such as motion by mean curvature, the infinity Laplacian, the Monge-Ampere equation, and also for some less well-known or newer equations, including the Pucci Equations and a new PDE for the convex envelope,were discussed. Another subject is on finding non-generic stochastic

control or game interpretations of the PDEs. These interpretation are linked to simple numerical approximation schemes.

- Foliations of hyperbolic space and minimal surfaces with voids (by D. Chopp). Two geometric computations done using the level set method were presented. In the first problem it is shown that hyperbolic space can be foliated by a family of constant mean curvature disks sharing an ideal boundary. While it has been proven to be possible when the boundary is star-shaped, the numerical result shows that it is probably true for arbitrary smooth boundaries. In the second problem, periodic minimal surfaces in domains which contain voids were computed. It is shown that the periodic surface of least area is not necessarily flat.

- Numerical methods for Willmore flow (by G. Dziuk). Discretization techniques for the elastic flow of surfaces were discussed. These techniques depend on the mathematical model for the surface or curve. The methods are quite different for parameterized surfaces and for graphs or level sets. Numerical analysis for the problem were presented. Anisotropic Willmore flow was described.

- Discrete gradient flows for shape optimization and applications (by N. Ricardo). A variational framework for shape optimization problems that hinges on devising energy decreasing flows based on shape differential calculus followed by suitable space and time discretizations (discrete gradient flows) was presented. A key ingredient is the flexibility in choosing appropriate descent directions by varying the scalar products, used for computation of normal velocity, on the deformable domain boundary. We discuss applications to image segmentation, optimal shape design for PDE, and surface diffusion, along with several simulations exhibiting large deformations as well as pinching and topological changes in finite time.

Pan-American Advanced Studies Institutes Program (PASI)
Final Report
Mathematical Sciences Research Institute
Training Program on Stringy Topology in Morelia, Mexico
January 09,2006 to January 20,2006
Lectures on String(y) Topology, Cuernavaca, Mexico
October 16-18, 2006

Organized By: R. Cohen (Stanford), J. Morava (Johns Hopkins), A. Adem (UBC/UW--Madison), Y. Ruan (UW-Madison); Local Organizers: M. Aguilar (UNAM-Mexico City), D. Juan-Pineda (UNAM-Morelia), J.Seade (UNAM-Cuernavaca)

Introduction

This program was supported by the National Science Foundation as a Pan-American Advanced Studies Institute. The first week, organized by Ernesto Lupercio (CINVESTAV, Mexico) and Bernardo Uribe (Universidad de los Andes, Colombia), was a training program directed toward graduate students and young researchers, while the second week was a research workshop, featuring presentations and discussions on new results in the topology of strings.

New ideas in string theory, in particular D-branes and their relevance to open strings, have in many ways revolutionized modern quantum field theory, but this subject is currently highly heuristic: its formalization and mathematical development has barely begun. The geometric naturality and flexibility of these concepts has fostered rapid development, but their codification is completely open. Orbifolds, gerbes, and stacks are all topics with well-established classical literatures, but the idea that they should be grouped together, and that the various kinds of twistings they manifest are relevant to physics, is a new idea in mathematics.

Structure

The central purpose was to introduce these concepts to young research mathematicians from both South and North America. The introductory lectures given during the first week provided the necessary background; supplemented, during the second week, with overview lectures in the mornings preparatory to the research lectures on recent progress in the afternoons. Many of the trainees in this program had attended a summer school in String Theory, organized by Bernardo Uribe, at the University of the Andes in Colombia. These participants were particularly well prepared for the program, and got a great deal out of it. In all, there were 44 trainees supported by the NSF award, 8 of whom were women. The breakdown by nationality is:

Country	Trainees	Male	Female
Argentina	2	1	1
Australia	1	1	
Canada	2	2	
China	5	5	
Colombia	2	2	

France	1	1	
Germany	2	2	
Italy	1	1	
Japan	2	2	
Mexico	14	12	2
Portugal	1	1	
Spain	1	0	1
United Kingdom	4	3	1
United States	20	16	4
Uruguay	3	1	2
Venezuela	2	2	
Totals	63	52	11

Including local participants, and those coming with other support, there were over 50 trainees. Most trainees remained for the second (research) week of the program.

The second week of the program served as the Introductory Workshop for the MSRI program, Spring, 2006, in New Topological Structures in Physics. There were 28 researchers supported by the PASI award, 4 of whom are women, as follows:

Country	Researchers	Male	Female
Argentina	1	1	
Canada	2	2	
Colombia	1	1	
Finland	1		1
France	1		1
Germany	1		1
Japan	2	2	
Mexico	8	8	
Netherlands	1	1	
United Kingdom	4	4	
United States	13	11	2
Totals	34	29	5

In all, 98 mathematicians participated in the program, of whom 16 are female. The geographic distribution by continent is: North America, 37; Central and South America, 33; Europe, 18; Asia, 10.

Local Organization

The trainees were offered support for the entire two week program, and most remained for the second week. They were housed at the Howard Johnson in Morelia, and took their afternoon meals together with the researchers at the University Center. During the first week this was followed by structured discussions with particular researchers. For the Introductory workshop, the day was organized so that the lectue sessions took place in the morning and evenings, and there was a three hour break in the afternoons. This turned

out to be ideal for informal discussions and get-togethers among the trainees and researchers.

Trainees applied through a website set up by the local organizer, Danield Juan-Pineda. Links to this website were available at various locations, including the MSRI site. Researchers also registered and applied for funding through this website. There were 36 participants not supported by the PASI award. This includes 14 junior members of the parent program at MSRI for the semester.

Follow-up Meeting in Cuernavaca

Toward the end of the MSRI program in New Topological Methods in Physics, at the suggestion of the PASI program director, it was decided to use residual funds for a followup meeting in Fall, 2006 somewhere in Mexico. Hugo Rossi acted as organizer of this meeting, and Jose Seade as local organizer. The meeting was held in Cuernavaca, October 16-18, 2006. There were 45 participants of whom 32 received some support from the PASI grant (lodging and meals for all, and travel for those from distant locations). All were from Institutions in Mexico, although 2 were visiting in Mexico from South American Institutions. There were 21 were students (12 of whom had attended the training program in Morelia), and 9 women, of whom 7 were students.

Each of the main speakers gave three lectures; there were 5 additional presentations. The main lectures were specifically directed to the students. Alejandro Adem provided the background in orbifold and invariant theory, and Ralph Cohen's lectures provided the geometric and topological foundations of the program. The talks of Yongbin Ruan were more technical - dealing with the machinery necessary to endow cohomological structures with a product structure. The later lectures of these three, as well as the individual lectures, were about current research, much of which was completed during the MSRI semester program. Most of the participants stayed at the Posada Tlaltenango, a hotel not far from the UNAM Institute on the grounds of the Universidad Autonoma del Estado de Morelos. The long lunch break allowed for much interaction among the students and senior participants.

One anecdote illustrates the contribution this PASI award made to the program. Ernesto Lupercio's talk was an exposition of theorems proving the equivalences between various formulations of string(y) topological invariants. These equivalences are essential to the computatibility of the invariants which are central to the physical applications. Lupercio mentioned that this work (co-authored with Bernardo Uribe of Colombia and others) began at the Morelia workshop when Yongbin Ruan asked him if the techniques he discussed there could result in theorems of equivalence. Subsequently, while at MSRI in the Spring, he and Uribe began to outline the program, and continued to work on it during the summer and early Fall. A central contribution to the completion of the program was made by Lupercio's student, Ana Gonzalez - this work will appear in her thesis.

Schedule of the Training Program, MORELIA

Monday, January 9
8:30am - 9:00 Welcome
9:00am - 10am Introduction to algebraic topology (cell complexes, homology and cohomology, manifolds) B. Uribe
10:30am -11:30am Introduction to algebraic topology (Transversality, Thom isomorphism) E. Lupercio
12:00m - 1:00pm Introduction to algebraic topology (K-theory) B. Uribe
1:00pm - 4:00pm LUNCH
4:00pm – 6:00pm Discussion session with the lecturers.

Tuesday, January 10
9:00am - 10am Introduction to algebraic topology (Simplicial complexes) B. Uribe
10:30am -11:30am Introduction to Algebra (Algebras coming from physics, work of Gerstenhaber) E. Lupercio
12:00m - 1:00pm Introduction to Algebra (Operads, BV algebras) E. Lupercio
1:00pm - 4:00pm LUNCH
4:00pm – 6:00pm Discussion session with the lecturers.

Wednesday, January 11
9:00am - 10am Twisted K-theory (I) C. Teleman
10:30am -11:30am String Topology (I) V. Godin
12:00m - 1:00pm A^{∞} -algebras (I) J. McClure
1:00pm - 4:00pm LUNCH
4:00pm - 4:30pm Discussion session with C. Teleman.
4:30pm - 5:00pm Discussion session with V. Godin.
5:30pm - 6:00pm Discussion session with J. McClure.

Thursday, January 12
9:00am - 10am Loop Groups (I) N. Kitchloo
10:30am -11:30am Twisted K-theory (II) C. Teleman
12:00m - 1:00pm A^{∞} -algebras (II) J. McClure
1:00pm - 4:00pm LUNCH
4:00pm - 4:30pm Discussion session with N. Kitchloo
4:30pm - 5:00pm Discussion session with C. Teleman
5:30pm - 6:00pm Discussion session with V. Godin.

Friday, January 13
9:00am - 10am String Topology (II) V. Godin
10:30am -11:30am Loop Groups (II) N. Kitchloo
12:00m - 12:30pm Discussion session with V. Godin.
12:30pm - 1:00pm Discussion session with N. Kitchloo.
1:00pm - 4:00pm LUNCH

Monday, January 16
9:00am - 10am Peter Teichner, Generalized Cohomology and Quantum Field Theory, I
10:30am -11:30am Dennis Sullivan, String topology at level I
11:45am - 12:45pm Ulrike Tillman, Configurations and Cobordism Theories

4:00pm-4:45pm, Nitya Kitchloo, TBA
5:00pm-5:45pm, Jorge Devoto, K3-cohomology and elliptic objects
6:00pm- 6:45pm, Parallel Discussions
Craig Westerland, Equivariant operads and string topology
Christopher Douglas, Semi-infinite Homotopy Theory

Tuesday, January 17
9:00am - 10am Peter Teichner, Generalized Cohomology and Quantum Field Theory, II
10:30am -11:30am Dennis Sullivan, String topology at level II
11:45am - 12:45pm Soren Galatius, The Space of Graphs and Homology of Aut(F_n)

4:00pm-4:45pm, Ezra Getzler, Homotopy Frobenius Manifolds and BV Algebras
5:00pm-5:45pm, Veronique Godin, Towards Parametrized String Topology Operations
6:00pm- 6:45pm, Parallel Discussions
Vassily Gorbounov, TBA; Antonio Ramirez, TBA

Wednesday, January 18
9:00am - 10am Stephan Stolz, Generalized Cohomology and Quantum Field Theory, III
10:30am -11:30am Kenji Fukaya, Loop Space, Floer Theory of Lagrangian Submanifolds
11:45am - 12:45pm Mikhail Kapranov, TBA

Thursday, January 19
9:00am - 10am Michael Hopkins, Topological Examples of Topological Field Theories, I
10:30am -11:30am Dan Freed, TBA
11:45am - 12:45pm Jim McClure, TBA

4:00pm-4:45pm, Matthewu Ando, TBA
5:00pm-5:45pm, Nathalie Wahl, Mapping Class Groups of Non-orientable Surfaces
6:00pm- 6:45pm, Parallel Discussions
Bernardo Uribe, Extended Tangent Bundles in Generalized Complex Geometry
Nora Ganter, Orbifold Genera, The K(n)-local Categories

Friday, January 20
9:00am - 10am Michael Hopkins, Examples of Topological Field Theories, II
10:30am -11:30am Constantin Teleman, The Structure of Semi-simple 2D Field Theories
11:45am - 12:45pm Izak Moerdijk, Extensions of Lie Groupoids and Nonabelian Cohomology

4:00pm-4:45pm, Ernesto Lupercio, Orbifold String Topology
5:00pm-5:45pm, Paul Norbury, Volumes of Moduli Spaces of Hyperbolic Surfaces
6:00pm- 6:45pm, Miguel Xicotencatl, Orbifold Operations in String Topology

Introductory Workshop: New Topological Structures in Physics
January 16-20, 2006

Titles and Abstracts

Series of Lectures

Michael Hopkins: Topological Examples of Topological Field Theories

I will describe open-closed topological conformal field theories and several examples that come up in homotopy theory.

Dennis Sullivan: String topology at levels I,ll and III

The original transversality idea leads to string topology at the first level: partial chain operations in the loop space associated to certain graphs called string diagrams. Perturbed transversality leads to string topology at the second level: fully defined operations for an extended set of diagrams obtained by taking all limits. There is a vanishing result for most of the new diagrams. Using the propagator of the perturbation leads to the third level: operations defined for chains on open moduli spaces with two types of nonvanishing terms at infinity. One is absorbed by partially compactifying moduli space. From the chains on this modified moduli space and the appropriate chains in the string space one constructs, by gluing, chains in a type of Weyl algebra. Applying duality to moduli space yields an element m in the Weyl algebra that satisfies $\partial m = m^2$. We will discuss the case of closed strings and only indicate directions for open strings.

P. Teichner and S. Stolz: Generalized cohomology and quantum field theory

We shall survey an interpretation of certain spaces of super symmetric (susy) quantum field theories as the classifying spaces for generalized cohomology theories. In joint work with Stephan Stolz, we prove that the space of susy I-dimensional field theories is a classifying space for K-theory and we propose a picture for susy 2- dimensional field theories as classifying space for elliptic cohomology, or more precisely, for the theory TMF of "topological modular forms" of Hopkins and Miller. There is also a relation of susy O-dimensional field theories with deRham cohomology.

Individual Lectures

F. Cohen: On the homology of spaces of knots in dimension 3 (joint work with R. Budney)

Let $K_{3,1}$ denote the space of long knots in R^3 with the path component of the *long knot* f denoted $K_{3,1}(f)$

(1) The homology of the space of$K_{3,1}$ with (a) coefficients in the rationals is a free Poisson algebra and (b) with coefficients in the field with p elements is a *free restricted Poisson algebra*.

(2) The growth of p-torsion in the integral homology of $K_{3,1}(f)$ is a reflection of a kind of *complexity* of the knot.

(3) Related speculation will be given concerning the above and connections to a Lie algebra of T. Kohno together with results of Berrick, Wong, Wu and the speaker regarding braid groups and the loop space of the 2-sphere.

J. Devoto: $K3$-cohomology and elliptic objects

$K3$-cohomology is a generalized cohomology associated to $K3$ surfaces. We shall discuss the definition and construction of $K3$-cohomology and outline a possible geometric interpretation which generalize the idea of elliptic objects of G. Segal.

C. Douglas: Semi-Infinite Homotopy Theory

String homology studies finite-dimensional cycles in the free loop space. Floer homology by contrast involves semi-infinite-dimensional cycles in, for example, the free loop space. Ordinary stable homotopy is well suited to describing string topology (as demonstrated for instance by Cohen and Jones' homotopy-theoretic realization of the loop product), but ill suited for describing Floer topology. We define and describe the foundations of a semi-infinite stable homotopy theory more closely connected than classical stable homotopy to the geometric structures arising in Floer theory.

D. Freed: TBA

K. Fukaya: Loop space and Floer theory of Lagrangian submanifolds

Using the L_∞ algebra of Loop space homology introduced by Chas- Sullivan, a de Rham version of Floer homology of Lagrangian submanifolds will be discussed. It has several applications to symplectic topology. But in this talk I would like to focus its application to some aspects of Mirror symmetry and also explain how it unifies various approaches to study Lagrangian submanifolds using pseudo-holomorphic discs. I will also explain how to include interior marked points to the story based on the resent progress of the joint work with Oh-Ohta-Ono.

S. Galatius: The space of graphs and homology of $Aut(F_n)$

N. Ganter : Orbifold genera, the $K(n)$-local categories, product formulas and power operations

I will talk about the connection between the string theoretic notions of orbifold genera and their product formulas to stable homotopy theory.

E. Getzler: Homotopy Frobenius manifolds and Homotopy BV algebras

Stasheff introduced A^∞ algebras as a homotopy generalization of differential graded associative algebras: a complex chain homotopy equivalent to an A^∞ algebra is an A^∞ algebra. In this talk, I present analogous constructions for Frobenius manifolds and Batalin-Vilkovisky algebras, due respectively to myself and to Tamarkin and Tsygan. It turns out that Frobenius$^\infty$ manifolds form a subcategory of BV^∞ algebras, an analogue in homotopical algebra of coupling to topological gravity.

V. Godin: Towards parameterized string topology operations

This is a presentation of work in progress with Antonio Ramirez. Using a graph-model for the moduli spaces of Riemann surfaces, we will define operation in the homology of the loop space of a manifold. We will also explain how these operations should give a homological conformal field theory.

V. Gorbounov: Elliptic genus test for mirror symmetry

At the level of topological quantum field theories mirror symmetry partners have been identified for a large class of manifolds. The work of Hori and Vafa is a good reference for these results. Investigations beyond the level of the topological theories is difficult because of the lack of mathematical structure describing quantum field theories. The chiral de Rham complex is a good approximation to such a description. The elliptic genus is an important characteristic of the chiral de Rham complex. In this talk we describe the test for Hori-Vafa's construction of mirror partners from the point of view of the chiral de Rham complex. Our results refine Hori- Vafa's conclusions. As an application to topology we calculate the elliptic genus for a large class of complete intersections in toric varieties in terms of the mirror Landau-Ginsburg orbifold.

E. Lupercio: Orbifold String Topology

In this talk we put forward a generalization of String Topology in which the manifold is replaced by an orbifold. Several themes that appear both in orbifold string theory and in the Chen-Ruan cohomology make their appearance here as well: discrete torsion and twisted sectors, for example. The theory can be thought of as a sort of equivariant version of String Topology. This is joint work with Bernardo Uribe and Miguel Xicotencatl.

I. Moerdijk: Extensions of Lie Groupoids and Non abelian cohomology

I will present a classification of regular Lie groupoids. The main ingredients are the extensions of bundles of Lie groupoids on which the holonomy of a certain foliation acts, and principal bundles under bitorsors over such a bundle of Lie groupoids.

P. Norbury: Volumes of moduli spaces of hyperbolic surfaces

The moduli space of genus g curves with n marked points can be reformulated as the moduli space of genus g hyperbolic surfaces with n cusps. This viewpoint brings a symplectic structure to the moduli space, so in particular volume makes sense. Mirzakhani calculated the volume of a more general moduli space -the moduli space of genus g hyperbolic surfaces with n geodesic boundary components of specified lengths - and showed that it is a polynomial in the boundary lengths. Mirzakhani showed the coefficients in these polynomials are related to the intersection numbers on the moduli space and used this to reprove the Witten-Kontsevich theorem. I will explain this work and further consequences of the hyperbolic geometry on intersection numbers.

C. Teleman: The structure of Semi-Simple $2D$ field theories

B. Uribe: Extended tangent bundles in Generalized complex geometry

I will talk on my recent work with Shengda Hu, on the equivalence of generalized extended structures and twisted generalized complex structures. This relation could be seen as a duality on which one side is a geometric construction and on the other, algebraic. To make the talk accessible I will give a brief summary on the work of Hitchin and Gualtieri in generalized complex manifolds.

A. Ramirez: Open-closed string topology

The area of string topology began with a construction by Chas and Sullivan of previously undiscovered algebraic structures on the homology $H^*_{\mathcal{L}M}$ of the free loop space of an oriented manifold M. Among other results, Chas and Sullivan showed that $H^*_{\mathcal{L}M}$ suitably regraded carries the structure of a graded-commutative algebra. The product pairing was subsequently extended by Cohen and Godin into a form of topological quantum field theory (TQFT). Open-closed string topology, first sketched by Sullivan, arises when considering spaces of paths in M with endpoints constrained to lie on given submanifolds (the so-called D-branes). In this talk, I describe a way to extend the TQFT structure of string topology into an analogue of TQFT which incorporates open strings. The method of construction is homotopy theoretic, and it makes use of constrained mapping spaces from fat B-graphs (which I define) into the ground manifold M.

U. Tillmann: Configurations and cobordism categories

A classical theorem of Graeme Segal identifies the configuration space of points in R^∞ - after group completion - with the space of stable maps from the sphere to a sphere. Points are naturally O-dimensional manifolds. We will generalize this to all dimensions n. The case $n = 2$ is closely related to the theorem of Madsen and Weiss which implies the Mumford conjecture. This is joint work with Ib Madsen, Soren Galatius and Michael Weiss.

A. Voronov: The master equation of open-closed sigma model

We report on a joint work with Javier Zuniga, which describes the quantum master equation of open-closed sigma model, generalizing results of Zwiebach and Sullivan to the open-closed case. Mathematically speaking, the master equation governs the boundary structure of the moduli space of holomorphic maps from Riemann surfaces with boundary to a fixed compact, complex manifold, subject to boundary conditions given by a set of Lagrangian submanifolds(a.k.a D-branes).

N. Wahl: Mapping class groups of non-orientable surfaces

We prove that the homology of the mapping class groups of non-orientable surfaces stabilizes with the genus of the surface. Combining our result with recent work of Madsen and Weiss, we obtain that the classifying space of the stable mapping class group of non-orientable surfaces, up to homology isomorphism, is the infinite loop space of a Thorn spectrum built from the canonical bundle over the Grassmannians of 2-planes in R^{n+2}.

In particular, we show that the stable rational cohomology is a polynomial algebra on generators in degrees $4i$—this is the non-oriented analogue of the Mumford conjecture.

C. Westerland: Equivariant operads and string topology.

The free loop space $\mathcal{L}M$ of a manifold M admits an action of the circle by rotating loops. We show that its equivariant homology is an algebra over the Getzler's gravity operad, constructed from the moduli spaces of points in the Riemann sphere. Moreover, we describe a general procedure for constructing new operads akin to the gravity operad and make some conjectures regarding their application to higher dimensional analogues of string homology.

M. Xicotencatl: Orbifold operations in string topology

In recent joint work with Ernesto Lupercio and Bernardo Uribe, we have defined a BV algebra structure in the homology of the free loop space of an orbifold. In this talk we look at the case of the global quotient given by the action of the symmetric (or the cyclic group) on the p-th power of a manifold M and show how this can be used to produce operations in the homology of $\mathcal{L}M$.

January 9-20, 2006
Training Program in String Topology
Morelia, Mexico

Participant Name	Workshop Role	Institution
Abouzaid, Mohammed	trainee	University of Chicago
Adem, Alejandro	organizer	University of British Columbia
Aguilar, Haydee		Universidad Nacional Autonoma de Mexico
Aguilar, Marcelo A.	organizer	UNAM
Alonso, Juan M.	trainee	Facultad de Ciencias
Ando, Matthew	Speaker 2nd week	University of Illinois, Urbana-Champaign
Boege, Margareta		UNAM
Bouchard, Vincent	MSRI PD	University of Pennsylvania
Brambila-Paz, Leticia	trainee	CIMAT
Cantarero-Lopez, Jose Maria	trainee (PIMS)	University of British Columbia
Chen, Xiaojun	trainee	Stony Brook University
Cheung, Pokman	trainee	Stanford University
Cohen, Ralph	organizer	Stanford University
Colman, Hellen	trainee	Wilbur Wright College
Creutzig, Thomas	trainee	berkeley concurrent enrollment
Devoto, Jorge Andres	invitee	ITBA
Diaz, Rafael	trainee	Universidad Central de Venezuela
Douglas, Christopher Lee	invitee	Stanford University
Drummond-Cole, Gabriel C.	trainee	SUNY Stonybrook
Flores, Johana Luviano	trainee	UNAM
Freed, Daniel S.	invitee	University of Texas, Austin
Fukaya, Kenji	invitee	Kyoto University
Galatius, Soren	Speaker	Stanford University
Gálvez Carrillo, Imma	trainee	London Metropolitan University
Ganter, Nora	MSRI PD	MSRI
Getzler, Ezra	invitee	Northwestern University
Giansiracusa, Jeffrey Herschel	trainee	Oxford University
Godin, Veronique	intro speaker	Harvard University
Karina	trainee	Centro de Matematica
Howard	trainee	CINVESTAV - IPN
Gonzalez, Eduardo	trainee	UT Austin
Gorbounov, Vassily	invitee	university of kentucky
Gruher, Kathleen	trainee	Stanford University
Hanbury, Elizabeth	trainee	University of Oxford
Herrera, Wilberth Christián	trainee	CINVESTAV
Hopkins, Michael J.	lecture series	MIT
Iguri, Sergio Manuel	trainee	IAFE
Iritani, Hiroshi	MSRI PD	MSRI
Juan Pineda, Daniel	local organizer	UNAM
Kimura, Takashi	MSRI GM	Boston University
Kitchloo, Nitya Ranjan	intro speaker	University of California, San Diego
Laufer, Michael Swan	Speaker	CUNY graduate center
Lee, Yi-Jen	MSRI GM	Purdue
Lozano, Cesar Adrian	trainee	CINVESTAV IPN
Lupercio, Ernesto	intro lecturer	UNAM
Martinez Navas, Hermes Jackson	trainee	Universidad de los Andes
Mautner, Carl	trainee	University of Texas in Austin
McClure, James E.	intro speaker	US
Menichi, Luc	trainee	University of Angers
Moerdijk, Izak	invitee	Netherlands
Noetzel, Gregor	trainee	Max Planck Institute for Mathematics in the Sciences
Norbury, Paul	invitee (MSRI KSS)	UK
Ochoa Daza, Maicol Arley	trainee	Universidad Central de Venezuela
Oeckl, Robert	invitee	UNAM
Ohta, Hiroshi	trainee	Nagoya University
Ono, Kaoru	trainee	Hokkaido University
Paniagua, Pablo	trainee	Centro de Investigación y Estudios Avanzados, CINVESTAV
Pedroza, Andrés	trainee	Universidad de Colima
Poddar, Mainak	MSRI GM	University of Waterloo
Prassidis, Stratos	RP	Canisisus College
Puente Vazquez, Elsa		UNAM
Ramirez, Antonio	invitee	UBC
Reyes, Enrique	RP	Cinvestav
Riveros Pacheco, David Ricardo	trainee	Universidad de los Andes
Rodriguez-Ceballos, Joel Arturo	trainee	Universidad Michoacana de San Nicolás de Hidalgo
Rounds, Nathaniel	trainee	UK
Ruan, Yongbin	organizer	University of Wisconsin, Madison
Ruuska, Vesa	invitee	Finland
Salter, Mary Frances	MSRI GM	MSRI
Santos, Joao Paulo		Instituto Superior Tecnico
Sati, Hisham Ahmad	MSRI GM	University of Adelaide
Schwarz, Matthias	invitee	UK
Seade, Jose	local organizer	Cuernavaca
Seeliger, Nora	speaker	Georg-August-Universität Göttingen
Stolz, Stephan	invitee	Notre Dame
Sullivan, Dennis P.	lecture series	suny stonybrook, cuny grad center
Teichner, Peter	lecture series	UC Berkeley
Teleman, Constantin	intro speaker	St. John's College
Tillmann, Ulrike	invitee	Oxford University
Tonks, Andrew Peter	trainee	London Metropolitan University
Torres, Rafael	trainee	CINVESTAV-IPN
Uribe, Bernardo	intro lecturer	Universidad de los Andes
Vega, Manuel Vladimir	trainee	CINVESTAV
Verjovsky, Alberto	trainee	UNAM
Villa Díaz, Félix	trainee	CINVESTAV-IPN
Voronov, Alexander A.	invitee	US
Wahl, Nathalie	invitee	University of Chicago
Westerland, Craig Christopher	invitee	University of Wisconsin, Madison
Whitcher, Ursula Anne	trainee	University of Washington
Wiethaup, Moritz	trainee	Georg-August-Universität Göttingen
Willerton, Simon	trainee	University of Sheffield
Wilson, Scott Owen	trainee	University of Minnesota
Xavier, Juliana	trainee	Facultad de Ciencias
Xicotencatl, Miguel	invitee	UNAM
Xing, Hao	trainee	University of Michigan
Xu, Dezhen	trainee	Stony Brook University
Zhang, Bin	trainee	Max-Planck-Institute fur Mathematik
Zuniga, J. Javier	trainee	University of Minnesota

Program of the Lectures, CUERNAVACA

Monday October 16

9:30 Welcome
11:00 Alejandro Adem, Orbifold Cohomology
12:15 Yongbin Ruan, Computation of Orbifold Cohomology, I
Lunch
3:30 Ralph Cohen, String Topology, I
4:45 Miguel Xicotencatl, Loop Orbifold of the Symmetric Product

Tuesday, October 17

9:30 Ernesto Lupercio, Virtual Orbifold Cohomology
11:00 Alejandro Adem, Twistings
12:15 Yongbin Ruan, Computation of Orbifold Cohomology, II
Lunch
3:30 Ralph Cohen, String Topology, II
4:45 Daniel Juan, Nil Groups in Topology

Wednesday, October 18

9:30 Jose Seade, On Contact Structures on Singularity Links
11:00 Alejandro Adem, Orbifold K-theory
12:15 Ralph Cohen, String Topology, III
Lunch
3:30 Yongbin Ruan, Computation of Orbifold Cohomology, III
4:45 Oscar Loaiza, String Theory Flux Compactification

Abstracts

Cohomology, Twisitings and K-theory of Orbifolds, Alejandro Adem, University of British Columbia
These lectures begin with an elementary review of classical orbifold invariants, after which we discuss so-called stringy invariants. Among other topics are: gerbes, discrete torsion and stringy products in the twisted K-theory of orbifolds.

String Topology, Ralph Cohen, Stanford University
These lectures begin with the basic structure on the homology of loop spaces and path spaces discovered by Chas and Sullivan. Further topics discussed, from a perspective of homotopy theory, are: Hochshild cohomology, fat graph models for moduli spaces, symplectic topology of cotangent bundles, and relationship with work of Freed, Hopkins and Teleman on loop group representations.

Orbifold Cohomology and its Computation, Yongbin Ruan, University of Michigan
First we introduce some basic objects of stringy orbifold theory such as the inertia orbifold and higher moduli paces of constant morphisms from Riemann surfaces. We use those objects to define the orbifold cohomology ring. Most of the time is devoted to methods of computing the ring structure of orbifold cohomology, such as the deRham model for abelian orbifolds and the representation theoretic techniques for the symmetric product.

Orbifold String Topology and Virtual Orbifold Cohomology, Ernesto Lupercio, CINVESTAV (joint work with B. Uribe, M. Xicotencatl and A. Gonzalez).
We introduce a generalization for the orbifold case of the string topology of Chas and Sullivan, and go on to an interesting family of topological quantum field theories that appear through a localization procedure we call virtual orbifold cohomology.

The Atiyah-Hirzebruch Spectral Sequence and String Theory Flux Compactification, Oscar Loaiza, UNAM (Physics)
The Atiyah-Hirzebruch Spectral Sequence has a very interesting physical interpretation in terms of instantonic D-branes. Under such an interpretation, we consider the presence of topological transition between fluxes and D-branes. These processes must be considered in a flux compactification which in turn leads us to a mechnism to stabilize the moduli. Furthermore, since we require the existence of a non-trivial NS-NS 3-form flux in the background, it is possible to show that under T-duality, we can compactify a string theory on twisted tori. As a result we have the appearance of new instantonic branes and a mechanism to freeze all moduli.

October 16 - 18, 2006
Lectures on String(y) Topology
Curenavaca, Mexico

Participant

Last	**First**	From	Role
Adem	Alex	Canada	lecture series
Aguilar	Miguel	- CINVESTAV	trainee
Aguilar	Marcelo	UNAM-Mexico City	invitee
Boege von Me	Margareta	Cuernavaca	invitee
Bracho	Javier	UNAM-Mexico City	invitee
Cisneros	Jose	Cuernavaca	invitee
Cohen	Ralph	US	lecture series
Espinoza	Enrique	- CINVESTAV	trainee
González	Carlos	- CINVESTAV	trainee
González	Ana	- CINVESTAV	trainee
Hernández Ar	Rosalía	Cuernavaca	trainee
Itza	Benjamin	Univ. Pachuca	invitee
Jiménez	Rita	- CINVESTAV	trainee
Jiménez	Rolando	UNAM-Oaxaca	invitee
Juan	Daniel	UNAM-Morelia	speaker
Laris	Mariano	UNAM-Mexico City	trainee
León	Gaspar	UNAM-Morelia	trainee
Loaiza	Oscar	- CINVESTAV	speaker
López	Jorge	Univ. Michoacan	invitee
López de Mec	Santiago	UNAM-Mexico City	invitee
Lozano Huert	Lozano	- CINVESTAV	trainee
Lupercio	Ernesto	- CINVESTAV	speaker
Luviano	Johana	- CINVESTAV	trainee
Martínez	Berenice	- CINVESTAV	trainee
Millán	Silvia	UNAM-Morelia	trainee
Mostovoy	Jacob	Cuernavaca	invitee
Muller	Olaf	UNAM-Morelia	invitee
Paniagua	Pablo	- CINVESTAV	trainee
Prieto	Carlos	UNAM-Mexico City	invitee
Ramírez	Wilbert	- CINVESTAV	trainee
Rossi	Hugo	US	organizer
Ruan	Yongbin	US	lecture series
Seade	Jose	Cuernavaca	organizer
Solá	Alberto	Cuernavaca	invitee
Vega	Guillermo	- CINVESTAV	trainee
Villa	Félix	- CINVESTAV	trainee
Xicotencatl	Miguel	- CINVESTAV	speaker

REPORT ON CMI/MSRI HOT TOPICS WORKSHOP
"Modularity for GL(2) and Beyond"
Held at MSRI, October 30, 2006 – November 3, 2006

Organizers: *Michael Harris, Mark Kisin, Kenneth Ribet, Richard Taylor, David Ellwood*

To prove that a mathematical object is modular is to link it to an automorphic representation. In the past few years, three outstanding modularity conjectures have been settled in a large number of cases: Serre's conjectures on mod p Galois representations; the Fontaine-Mazur conjecture for p-adic Galois representations; the Sato-Tate conjecture for elliptic curves. The aim of the Hot Topics workshop held at MSRI between October 30 and November 3, 2006, was to summarize the results and techniques in these directions and to sketch out a research program that will take us from GL(2) to unitary groups of higher rank.

The first day of the workshop was devoted to general talks, intended both to introduce the subject to non-specialists (in the San Francisco area) and to orient participants in the week's activities. Two talks by Richard Taylor focused on the general problem of modularity, both as formulated by Langlands in the setting of his functoriality conjectures and in the more arithmetic versions due to Fontaine and Mazur. Ken Ribet's talk was a survey of recent results on modularity for 2-dimensional representations, and Nick Katz presented an overview of the Sato-Tate conjecture and related questions.

The remainder of the workshop was divided into two roughly equal parts, concentrating respectively on recent developments in modularity for two-dimensional Galois representations (the Serre conjecture and the Fontaine-Mazur conjecture) and on the relation between Galois representations of arbitrary dimension n and automorphic representations of GL(n) and unitary groups, culminating in a description of work on the Sato-Tate conjecture for elliptic curves. Although several speakers were asked to provide background material on automorphic representations, Shimura varieties, p-adic Hodge theory, and the family of Calabi-Yau hypersurfaces used in the proof of the Sato-Tate conjecture, most speakers saw their primary task as explaining how the techniques initiated in the historic articles of Wiles and Taylor-Wiles on Fermat's Last Theorem can be adapted to treat increasingly general classes of p-adic Galois representations.

Coverage of the recent work on two-dimensional Galois representations was thorough. Technical questions were divided among several talks, which provided detailed proofs in most cases. Richard Taylor provided an overview of modularity lifting theorems in a new and more flexible formulation, based largely on Mark Kisin's approach via framed deformations. Ken Ribet's talk on the Serre Conjecture identified the key ideas of the Khare-Wintenberger proof.

The discussion of modularity for representations of arbitrary dimension was necessarily less complete. Given that participants were not assumed to be familiar with the general theory of automorphic representations, the goal of speakers was to outline the shape of

this vast theory and to hint at some of the analogies with the theory of elliptic and Hilbert modular forms considered in the other half of the program.

The meeting was capped by a lecture by Robert P. Langlands, in which he outlined his hopes that application of techniques of analytic number theory to the trace formula would lead to proofs of his functoriality conjectures in situations inaccessible to other available techniques. In the last few years there have been several international meetings on Serre's Conjecture alone, as well as a semester-long program at Harvard on deformation of p-adic representations, in which most of the results covered in this workshop were discussed, with particular emphasis on questions related to the Fontaine-Mazur conjectures. The Sato-Tate Conjecture is the subject of study groups in several universities in the United States and Canada. The workshop at MSRI has been the only attempt to introduce all of these developments in the course of a single week. It was well attended -- it was one of the largest workshops ever organized at MSRI -- and graduate students and young researchers were particularly well represented. Taken in conjunction with the other activities on the general topic of modularity of Galois representations, we feel the MSRI workshop has made a significant contribution to informing the mathematical community of the work in a branch of number theory that has seen considerable progress in recent years.

INVITED SPEAKERS

N. Katz (Princeton University), K. Ribet (University of California, Berkeley), C. Breuil (Université de Paris), M. Emerton (Northwestern University), T. Gee (Imperial College, London), M. Kisin (University of Chicago), R. Taylor (Harvard University) D. Blasius (University of California, Los Angeles), M. Harris (Université de Paris), N. Shepherd-Barron (Cambridge University), R. Langlands (School of Mathematics , Princeton), J. Bellaiche (Columbia University) and T. Yoshida (Harvard University).

SCHEDULE

Monday, October 30
These lectures are aimed at non-specialists. In particular the morning lectures will provide a colloquium style introduction to the main results to be discussed in the workshop.

9:30-10:30 *Ken Ribet, Berkeley: Recent advances in modular forms.*
This will be a colloquium style introduction to recent developments in the theory of modular forms, particularly Serre's conjecture and applications to the modularity of rank two motives, the Fontaine-Mazur conjecture in dimension 2 and perhaps the Sato-Tate conjecture.

11:00-12:00 *Nick Katz, Princeton: The Sato-Tate Conjecture*
This will be a colloquium style introduction to the Sato-Tate conjecture and its relation to L-functions and automorphicity.

2:00-3:15 *Richard Taylor, Harvard: Galois representations and automorphic forms: basic conjectures.*
This will explain some of the basic concepts in the study of Galois representations and state some motivational conjectures about Galois representations and particularly their relationship to automorphic forms.

3:45-5:00 *Richard Taylor, Harvard: Automorphic forms and Galois representations: examples and techniques.*
Illustrations of the conjectures discussed in the previous talk. Also a discussion of the known techniques to attack them and their limitations.

Tuesday, October 31
These talks will aim to explain recent developments in modularity lifting theorems for GL_2/Q to graduate students and people whose main interest is in automorphic forms.

9:00-10:00 *Richard Taylor, Harvard: Modularity lifting theorems I*

10:30-11:30 *Richard Taylor, Harvard: Modularity lifting theorems II*
Modularity lifting theorems assert that a suitable l-adic lift of an automorphic mod l

representation must itself be automorphic. This will describe how to prove such theorems in the simplest possible case: GL_2/Q, weight less than l and level prime to l. It will not follow the original arguments of Wiles and Taylor-Wiles; rather it will incorporate subsequent simplifications due to Diamond/Fujiwara, Kisin and Taylor. In particular it will not use arithmetic algebraic geometry nor Ihara's lemma.

1:30-2:30 *Mark Kisin, Chicago: Modularity of potentially Barsotti-Tate representations*
This will explain the modularity lifting theorems in weight 2 for GL_2 over a totally real field. There will be no restriction on the power of l in the level.

2:45-3:45 *Toby Gee, Imperial College: The weight in Serre's conjecture*
This will explain the conjecture of Diamond et al on the weight in Serre's conjecture for GL(2) over a totally real field. It will also discuss Gee's proof of this conjecture in many cases.

4:00- 5:00 *Teruyoshi Yoshida, Harvard: Potential modularity*
Will discuss potential modularity theorems for GL_2 and their applications. In particular the meromorphic continuation of the L-function of regular rank two motives and the embedding of a two dimensional odd mod l representation of G_Q into a compatible system of l-adic representations with prescribed types.

Wednesday, November 1
These talks will summarize the main facts about automorphic forms on unitary groups and the associated Galois representations. They will be aimed at graduate students and experts on elliptic modular forms.

9:00-10:30 *Don Blasius, UCLA: Automorphic forms on unitary groups I*

11:00-12:30 *Joel Bellaiche, Columbia: Automorphic forms on unitary groups II*
These talks will cover the following topics. The classification of unitary groups over local fields and number fields. The spectral decomposition of automorphic forms on an anisotropic unitary group in terms of cusp forms on general linear groups, including multiplicity formulas: conjectures and known cases. Shimura varieties attached to unitary groups as moduli spaces and their zeta functions; compatibility of the associated Galois representations with the local Langlands correspondence.
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Thursday, November 2
This will be a continuation of Tuesday's program but will also discuss the beginnings of p-adic Langlands conjectures for GL_2 and recent work on Serre's conjecture for GL_2. It will be aimed at graduate students and experts on automorphic forms.

9:00-10:00 *Christophe Breuil, IHES: Deformations of p-adic representations of p-adic Galois groups*
This will explain the existence of local deformation rings for De Rham representations of

G_Q_l with fixed Hodge-Tate numbers and given type. (Probably without any proof.) It will then explain the Breuil-Mezard conjecture.

10:15-11:15 *Mark Kisin, Chicago: p-adic local Langlands*
A discussion of the p-adic local Langlands conjecture for GL_2(Q_p).

11:30-12:30 *Mark Kisin: The Breuil-Mezard conjecture and modularity lifting theorems*
Will discuss the proof of many cases of the Breuil-Mezard conjecture and its application to general modularity lifting theorems for GL_2(Q).

2:30-3:30 *Matt Emerton, Northwestern: The p-adic completion of cohomology*
This lecture will give the statement of a p-adic global Langlands conjecture for GL_2, and sketch a proof of this conjecture in many cases. Applications of the conjecture to the Fontaine-Mazur conjecture for two-dimensional Galois representations, as well as a related conjecture of Kisin, will also be described.

4:00-5:00 *Ken Ribet, Berkeley: Serre's conjecture*
Will discuss the Khare-Wintenberger proof of many cases of Serre's conjecture for GL_2(Q).

Friday, November 3

9:00-10:00 *Michael Harris, Paris: Modularity lifting theorems for unitary groups*
Discussion of the generalization of modularity lifting theorems from GL_2 to higher rank unitary groups.

10:30-11:30 *Nick Shepherd-Barron, Cambridge: Geometry of the Dwork family*
Discussion of the geometric properties of the Dwork family needed for potential modularity results. In particular discussion of its monodromy both locally and globally. [As in section 1 of Harris, Shepherd-Barron, Taylor.]

1:30- 2:30 *Michael Harris, Paris: Potential modularity for n-dimensional representations*
The use of the Dwork family and modularity lifting theorems for unitary groups to prove potential modularity results for higher dimensional representations. Also, arithmetic applications (e.g. the Sato-Tate conjecture and L-functions for elements of the Dwork family).

3:00- 4:00 *Robert Langlands, IAS: Whither the trace formula*
Whither the trace formula and why: relation between trace formula and functoriality -- brief review of history, recent progress, and of scarcely explored approaches; functoriality and reciprocity between automorphic forms and motives -- questions for the audience.

Currently Available Videos on VMath

- **Kenneth Ribet**, Recent Advances in Modular Forms *October 30, 2006, 09:30 AM to 10:30 AM*
- **Nicholas Katz**, The Sato-Tate Conjecture *October 30, 2006, 11:00 AM to 12:00 PM*
- **Richard Taylor**, Galois Representations and Automorphic Forms: Basic Conjectures. *October 30, 2006, 02:00 PM to 03:15 PM*
- **Richard Taylor**, Automorphic Forms and Galois Representations: Examples and Techniques *October 30, 2006, 03:45 PM to 05:00 PM*
- **Richard Taylor**, Modularity Lifting Theorems I *October 31, 2006, 09:00 AM to 10:00 AM*
- **Richard Taylor**, Modularity Lifting Theorems II *October 31, 2006, 10:30 AM to 11:30 AM*
- **Mark Kisin**, Modularity of Potentiality Barsotti-Tate Representations. *October 31, 2006, 01:30 PM to 02:30 PM*
- **Toby Gee**, The Weight in Serre's Conjecture *October 31, 2006, 02:45 PM to 03:45 PM*
- **Teruyoshi Yoshida**, Potential Modularity *October 31, 2006, 04:00 PM to 05:00 PM*
- **Joel Bellaiche**, Automorphic Forms on Unitary Groups I *November 01, 2006, 09:00 AM to 10:30 AM*
- **Don Blasius**, Automorphic Forms on Unitary Groups I *November 01, 2006, 11:00 AM to 12:30 PM*
- **Christophe Breuil**, Deformations of P-adic Representations of P-adic Galois Groups *November 02, 2006, 09:00 AM to 10:00 AM*
- **Mark Kisin**, P-adic Local Langlands *November 02, 2006, 10:15 AM to 11:15 AM*
- **Mark Kisin**, The Breuil-Mezard Conjecture and Modularity Lifting Theorems *November 02, 2006, 11:30 AM to 12:30 PM*
- **Mark Kisin**, The Breuil-Mezard Conjecture and Modularity Lifting Theorems *November 02, 2006, 11:30 AM to 12:30 PM*
- **Matthew Emerton**, The P-adic Completion of Cohomology *November 02, 2006, 02:30 PM to 03:30 PM*
- **Kenneth Ribet**, Serre's Conjecture *November 02, 2006, 04:00 PM to 05:00 PM*
- **Michael Harris**, Modularity Lifting Theorems for Unity Groups *November 03, 2006, 09:00 AM to 10:00 AM*
- **Nicholas Shepherd-Barron**, Geometry of the Dwork Family *November 03, 2006, 10:30 AM to 11:30 AM*
- **Michael Harris**, Potential Modularity for N-dimensional Representations *November 03, 2006, 01:30 PM to 02:30 PM*
- **Robert Langlands**, Whither the Trace Formula *November 03, 2006, 03:00 PM to 04:00 PM*

REPORT ON CMI/MSRI HOT TOPICS WORKSHOP

"Minimal and Canonical Models in Algebraic Geometry**"**
Held at MSRI, April 16, 2007 to April 20, 2007

Organizers: Alessio Corti, Jean-Pierre Demailly, János Kollár, Shigefumi Mori

Two algebraic varieties are said to be birational if their fields of rational functions are isomorphic.

There is a unique smooth projective curve in each birational equivalence class of curves. For surfaces, the situation is a little more complex, but was completely understood in by the early 20th century: most surfaces have unique "minimal" models, and when this is not the case the set of minimal models is easy to understand. Shigefumi Mori won the Fields medal in 1990 for proving a similar theorem for 3-folds, and there has been intense work on extending Mori's Program to higher dimensions, ever since. A closely related problem is the finite generation of the canonical ring of a variety of general type and thus the existence of canonical models for these varieties. Very recently Yum-Tong Siu on one hand and Birkar, Cascini, Hacon and McKernan on the other announced proofs of this finite generation. This has as a consequence the extension of the Mori's Program to all dimensions, and also has many other applications.

The workshop was divided roughly into two parts. The first half was devoted to a survey of the two approaches, giving as complete proofs as possible. The lecturers shed a different light on the arguments and several key steps have been simplified. The notes of the algebraic lectures are available at http://arxiv.org/abs/0706.0494 (Lectures on flips and minimal models, by Alessio Corti, Paul Hacking, János Kollár, Robert Lazarsfeld and Mircea Mustata). Videos of all lectures are available from MSRI's VMath library.

The second half of this workshop was devoted to recent applications of these ideas and results and to an overview of further progress. One of these was the lecture of Eyssidieux on the existence of Kaehler-Einstein metrics on minimal models. Another was a lecture by Shokurov explaining how his series of conjectures would lead to substantial improvements of the current approach to minimal models.

The participants were surveyed and believed that the meeting was very successful.
The introductory lectures were especially well-received and led to new interactions between the algebraic and the analytic approaches. Several of the new ideas outlined are currently being developed further.

INVITED SPEAKERS

R. Lazarfield (University of Michigan), M. Mustata (University of Michigan), B. Berndtsson (Chalmers Tekniska Högskola), P. Eyssidieux (Institut de Mathématiques de Toulouse), Yum-Tong Siu (Harvard University), C. Hacon (University of Utah), V. Shokurov (Johns Hopkins University), M. Kawakita (Kyoto University), C. Birkar (Cambridge University), H. Tsuji (Sophia University), M. Reid (University of Warwick),

SCHEDULE

Monday, April 16

9:30-10:30 *Robert Lazarsfeld, Michigan: Lifting Theorems.*

11:00-12:00 *Alessio Corti, Imperial College London: Existence of Flips.*

2:00-3:00 *Mircea Mustata, Michigan: Existence of Flips.*

3:45-5:00 *János kollár, Princeton: Termination of Flips.*

Tuesday, April 17

9:30-10:30 *Bo Berndtsson, Chalmers Tekniska Högskola: A survey of the main analytic tools and their use in algebraic geometry.*

11:00-12:00 *Jean-Pierre Demailly, Universite de Grenoble: Further applications of the main L^2 existence theorems*

2:00-3:30 *Phillipe Eyssidieux, Institut de Mathématiques de Toulouse: Analytic approach of the finite generation of the canonical ring.*

3:45-4:45 *Jean-Pierre Demailly, Universite de Grenoble: Extension of non vanishing theorems to higher codimension.*

Wednesday, April 18

9:30-10:30 *Yum-Tong Siu, Harvard University, Analytic Proof of Finite Generation of Canonical Ring for General Type.*

11:00-12:00 *Christopher Hacon, Utah.*

2:00-5:00 *Short Communications.*

.

Thursday, April 19

9:30-10:30 *Vyacheslav Shokurov, Johns Hopkins: Log Termination: Complete and Directed.*

11:00-12:00 *Masayuki Kawakita, Kyoto: On minimal log discrepancies.*

2:00-3:00 *Caucher Birkar, Cambridge.*

3:45-4:45 *Hajime Tsuji, Sophia: Extension of log pluricanonical systems and semipositivity of pluricanonical systems.*

Friday, April 20

9:30-10:30 *Philippe Eyssidieux, Institut de Mathématiques de Toulouse: KE-metics on Minimal Models*

11:00-12:00 *Miles Reid, Warwick: Problem Session*

2:00- 5:00 *Short Communications*

Currently Available Videos on VMath

- **Alessio Corti**, Existence of Flips *April 16, 2007, 11:00 AM to 12:00 PM*
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- **Christopher Hacon**, TBA *April 18, 2007, 11:00 AM to 12:00 PM*
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- **Osamu Fujino**, TBA *April 18, 2007, 03:45 PM to 04:45 PM*
- **Vyacheslav Shokurov**, Log Termination: Complete and Directed *April 19, 2007, 09:30 AM to 10:30 AM*
- **Masayuki Kawakita**, On Minimal Log Discrepencies *April 19, 2007, 11:00 AM to 12:00 PM*
- **Florin Ambro**, TBA *April 19, 2007, 02:00 PM to 02:30 PM*
- **Ivan Cheltsov**, TBA *April 19, 2007, 02:30 PM to 03:00 PM*
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- **Paul Hacking**, Noncommutative Deformations of K3 Surfaces *April 20, 2007, 02:00 PM to 03:00 PM*

- **Shunsuke Takagi**, TBA *April 20, 2007, 03:45 PM to 04:15 PM*

- **Chuanyi Xu**, TBA *April 20, 2007, 04:15 PM to 05:00 PM*

REPORT ON CMI/MSRI HOT TOPICS WORKSHOP
"Advances in Algebra and Geometry"
Held at MSRI, April 28- May 4, 2007.

Organizers: Joe Harris, Craig Huneke, Frank-Olaf Schreyer (chair), Bernd Sturmfels.

This workshop focused on developments in algebra and geometry that have been influenced by David Eisenbud, and the workshop was in part a celebration of his term as Director of MSRI. The idea of the workshop was to bring together the many researchers in the broad range of mathematics which Eisenbud influenced to foster interaction. In these terms the workshop was a success. Over 160 people registered for the workshop, in a great many areas. There were about nineteen full talks over a six-day workshop, which allowed a great deal of time for joint work and interaction. In addition there were several informal talks in the late afternoon, often in parallel for participants who had interesting results to share.

The topics of the workshop, as outlined in the proposal, were the enumerative and birational geometry of the moduli space of curves, homological algebra, symbolic computation, commutative algebra, postulation, equations, and syzygies, and special varieties. However, the range of the talks and the participants was in fact much greater than just these areas. The main speakers ranged over older leaders in various fields, as well as many young researchers, including several former students of Eisenbud. Some of the areas covered during the talks include classical algebraic geometry, commutative algebra, homological algebra, combinatorial and computational algebraic geometry, representation theory and quivers, and geometry. The talks were high quality in general. Some talks were broader and less typical than in the usual conferences in these areas, such as the talk of Vladimir Arnold on continued fractions, the talk of David Buchsbaum which traced some of the history in the development of homological methods in commutative algebra, and the talks of Jim Simons and Dennis Sullivan. In particular, many appreciative comments from younger participants were made about the talk of David Buchsbaum.

During a banquet in honor of Eisenbud, the conference participants were treated to the announcement of a remarkable bequest of $10 million for MSRI by Jim Simons. This will hopefully not only have a great impact on MSRI, but also on participants in terms of their realization that mathematics is not supported in a vacuum.

The support was given in large part to young mathematicians and the main speakers, who in general paid for their travel to the conference.

INVITED SPEAKERS

R. Lazarfield (University of Michigan), M. Mustata (University of Michigan), B.

Berndtsson (Chalmers Tekniska Högskola), P. Eyssidieux (Institut de Mathématiques de Toulouse), Yum-Tong Siu (Harvard University), C. Hacon (University of Utah), V. Shokurov (Johns Hopkins University), M. Kawakita (Kyoto University), C. Birkar (Cambridge University), H. Tsuji (Sophia University), M. Reid (University of Warwick),

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2:00- 5:00 *Short Communications*

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- **Chuanyi Xu**, TBA *April 20, 2007, 04:15 PM to 05:00 PM*

Workshop Report:
2006 and 2007 Summer Graduate Workshops on Data Assimilation for the Carbon Cycle

Inez Fung
University of California, Berkeley

Dates

July 16-28, 2006
MSRI

July 8-13, 2007
National Center for Atmospheric Sciences (NCAR), Boulder, CO

Principal Organizers

Inez Fung, University of California, Berkeley
Doug Nychka, NCAR
Eugenia Kalnay, University of Maryland

Schedule of Talks

2006 Lectures:

Monday, 17 July

- *Carbon Cycle*, Inez Fung, University of California, Berkeley
- *Introduction to data assimilation and review of empirical methods (sections 5.1 and 5.2)*, Eugenia Kalnay, University of Maryland
- *The Likelihood, Bayesian Statistics and spatial data*, Doug Nychka, NCAR

Tuesday, 18 July

- *Atmospheric circulation and transport*, Inez Fung, University of California, Berkeley
- *Introduction to least squares; multi-variate statistical data assimilation (Section 5.3 and part of Section 5.4)*, Eugenia Kalnay, University of Maryland
- *Bayes, the Kalman filter and variational methods*, Doug Nychka, NCAR

Wednesday, 19 July

- *Carbon source/sink: statement of the problem*, Inez Fung, University of California, Berkeley
- *3D-Var, OI and PSAS (parts of section 5.5, and sections of the thesis by Takemasa Miyoshi,*
- *http://www.atmos.umd.edu/~ekalnay/MiyoshiThesis.pdf where he implemented 3D-Var and LEKF on the SPEEDY global primitive equations model)*, Eugenia Kalnay, University of Maryland
- *Engineering the Ensemble Kalman filter*, Doug Nychka, NCAR

Thursday, 20 July

- *Atmospheric, land and ocean observations*, Scott Doney, Woods Hole Oceanographic institution
- *4D-Var and Ensemble Kalman Filter (parts of section 5.6)*, Eugenia Kalnay, University of Maryland
- *Smoothers and solving inverse problems*, Doug Nychka, NCAR

Friday, 21 July

- *The Orbiting Carbon Observatory*, Charles Miller, Califonia Institute of Technology
- *Comparison of 4D-Var, and different types of Ensemble Kalman Filter*, Eugenia Kalnay, University of Maryland
- *Estimating parameters and using DART*, Doug Nychka, NCAR

Monday, 24 July

- *4D Var for CO2 source/sinks - introduction to project*, David Baker, NCAR
- *Ensemble Kalman Filter for CO2 source/sink estimation*, David Baker, NCAR
- *Geostatistics - Principles of spatial analysis*, Anna Michalak, University of Michigan

Tuesday, 25 July

- *Inversion - history, computational requirements*, Ian Enting, University of Melbourne and Anna Michalak, University of Michigan
- *Statistics of Inversions*, Ian Enting, University of Melbourne
- *Statistics of analyzing inversion results*, Anna Michalak, University of Michigan

Wednesday, 26 July

- *Operational data assimilation of atmospheric trace gases from AIRS, IASI, CrIS*, Chris Barnet, NOAA
- *Assimilating model parameters*, David Schimel, NCAR
- *Automatic differentiation*, Ian Enting, University of Melbourne

Thursday, 27 July

- *Validation of satellite retrievals*, Chris Barnet, NOAA
- *Carbon Observations in the Forbidding Ocean*, Jim Bishop, Lawrence Berkeley National Laboratory

2007 Lectures:

Monday, 9 July

- *The Carbon Cycle*, Inez Fung, University of California, Berkeley
- *Data Assimilation and Forecasting the Weather*, Eugenia Kalnay, University of Maryland
- *A Statistician's View of the Carbon Problem*, Doug Nychka, NCAR
- *Synthesizing Information for the Environmental Sciences*, James S. Clark, Duke University

Tuesday, 10 July

- *Carbon Cycle: An Inverse Problem*, Inez Fung, University of California, Berkeley
- *Distributions, Spatial Statistics and a Bayesian Perspective*, Doug Nychka, NCAR
- *The Likelihood, the Prior and Bayes Theorem*, Doug Nychka, NCAR
- *Ancient and Modern Ways to Evaluate the Posterior,* Doug Nychka, NCAR
- *Data Assimilation for Tropospheric CO*, Avelino Arellano, NCAR

Wednesday, 11 July

- *Ensemble Kalman Filter in the Presence of Model Errors*, Eugenia Kalnay, University of Maryland

Thursday, 12 July

- *A Parametric and Process-oriented View of the Carbon System*, David Schimel, NCAR
- *The TransCom3 Time-Dependent Global CO_2 Flux Inversion ... and More*, David Baker, NCAR
- *Aircraft CO_2 Observations and Global Carbon Budgeting*, Britton Stephens, NCAR

Friday, 13 July

- *Simulation of Atmospheric CO_2 Concentration with SPEEDY*, Ji-Sun Kang, University of Maryland
- *The application of ensemble Kalman filter in adaptive observation and information content estimation studies*, Junjie Liu, University of Maryland
- *Ground-based Observations of Total Column CO_2*, Gretchen Keppel Aleks, California Institute of Technology
- *Physical-Statistical Modeling*, Rajib Paul, Ohio State University
- *A Funny Twist on Geostatistics*, Ben Shaby, Cornell University
- *Ensemble Kalman Filter: The Movie*, Doug Nychka, NCAR

Participant List

2006 Lecturers:

David Baker, NCAR
Chris Barnet, NOAA
Jim Bishop, Lawrence Berkeley National Laboratory
Scott Doney, Woods Hole Oceanographic Institution
Ian Enting, University of Melbourne
Inez Fung, University of California, Berkeley
Eugenia Kalnay, University of Maryland

Charles Miller, Califonia Institute of Technology
Anna Michalak, University of Michigan
Doug Nychka, NCAR
David Schimel, NCAR

2006 Students: (8F, 19M. Ethnicity data was not collected)
Alanood Alkhaled, University of Michigan
Troy Bulter, Colorado State University
Elliott Campbell, University of Iowa
Haiyan Cheng, Virginia Tech
Vani Cheruvu, ASP / NCAR
James Ferguson, University of Victoria
Humberto Godinez, Portland State
Carl Hammarsten, Rice University
Arta Jamshidi, Colorado State University
Ji-Sun Kang, University of Maryland
Charlie Koven, University of California, Berkeley
Nir Krakauer, Caifornia Institute Of Technology
Hiu Fung Roger Kwok, Hong Kong University of Science & Technology
Quanlin Li, Duke University
Junjie Liu, University of Maryland
Chi On Andrew Lo, Hong Kong University of Science & Technology
Erica McGrath-Spangler, Colorado State University
Kazuyuki Miyazake, Japan Agency for Marine - Earth Science
Kim Mueller, University of Michigan
Kristjan Onu, University of Illinois, Urbana-Champaign
Jun H. Park, University of Illinois, Urbana-Champaign
Jeremy Praissman, University of Georgia
Alexander Stine, University of California, Berkeley
Abby Swann, University of California, Berkeley
Jerry Tjiputra, University of Wisconsin
Tadeusz Tworek, University of Illinois, Chicago
Adam Wolf, Carnegie Institution

2007 Lecturers:
Jeffrey Anderson, NCAR
Avelino Arellano, NCAR
David Baker, NCAR
James Clark, Duke University
Inez Fung, University of California, Berkeley
Eugenia Kalnay, University of Maryland
Douglas Nychka, NCAR
David Schimel, NCAR
Britton Stephens, NCAR

2007 Students: (13F, 17M. Ethnicity data was not collected)
Gretchen Keppel Aleks, California Institute of Technology
Alison Appling, Duke University
Greg Barron, Gafford University of Arizona
Jonathan Beezley, University of Colorado, Denver
Jay Breidt, Colorado State University
Troy Butler, Colorado State University, Ft. Collins
Haiyan Cheng, Virginia Tech
Dan Cooley, NCAR
Sambingo Da Silva Cardoso, NCAR
Ankur Desai, NCAR

Sherri Heck, NCAR
Taka Ito, Colorado State University, Ft. Collins
Ji-Sun Kang, University of Maryland
Yongku Kim, Ohio State University
Nir Krakauer, University of California, Berkeley
Ed Lee, NCAR
Junjie Liu, University of Maryland
Amy Nail, North Carolina State University
Yumiko Nakatsuka, National Institute for Environmental Studies, Japan
Yosuke Niwa, University of Tokyo
Rajib Paul, Ohio State University
Haifeng Qian, University of Maryland
Ben Shaby, Cornell University
Shagi-Di Shih, University of Wyoming
Pierre C. Sibiry Traore, University of Florida
Tamara Singleton, University of Maryland
Elaine Spiller, SAMSI
Zan Stine, University of California, Berkeley
Francesca Terenzi, Columbia University
Nedjeljka Zagar, NCAR

Short Summary of the Workshop Goals

These were the first two Summer Graduate Workshop on Carbon Data Assimilation, jointly sponsored by MSRI and NCAR. The workshops are designed to seed a new field of multi-disciplinary research – assimilation of asynchronous satellite observations of carbon dioxide concentrations into global atmospheric circulation models to produce synoptic maps of carbon dioxide from which surface exchange (source/sink functions) of carbon dioxide can be estimated. The workshops expose students and researchers in the geosciences, ecology and mathematics to multidisciplinary Earth science through an urgent science problem that demands a new mathematical approach. The urgency comes from the vast data stream anticipated from the satellite "Orbiting Carbon Observatory" scheduled for launch in December 2008, and from the societal need to manage carbon dioxide sources and sinks to slow down global warming.

Concrete outcomes of the workshop

The lecturers come from several disciplines, and so the workshop is a multi-disciplinary education for the lecturers as well as for the graduate students and postdocs. As a result of the 2006 workshop, a proposal to expand data assimilation for weather prediction to include the carbon cycle was submitted to, and has since been accepted by, the Department of Energy (PI: Kalnay and Fung). The research will be carried out using NERSC computers and will support several graduate students who participated in the Workshop.

The 2006 workshop was supplemented with computer exercises. NERSC kindly provided access for all participants. Exercises on data assimilation using Local Transform Ensemble Kalman Filter and 4D Var were provided by Drs. Kalnay and Baker, and Dr. Schimel provided exercises on MCMC. Participants were invited to adapt the exercises in their own research.

The 2007 workshop was supplemented with computational examples using the Data Assimilation Research Testbed (DART), developed by Dr. Jeff Anderson of NCAR. http://www.image.ucar.edu/DAReS/DART/ A common room at NCAR was set up with computers (2 participants per computer), and two programmer/analysts were on hand to assist all aspects of the software and hardware issues. Dr. Anderson guided the workshop participants, worked through the exercises and led the discussion of the results. DART software is publicly available, and so the participants gained not only exposure to new areas of research, but also tools they can adapt and apply to their own work.

Dissemination

http://www.atmos.berkeley.edu/~inez/MSRI-NCAR_CarbonDA/
http://www.image.ucar.edu/Workshops/CDAS_2007/
http://www.msri.org/communications/vmath/semester/dr/2006070220070101/show_semester

Evaluations

Evaluation questionnaires were distributed to all students in both years. All respondents were highly satisfied with what they got out of attending the courses.

Pictures

The Participants at MSRI, Berkeley, California, July 2006

The Participants at Boulder, Colorado, July 2007