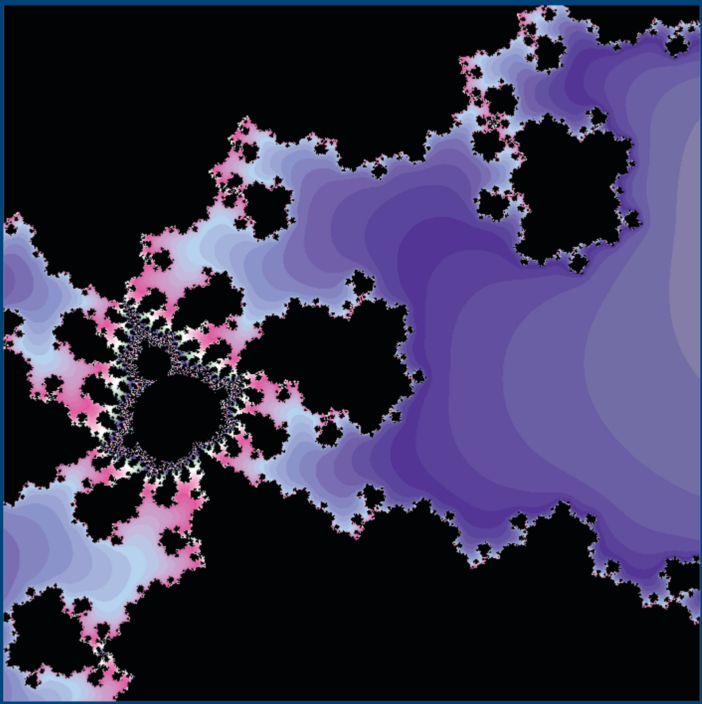
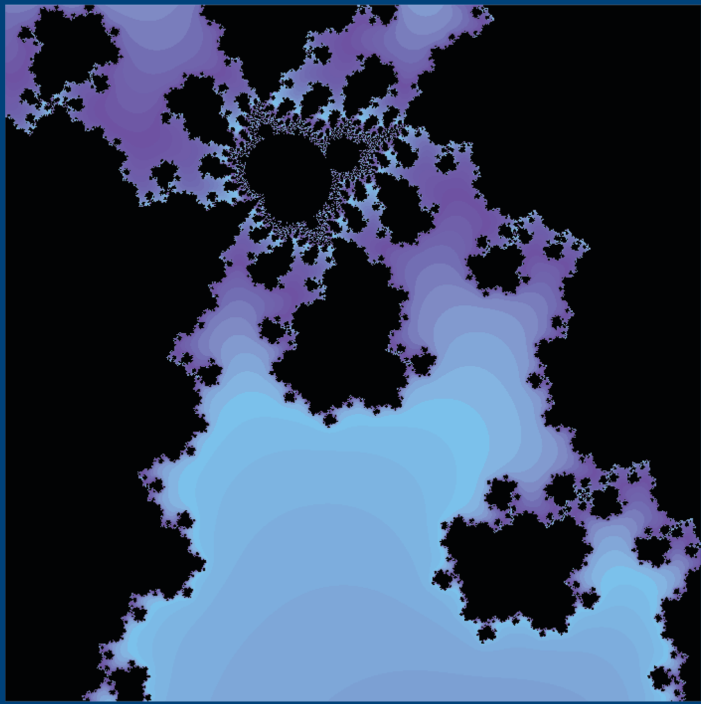
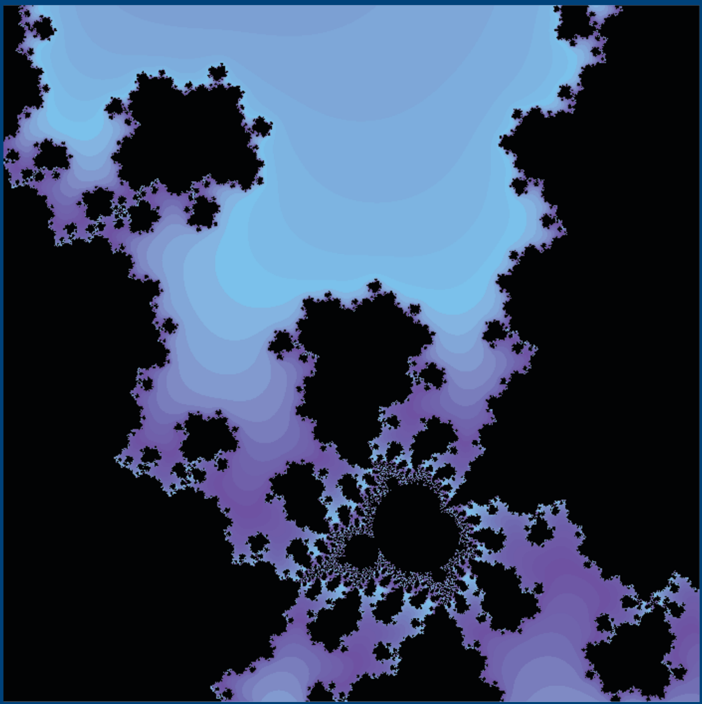
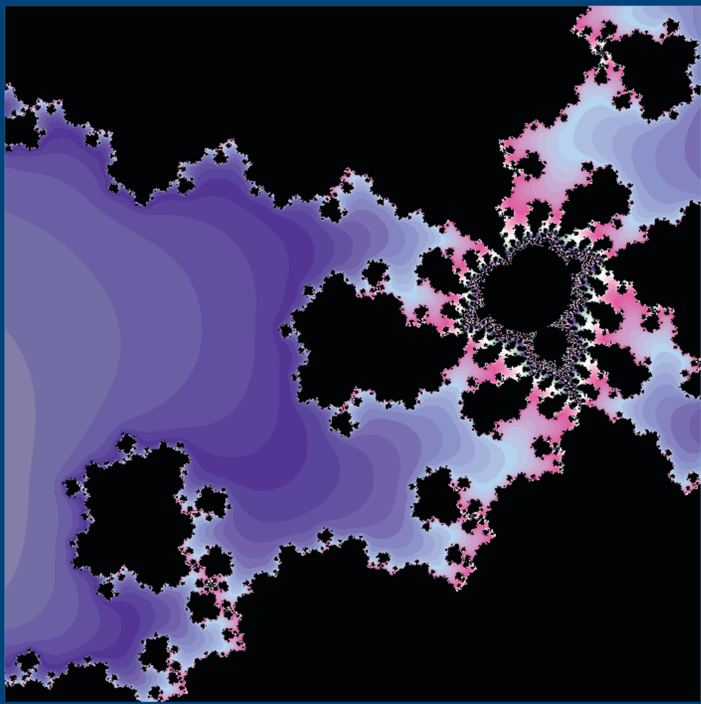
Annual Report 2005–2006









Cornell University
Department of Mathematics

In two color schemes and four orientations, the front cover pictures the parameter space for cubic polynomials $p(x) = x^3 - 3a^2x + b$, where a and b are complex parameters. Specifically, we are looking in a b parameter plane at the slice $a = -0.5 + 0.1i$. Notice that there is a baby Mandelbrot set in this picture, which means that the the cubic polynomial p sometimes *behaves* like a quadratic polynomial. This picture was drawn by graduate student Sarah Koch (pictured left) with ***FractalAsm***, a computer program written by Karl Papadantonakis while he was an undergraduate at Cornell University. Karl graduated summa cum laude in mathematics in May 2000 and was that year's recipient of the Kieval Prize in Mathematics.

CORNELL UNIVERSITY
DEPARTMENT OF MATHEMATICS

ANNUAL REPORT 2005-2006

The Department of Mathematics at Cornell University is known throughout the world for its distinguished faculty and stimulating mathematical atmosphere. Close to 40 tenured and tenure-track faculty represent a broad spectrum of current mathematical research, with a lively group of postdoctoral fellows and frequent research and teaching visitors. The graduate program includes over 70 graduate students from many different countries. The undergraduate program includes several math major programs, and the department offers a wide selection of courses for all types of users of mathematics.

A private endowed university and the federal land-grant institution of New York State, Cornell is a member of the Ivy League and a partner of the State University of New York. There are approximately 19,500 students at Cornell's Ithaca campus enrolled in seven undergraduate units and four graduate and professional units. Nearly 14,000 of those students are undergraduates, and most of those take at least one math course during their time at Cornell.

The Mathematics Department is part of the College of Arts and Sciences, a community of 6,000 students and faculty in 50 departments and programs, encompassing the humanities, sciences, mathematics, fine arts, and social sciences. We are located in Malott Hall, in the center of the Cornell campus, atop a hill between two spectacular gorges that run down to Cayuga Lake in the beautiful Finger Lakes region of New York State.

Department Chair:	Prof. Kenneth Brown
Director of Undergraduate Studies (DUS):	Prof. Allen Hatcher
Director of Graduate Studies (DGS):	Prof. Michael Stillman
Director of Teaching Assistant Programs:	Dr. Maria Terrell
Administrative Manager:	William Gilligan

Department of Mathematics, 310 Malott Hall, Cornell University, Ithaca, NY 14853-4201
Phone: (607) 255-4013 • Fax: (607) 255-7149 • email: *math@math.cornell.edu*

Message from the Chair, Kenneth S. Brown

Dear friends and colleagues,

Just over four years ago, one of my friends on the faculty, whom I'll call "L," asked me to consider being department chair. My initial reaction was negative. I felt that the best way I could serve the department was to continue teaching and doing research. I asked L if he would ever consider being chair. This was intended as a rhetorical question, because I was convinced that he would be as opposed to it as I was. But he surprised me by saying that he fully expected to take his turn as chair some day. When I asked him why, he replied, "This is a good department, and it's a privilege to be part of it. I'd like to give something back." This simple answer did the trick. Having been in the department since 1971, I decided it was time for *me* to give something back.

Four years have passed, and I'm glad that I listened to L; being chair has been very rewarding. I confess that I'm also glad that I'm no longer chair. Four years is enough. I'm ready to move on, and the department is ready for a new chair, Dan Barbasch. Dan served as "chair elect" during the past year, and, in this role, he was involved in everything that was going on. As a result, I anticipate a very smooth transition.

I would like to thank my faculty colleagues for their contributions to the department over the last four years. A great many people helped in some way, but I'd like to single out Rick Durrett, Allen Hatcher, Ravi Ramakrishna, Laurent Saloff-Coste, Birgit Speh, Mike Stillman, and Maria Terrell for their special efforts.

I would also like to thank the staff for their work behind the scenes to facilitate the teaching, research, and service missions of the department. Every staff member, without exception, has been a pleasure to work with. Bill Gilligan, our administrative manager, deserves special mention this year. Bill joined the department less than a year ago, but things are running so smoothly that you would never guess that we recently had a manager change. I have enjoyed working with Bill, and I have appreciated his good humor and his creative problem solving.

I send best wishes for success and happiness in retirement to Linda Clasby, who was my assistant for three years and eleven months. Linda retired at the end of May after almost 32 years at Cornell, the last five of which were in the Mathematics Department. Linda's resourcefulness was remarkable. In addition, I could always rely on her to do whatever I needed her to do, usually before I even knew I needed it. Linda will be sorely missed, but we were fortunate that Brenda Smith was available to fill the position. (See page 5.)

One of the issues that I've struggled with throughout my term as chair is diversity. Our tenure-track faculty consists mostly of white males. We have three tenured women (Irena Peeva, Birgit Speh, and Karen Vogtmann), and one tenure-track but non-tenured woman (Tara Holm). We have no black tenured or tenure-track faculty members, and two years ago we lost our one Latino faculty member (José Escobar), who died in January 2004.

This lack of diversity in Mathematics Departments is not unique to Cornell, and there are no easy answers. But we need to do whatever we can to improve the situation. The health of mathematics depends upon our using the talents of the entire population, and the lack of women and minorities in the subject is disheartening.

I'm pleased to report that there are two promising recent developments, both of which are described in more detail later in this Annual Report. The first is the newly endowed Ruth I. Michler Memorial Prize. This was funded by a generous gift from Professor Gerhard Michler and Mrs. Waltraud Michler in honor of their daughter Ruth, a talented mathematician whose life and career were cut short by a tragic accident. The prize will provide opportunities for other talented female mathematicians at the same stage of their careers as Ruth was at the time of her death. It will also, as a byproduct, provide recruitment opportunities for us. See page 7 for more information about the Michler Prize.

On behalf of the department, I am deeply honored that the Michlers chose Cornell for this tribute to their daughter. I expect their gift to increase our visibility as a department that respects and supports its women faculty members. It will also have a lasting impact on the overall goal of the mathematical community to provide more opportunities for talented female mathematicians to move toward parity with men.

The other development is the Summer Math Institute (SMI), intended for minority undergraduates who are interested in going to graduate school in mathematics. The goal is to help prepare them for admission to a top-tier graduate program and for success once they get there. In a joint effort between our department and the Center for Applied Mathematics, a pilot program is occurring as I write (July 2006), and we have applied for an NSF grant to continue SMI for five more years. Many people put in a huge amount of time and effort to make the pilot program a reality and to prepare the NSF proposal. We are very pleased with the way this summer's program is going so far, and we are optimistic about our chances for NSF funding. See page 39 for more details about this year's program.

In closing, I'd like to offer best wishes to Greg Lawler, who is moving on to the University of Chicago. Greg was a valued faculty member, and he will be difficult to replace.

I would also like to welcome our two new assistant professors, Xiaodong Cao and Martin Kassabov, and I would like to congratulate Reyer Sjamaar on his promotion to full professor.

Finally, I offer best wishes and all my support to Dan Barbasch as he begins his term as chair.

Sincerely yours,

Ken Brown

Professor and Chair of Mathematics

Table of Contents

Awards and Honors

Professors **Birgit Speh** and **Karen Vogtmann** have been invited to address the International Congress of Mathematicians, to be held in August 2006 in Madrid, Spain. Other speakers include alumni Martin Bridson (Ph.D. 1991) and Jon Kleinberg (B.A. 1993). The ICM is held once every four years and is attended by thousands of mathematicians from around the world. Professors Harry Kesten, Greg Lawler, and John Smillie gave invited addresses in August 2002 in Beijing.

Antonio Montalban was awarded the Sacks Prize by the Association of Symbolic Logic this year for the best dissertation in logic world wide. His dissertation, *Beyond the Arithmetic*, was written under the direction of Richard Shore. Antonio is our second winner. (Denis Hirschfeldt '99 was the first.)

In November, **Yuri Berest** was elected to a visiting fellowship at All Souls College of Oxford University (UK). He will visit Oxford for 3 months during his spring sabbatical in 2007.

On November 16th, the Academy Council of the Royal Society of New Zealand held its 40th Fellows' Annual General Meeting in Wellington. At the AGM, nine new fellows were elected, among them visiting Professor **Bakhadyr Khoussainov.**

Laurent Saloff-Coste was awarded a *Guggenheim Fellowship* by the John Simon Guggenheim Memorial Foundation. Prof. Saloff-Coste joins a select group of men and women who have demonstrated exceptional creative ability in the arts. Established in 1925 by United States Senator Simon Guggenheim and his wife in memory of their son, the foundation offers fellowships to further the development of scholars and artists by assisting them to engage in research in any field of knowledge and creation in any of the arts, under the freest possible conditions and irrespective of race, color, or creed. Previous winners in the department include Wolfgang Fuchs (1956), Harry Kesten (1972), Cliff Earle (1974), Leonard Gross (1974), Moss Sweedler (1980), John Guckenheimer (1983), and Richard Durrett (1988).

On May 3rd, The Association for Women in Mathematics (AWM) announced the selection of **Karen Vogtmann** from Cornell University as the 2007 AWM Noether Lecturer. The Noether Lectures honor women who have made fundamental and sustained contributions to the mathematical sciences. This one-hour expository lecture will be presented at the Joint Mathematics Meetings in New Orleans, January 2007. Emmy Noether was one of the great mathematicians of her time, someone who worked and struggled for what she loved and believed in. Her life and work remain a tremendous inspiration.

Gregory Lawler has been selected by the Society of Industrial and Applied Mathematics (SIAM) to receive the 2006 George Pólya Prize for groundbreaking work on the development and application of Stochastic Loewner Evolution (SLE). He will share the prize with Oded Schramm and Wendelin Werner for their joint work. Established in 1969, the George Pólya Prize is given every two years in one of two alternating categories. This year's prize will be awarded at the 2006 SIAM Annual Meeting to be held July 10-14, 2006 in Massachussetts. The Pólya Prize was awarded once before to a Cornell mathematician: Harry Kesten in 1994.

See also Teaching Program (p. 16), Graduate Program (p. 22), and Undergraduate Program (p. 31) for related honors and awards.

Department Prizes and Awards

Department Teaching Awards

Senior Faculty Award:	David Henderson
Junior Faculty Award:	Hsiao-Bing Cheng
Graduate Student Award:	Melanie Pivarski
	Treven Wall

Graduate Student Awards

Battig Graduate Prize:	Sarah Koch
	Andrei Maxim
Hutchinson Fellowships:	Henri Johnston
	Mauricio Velasco
York Award:	Guan-Yu Chen
	David Rothstein (Astronomy)

Harry S. Kieval Prize in Mathematics

Thomas Church and Wai Wai Liu

Freshman Math Prize Exam

1st: Julius Poh	3rd: Adam Neumann
2nd: Daniel Goldfein	4th: Vincent Chan

Michael D. Morley Ithaca High School Prize in Mathematics

Greg Durrett and Ben Zax

Mathematics Department Directory 2005-2006

Professors
Dan Barbasch
Louis Billera
Kenneth Brown, chair
Stephen Chase
Robert Connelly
R. Keith Dennis
Richard Durrett
Eugene Dynkin
Leonard Gross
John Guckenheimer
Allen Hatcher
David Henderson
John Hubbard
J. T. Gene Hwang
Yulij Ilyashenko
Peter Kahn
Gregory Lawler
Anil Nerode
Michael Nussbaum
Laurent Saloff-Coste
Alfred Schatz
Shankar Sen
Richard Shore
John Smillie
Birgit Speh
Michael Stillman
Robert Strichartz
William Thurston
Karen Vogtmann
Lars Wahlbin
James West

Professors Emeritus
James Bramble
Marshall Cohen
Clifford Earle
Roger Farrell
Harry Kesten
G. Roger Livesay
Michael Morley
Lawrence Payne
Alex Rosenberg
Moss Sweedler

Associate Professors
Yuri Berest
Irena Peeva
Ravi Ramakrishna
Reyer Sjamaar

Assistant Professors
Tara Holm
Camil Muscalu
Edward Swartz
Alexander Vladimirsky

Field Members
Timothy Healey	(T&AM)
Dexter Kozen	(Computer Science)
Philip Protter	(OR&IE)
Richard Rand	(T&AM)
James Renegar	(OR&IE)
Steven Strogatz	(T&AM)

Senior Lecturers
Patricia Alessi
Allen Back
David Bock
Maria Terrell
Robert Terrell

H.C. Wang Assistant Professors
Nathan Broaddus
Kariane Calta
Martin Kassabov
Alvaro Lozano-Robledo
Kasso Okoudjou
Alessandra Pantano
Etienne Rassart
Timothy Riley
Luke Rogers

VIGRE Assistant Professors
Hsiao-Bing Cheng
Sarah Day
Paul Jung

Escobar Assistant Professors
Todd Kemp
Carla Martin
Steve Morris (spring)

Postdoctoral Associates
Robert Clewley
Michael Drew LaMar
Joan Lind
Lea Popovic
Raazesh Sainudiin
David White

Senior Research Associate
Daina Taimina

Visiting Faculty
Marat Arslanov
Cilanne Boulet
Eknath Ghate
Bakhadyr Khoussainov
Wook Kim
Gerhard Michler
Damiano Testa
George Wilson

Visiting Program Faculty
Craig Johnson
Thomas Stiadle

Visiting Scholars
Dong-Shang Chang
Kazumasa Kuwada
Changhao Lin

Teaching Associates
Richard Furnas
Steven Sinnott

2005-2006 Faculty Leaves

Robert Connelly	sabbatical leave, 2005–2006
Richard Durrett	sabbatical leave, fall 2005
Tara Holm	leave, 2005–2006
Anil Nerode	sabbatical leave, fall 2005
Michael Nussbaum	sabbatical leave, spring 2006
Ravi Ramakrishna	sabbatical leave, spring 2006

Graduate Students

Bryant Adams
Jason Anema
Drew Armstrong
Heather Armstrong
Owen Baker
Marisa Belk
David Biddle
Jennifer Biermann
Saúl Blanco Rodríguez
Jason Bode
Joshua Bowman
Kristin Camenga
Andrew Cameron
Edoardo Carta
Raymond Cassella
Benjamin Chan
Guan-Yu Chen
Nikolai Dimitrov
Daniel Erb
Alimjon Eshmatov
Farkhod Eshmatov
Jennifer Fawcett
Bradley Forrest
Timothy Goldberg
William Gryc
Pavel Gyrya
Noam Horwitz
Henri Johnston
Evgueni Klebanov
Sarah Koch
Victor Kostyuk
Bastian Laubner
Hway Kiong Lim
Chris Alan Lipa
Jiamou Liu (nondegree, fall)
Peter Luthy
Jason Martin
Francesco Matucci
Andrei Maxim
Jeffrey Mermin
Robyn Miller
Mia Minnes
Vadims Moldavskis
Steve Morris (fall)
Gregory Muller
Radu Murgescu
Jonathan Needleman
Matthew Noonan
Michael O'Connor
Melanie Pivarski
Artem Pulemyotov
Sergio Andrés Pulido Niño
Franco Saliola
Peter Samuelson
Jay Schweig
Paul Shafer
Ingvar Sigurjonsson
Achilleas Sinefakopoulos
Steven Sinnott
Aaron Solo
Denise Terry
John Thacker
Russ Thompson
Mauricio Velasco
Anael Verdugo
Brigitta Vermesi
Treven Wall
Biao Wang
Gwyneth Whieldon
John Workman
James Worthington
Yan Zeng (fall)
Zhigen Zhao
Jessica Zuniga

Administrative Support Staff

Linda Clasby
William Gilligan, manager
Arletta Havlik
Joy Jones
Michelle Klinger
Gayle Lippincott
Donna Smith
Catherine Stevens

Computer Consultants

Douglas Alfors
Steven Gaarder

Instructional Technology Lab

Bryant Adams

Mathematics Support Center

Douglas Alfors, director
Richard Furnas

Mathematics Library Staff

Steven Rockey, librarian
Natalie Sheridan

Faculty, Staff, and Graduate Student Changes for 2006–2007

Departures

Faculty Who Have Left Cornell

(Includes location of next position)

Nathan Broaddus	University of Chicago
Hsiao-Bing Cheng	University of California, Irvine
Sarah Day	MSRI (fall) and College of William and Mary (spring)
Gregory Lawler	University of Chicago
Kasso Okoudjou	University of Maryland

Ph.D. Recipients — May/August 2006

(Includes location of first position.)

Drew Armstrong	University of Minnesota
Kristin Camenga	Houghton College
Guan-Yu Chen	National Hsing Hwa Univ.
William Gryc	Georgia State University
Jason Martin	James Madison University
Jeffrey Mermin	University of Kansas
Melanie Pivarski	Texas A&M University
Franco Saliola	Université du Québec Montréal
Steven Sinnott	Cornell University
John Thacker	Northrop Grumman IT, TASC
Brigitta Vermesi	University of Rochester

Faculty Updates

- ❖ Ken Brown completed his term as department chair on June 30, 2006, passing the baton to his successor, Dan Barbasch.
- ❖ Reyer Sjamaar was promoted to full professor, effective July 1, 2006.

Faculty Leaves

Yuri Berest	sabbatical leave, spring 2007
Kenneth Brown	sabbatical leave, fall 2006
Kenneth Brown	admin. leave, spring 2007
Xiaodong Cao	leave, spring 2007
R. Keith Dennis	sabbatical leave, fall 2006
John Hubbard	leave, 2006–2007
Alfred Schatz	sabbatical leave, spring 2007
William Thurston	sabbatical leave, spring 2007
Karen Vogtmann	sabbatical leave, fall 2006
Lars Wahlbin	sabbatical leave, spring 2007
James West	sabbatical leave, spring 2007

New Faculty and Graduate Students

(Includes institution of highest degree held.)

Tenure-Track Assistant Professors

Xiaodong Cao	MIT
Martin Kassabov	Yale University

Adjunct Professors

Gregory Lawler	Princeton University
Gerhard Michler	Frankfurt University

Graduate Students

Juan Alonso	Univ. Republic Uruguay
Mihai Bailesteanu	Univ. Bremen
Mingzhong Cai	Fudan University
Youssef El Fassy Fihry	Ecole des Mines de Paris
Igors Gorbovickis	Moscow State University
Kristine Jones	University of Chicago
Yasemin Kara	Bogazici University
Samuel Kolins	Bowdoin College
Ho Hon Leung	Imperial College London
Benjamin Lundell	University of Illinois at Urbana
Fatima Mahmood	Union College
Eyvindur Palsson	University of Iceland
Corinne Sheridan	University of South Carolina
Santi Tasena	Chiang Mai University
Thien Tam Tran*	University of Paris 7
Paul Young	Cornell University

**Non-degree student*

Short-Term Faculty

(Includes Ph.D. institution for postdoctoral associates and home institution for others, unless otherwise indicated.)

Postdoctoral Associates

Michael LaMar	University of Texas, Austin
Dan Merl	Univ. of California, Santa Cruz
Soumik Pal	Columbia University
Lea Popovic	Univ. of California, Berkeley

Visiting Scholars

William Dickinson	Grand Valley State University
Gunnar Floystad	University of Bergen
Elizabeth Meckes	Case Western Reserve Univ.
Gabriela Schmithuesen	Karlsruhe University

Teaching Visitors

Victor Alexandrov	Sobolev Inst. of Mathematics
Mohammad Asadzadeh	Chalmers Univ. of Technology (Sweden)
Collin Bleak	Binghamton University
Cilanne Boulet	MIT*
Serge Cantat	Université de Rennes I (France)
Vesselin Gasharov	N/A
Paul Jung	N/A
Bjørn Kjos-Hanssen	University of Connecticut
Adrian Lim	Univ. of California, San Diego*
James Parkinson	University of Sydney (Australia)
Erin Pearse	Univ. of California, Riverside*
Christophe Pittet	CMI (France)
Geoffrey Recktenwald	Cornell University*
Steven Sinnott	Cornell University*
Daina Taimina	N/A
Chong Wang	Cornell University*

**Recent Ph.D.*

Visiting Program Faculty

Harel Barzilai	Salisbury University
William Linderman	Kings College
Mark Meckes	Case Western Reserve Univ.

Staff Changes

Assistant to the Chair

At the beginning of April, Assistant to the Chair Linda Clasby announced her decision to retire at the end of May 2006 after nearly 32 years at Cornell. Linda joined the department in July of 2001 and spent her last five years at Cornell working with John Smillie during his final year as chair and serving with Ken Brown for all four years of his term as chair. In addition to providing executive assistant support to the chair, Linda was also responsible for processing the department's faculty and staff human resource appointments. Linda's extensive knowledge of the academic appointment process and visa and immigration issues was a real asset to the department due to the high number of foreign national academic appointments the department has annually.

We will all miss her for her many contributions to the department, not the least of which were her humor, her personality, and her graceful handling of all situations with faculty, visitors, students, college and university administration, and other members of the staff.

After a lengthy search process, the department hired Brenda Smith to be the new chair's assistant. She started in the middle of June, working briefly with Ken Brown until Dan Barbasch's term as chair began in July. Brenda worked for the department previously as the undergraduate coordinator for a two-year period ending in 2003. The department is very pleased that Brenda and her family returned to the Ithaca area from North Carolina and that our need and her availability coincided to allow her to rejoin the department staff.

Administrative Manager

As reported last year, following the departure of the department's nine-year veteran manager, Collete Walls, Bill Gilligan was hired from the Arts College Dean's Office. He will be coming up on his first anniversary as department manager at the beginning of August 2006.

Bill reports that this has been an interesting, challenging, and busy year, during which he has had the benefit of an extremely capable staff team. As evidenced by the many activities reported in other sections of this Annual Report, the Mathematics Department is very involved in the academic, research, and outreach mission of the university and makes significant contributions in all these areas. This past year, in addition to the "routine" work associated with the department — providing support to nearly 70 faculty, over 70 graduate students, and 200 plus majors, offering 207 courses, managing the funding for 290 accounts (of which about 90 are sponsored funds accounts), and offering a very full series of seminars, lecturers, and colloquia during the academic year — the department staff has also taken on the additional support required for the inaugural Chelluri Lecture, the Summer Math Institute, and increasing the level of support for the Topology Festival. Additional challenges were met in supporting faculty efforts to submit major grant proposals to the National Science Foundation for VIGRE, MCTB, and RTG grant programs. Looking forward to the upcoming year, the staff will continue to rise to the challenge of supporting a large and active faculty involved with a number of academic programs.

Gifts and Endowments

As always, we appreciate the kindness and generosity of alumni and other friends of mathematics. During the 2005–2006 academic year, designated donor gifts increased the principal of various department endowments. In addition, the department received some unrestricted gift donations, which are used to supplement departmental activities for the mathematics community at Cornell. In many cases, contributions were received in response to the department newsletter, *Math Matters*. By distributing this newsletter, we hope to keep our many friends current on department activities. If you would like to be added to the newsletter mailing list, please contact Catherine Stevens at cls15@cornell.edu.

2005-2006 Contributors

David R. Boochever
Sriram R. Chelluri
Alan M. Cody
R. Keith Dennis
Subba Rad Durvasula
L. Scott Feiler
William D. Gilligan
Bruce M. Hatton
Harvey J. Iglarsh
Andrew S. Joskow
Ira G. Kastrinsky
Alison S. Klugherz Kideckel
John Klopp
Lillian Jane Lee
Charlotte R. Lin
Robert S. Lubarsky
Shirley S. McGrath
Barbara Osofsky
Gerald J. Porter
Goutham Rao
Thomas Rishel
John W. Rosenthal
Kenneth W. Stemme
James Traverse
David N. Wall
Jane T. Wiegand

Endowments

The department is thankful to alumni, friends and family who support the department endowments. Without their generosity, we would be unable to provide many of the offerings that make our department unique.

The Department of Mathematics instituted departmental teaching awards for graduate students and faculty in 2001. The **Graduate Student Teaching Award** endowment was created to fund a generous prize to accompany this annual award in recognition of excellent teaching.

The **Chelluri Lecture Endowment** was established in 2004 with support from family and friends of Thyagaraju (Raju) Chelluri. Funds from this endowment will be used for an annual lecture series in memory of Raju, who graduated magna cum laude from Cornell with a Bachelor's degree in mathematics in 1999. Raju died in 2004, shortly after completing all requirements for the Ph.D. in Mathematics at Rutgers University, where he was awarded a Ph.D. posthumously. Each year, a distinguished mathematician will be invited to give the Chelluri Lecture. (See p. 38 for information about the first lecture.)

The **Colloquium Endowment Fund** was instituted to invite distinguished scientists to speak at the Oliver Club seminars. James E. Oliver founded the Oliver Club in January 1891 as the Mathematical Club of Cornell University. (Oliver Club talks are announced at www.math.cornell.edu/~oliver/.)

The **Eleanor Norton York Endowment** was established in honor of Eleanor Norton York, with the intent of recognizing outstanding graduate students in both Astronomy and Mathematics. The income from this endowment is used to provide annual prizes to continuing graduate students.

The **Faculty Book Endowment** is dedicated to providing the Cornell community with immediate access to one of the world's finest collections of mathematics books and publications.

The **Israel Berstein Memorial Fund** was established in honor of Israel Berstein, who was a professor in this department from 1962 through 1991. The memorial fund has as its central purpose helping young mathematicians in the field of topology.

The **Logic Endowment** was established as the direct result of a very generous gift from a former Cornell undergraduate. This endowment seeks to actively support promising logic students.

The **Robert John Battig Endowment** was established by his parents after his untimely death. Robert was awarded a January 1998 Ph.D. in mathematics. The fund provides an annual prize to an outstanding continuing graduate student in mathematics at Cornell.

The **Michael D. Morley Senior Prize in Mathematics** is presented to an Ithaca High School student who has excelled in mathematics and who has demonstrated originality and innovative power in mathematics.

Ruth I. Michler Endowment

Gerhard and Waltraud Michler of Essen, Germany, have established an endowment in the Department of Mathematics at Cornell University in memory of their daughter Ruth I. Michler. This endowment provides funding for the Ruth I. Michler Memorial Prize of the Association for Women in Mathematics for a fellowship. The recipient will spend a semester in the Cornell Mathematics Department, where she can pursue her research interests free from any teaching obligation. The prize is to be awarded annually to a woman recently promoted to associate professor or an equivalent position in the mathematical sciences. Professor Karen Vogtmann represents Cornell on the AWM selection committee. We look forward to hosting Rebecca Goldin of George Mason University as the first recipient of the Michler Prize in 2007–2008.

Professor Ruth Michler

At the time of her death, Ruth, an associate professor of mathematics at the University of North Texas, was in Boston as part of a one-year National Science Foundation grant as a visiting scholar at Northeastern University. She was killed on November 1, 2000 at the age of 33 in a tragic accident, cutting short the career of an excellent mathematician.

Ruth was born in Ithaca, New York on March 8, 1967, while her father, also a mathematician, was visiting Cornell. Her family was from Germany and she grew up there — in Tuebingen, Giessen, and eventually Essen. For her undergraduate work, she affiliated with Balliol College at the University of Oxford and graduated with a B.A. summa cum laude in mathematics in 1988. She completed her graduate studies at the University of California, Berkeley where she earned her Ph.D. in 1993. Her dissertation was titled *Hodge components of cyclic homology of affine hypersurfaces*.

After earning her Ph.D., Ruth worked as a postdoctoral fellow at Queen's University in Kingston, Ontario with Leslie Roberts. In 1994, she accepted a tenure-track position at the University of North Texas in Denton, where she was promoted to associate professor with tenure in 2000.

Ruth was also an outstanding athlete, routinely commuting to work on her bicycle and, as an avid runner, she participated in a number of ultra 100k runs and marathons. In 1998, in her Crater Lake (Oregon) Marathon debut, Ruth won the women's race and placed 12th overall, and she competed several times in the Boston Marathon.

Ruth Michler was truly a remarkable and inspirational person and the Cornell Department of Mathematics is honored to hold this endowment in her memory.

For additional information about Ruth's academic career and the esteem she was held in by her friends and colleagues, please see the dedication written by Caroline Melles, published in *Topics in Algebraic and Noncommutative Geometry: Proceedings in Memory of Ruth Michler*, Contemporary Mathematics Series **324**, American Mathematical Society, 2003 and reproduced at www.math.cornell.edu/News/2006-2007/michler_dedication.html.

Crochet Ties Mathematics With Art

Hyperbolic geometry was first developed in the 1820s by J. Bolyai and N. Lobachevsky. There was no known *complete* surface that had hyperbolic geometry. (The pseudosphere has *local* hyperbolic geometry.) In fact, in 1901, David Hilbert proved that such a complete surface cannot be described by real analytic equations. In 1955, N. Kuiper proved that there exists a differentiable (C^0) but was not able to give an explicit construction. In the 1970s, **William Thurston** described a way to construct a surface (using paper annuli) with hyperbolic geometry but the paper surfaces were fragile and difficult to use in classrooms. Seeing one of Thurston's tattered paper surfaces, **Daina Taimina** said to herself — there has to be a better way.

In 1997, Taimina figured out how to crochet the surface described by Thurston. She made a classroom set of crocheted hyperbolic surfaces that are still in use in Cornell geometry classes. In spring 2004, Taimina was invited by The Institute For Figuring to deliver an inaugural lecture about her crocheted planes to a gathering of artists, architects, and movie people in Los Angeles, starting an upwelling of interest among the general public in Taimina's crocheted hyperbolic planes. This interest seems to derive from the desire in many people to have contact with higher mathematics and be able to appreciate it, at least on an aesthetic level. All of her exhibits and lectures combine mathematics and art.

Taimina's crocheted planes are used in many colleges across the USA and are represented in the following permanent collections:

- Cornell's Department of Mathematics,
- the Smithsonian Institution (Washington, DC),
- the Eileen Norton Collection (Santa Monica, CA),
- The Institute For Figuring (Los Angeles, CA).

In *Nora* — a one-woman off-Broadway play by Victoria Roberts (February 22 – March 7, 2006) — a brief (and accurate!) history of the hyperbolic plane is given with Taimina's crocheting and mention of the Cornell Mathematics Department, **David Henderson**, and Taimina.

Taimina's work relating mathematics and art was partially supported by a grant from the Cookie Jar Fund of The Institute For Figuring.

Art Exhibits

Eleven Eleven Sculpture Space
(Washington, DC, June – September 2005);
Machine Project Gallery
(Los Angeles, July – August 2005);
American Center for Physics
(College Park, MD, October – April 2005);
Contemporary Art Galleries
(University of Connecticut, February – April 2006);
STUK
(Leuven University, Belgium, March – April 2006);
Gould Library, a solo exhibit
(Carleton College, March–June 2006).

Media Articles or Shows

Cabinet: A Quarterly of Art and Culture (Winter 2005);
Science Magazine (March 2005);
NPR Weekend All Things Considered (March 13, 2005);
Newsday (March 2, 2005);
Houston Chronicle (March 13, 2005);
Wired (June 2005);
New York Times (July 11, 2005);
Los Angeles Times (July 28, 2005);
Wheel, New Zealand (Issue 17, 2005);
The Christian Science Monitor (August 11, 2005);
Interweave Knits: Crochet (special issue, fall 2005);
Crochet Fantasy (No. 182, Fall 2005);
Los Angeles Weekly (Oct. 28–Nov. 3, 2005);
Cornell Alumni Magazine (Nov.–Dec. 2005);
Cornell Chronicle (December 8, 2005)
American Craft (Dec05/Jan06);
Diena, Riga, Latvia (Jan. 28–Feb. 3, 2006);
Discover (March 2006);
TV Science Central — interviewed on April 28, 2006, for two shows to appear later

Invited Mathematics/Art Lectures by Taimina

Lecture Series on Science and Art (CUNY, New York City, September 2005)
Public Lecture (Bard College, December 2005)
Science Cabaret (Ithaca, December 2005)
Math Club (Cornell, February 2006)
Public Lecture, University of Latvia (Riga, March 2006)
Workshop for CU graduate students (March 2006)
Gathering For Gardner (Atlanta, March 2006)
Artist/Mathematician Dialogue with Bernar Venet (Univ of Connecticut, March 2006)
Public Lecture (Carleton College, May 2006)
Workshop and presentation at STUK (Belgium, April 2006)

Faculty Research and Professional Activities

Grant and contract expenditures for the fiscal year 2005–2006 totaled $2,795,693. This included 42 grants and contracts from federal, state and private agencies awarded to 31 faculty members. Faculty submitted 21 new grant proposals, 11 of which (shown below) have been funded to date by the National Science Foundation.

New Grants Funded by the National Science Foundation

Principal Investigator.	Amount	Duration	Title of Grant
Louis Billera	$350,000	6/1/06–5/31/11	Quasisymmetric Functions and Eulerian Enumeration
Richard Durrett	$21,044	5/1/06–4/30/07	Travel Grants for the Conference on Stochastic Processes
Richard Durrett[1]	$824,379	7/1/06–6/30/11	EMSW21-MCTP: High School Outreach Activities
Martin Kassabov	$104,810	7/1/06–6/30/09	Properties T, Tau, and Kazhdan Constants
Gregory Lawler	$15,000	3/1/06–2/28/07	Travel Support: Brazilian Probability School and IMS Meeting 2006
Laurent Saloff-Coste	$261,000	9/1/06–8/31/09	Markov Processes in Geometric Environments
Alfred Schatz	$403,576	8/1/06–7/31/09	Algorithms and Numerical Analysis for Partial Differential Equations
Richard Shore	$210,000	6/1/06–5/31/09	Logic and Computability
John Smillie	$130,733	6/1/06–5/31/09	Complex Dynamics and Polygonal Billiards
Edward Swartz	$8,750	7/1/06–12/31/06	Enumerative and Topological Properties of Matroids[2]
Edward Swartz	$118,452	7/1/06–6/30/09	From Topology to Combinatorics and Back

[1] Co-P.I.s are David Bock, Kenneth Brown, Edward Swartz, and Maria Terrell.
[2] A 2006 REU Supplement.

NSF SCREMS Grant for the Cornell Mathematics Computing Environment

The Division of Mathematical Sciences (DMS) of the National Science Foundation has provided funds through a Scientific Computing Research Environments for the Mathematical Sciences (SCREMS) grant to facilitate computationally intensive mathematics research at Cornell University. The department purchased a shared memory Opteron system with eight dual processor CPUs and 128 GB of RAM. The computer will be available to all faculty and students in the Mathematics Department pursuing research that requires resources beyond a single PC. The following projects are planned for this machine.

- **R. Keith Dennis** and **Gerhard Michler** will investigate the structure of finite simple groups.
- **Michael Stillman** and his students will investigate algebraic problems arising from use of Bayesian networks in the statistical analysis of genomic data.
- **Dan Barbasch** will study irreducible representations of Lie groups and requires computing resources of this scale to push the research further.
- **Alexander Vladimirsky** will investigate parallelization of efficient algorithms for solving optimal control problems. This new system will enable the solution of larger problems than are currently feasible due to the exponential growth of computational effort with problem dimension.
- **Richard Durrett** and his students will simulate probabilistic models for genomic and evolutionary processes. One goal of this research is to test approximations that significantly reduce the computational time required to analyze large data sets.
- **John Guckenheimer** will investigate dynamical systems that arise in neuroscience, studies of locomotion, and chemical combustion.

The department also acquired eight additional dual-Opteron machines, each with 8 GB of memory, which will be added to four existing machines to form a small supercomputing cluster. Remaining funds will likely be used to purchase a smaller linux cluster.

Other Computing Facility Upgrades

The department made some significant upgrades to its computing facilities this year. Professor Bill Thurston provided funds for the purchase of ten new high-performance machines. Six workstations with large LCD displays were added to the graduate computing lab, and four high-performance dual-processor machines equipped with 8 or 16 GB of memory were installed to facilitate work in computational mathematics. These new machines have been nicknamed the “Math Vaders” because their case design seems to have been inspired by Darth Vader's helmet. Among the chief users are Professors Dan Barbasch, Mike Stillman, Alessandra Pantano, and Alvaro Lozano-Robledo, plus graduate students Jason Martin, Henri Johnston, Chris Lipa, and Mauricio Velasco.

Besides the new workstations and number crunchers, the department has also upgraded its file and web servers, installed uninterruptible power supplies in the server room, and purchased several new machines for use by visiting faculty.

NSF MCTP Grant for High School Outreach Activities

The Mathematics Department was recently awarded an NSF Mentoring through Critical Transition Points (MCTP) grant to support the Math Explorer's Club and Senior Seminar for the next five years. The grant will provide eight semesters of support each year for graduate students. The goal of the grant is to develop polished lecture notes for Senior Seminar modules and web-based archives of tested materials for the Math Explorer's Club. With this support, we hope to not only make our own activities better and easier to run but also to facilitate the development of similar activities in other locations. (See Community Outreach, p. 49.)

Conference in Honor of José Escobar

An international conference in memory of José Escobar was held January 30–February 3, 2006 at Universidad del Valle, where Chepe completed his undergraduate mathematics program. **Laurent Saloff-Coste** was a member of the eight-person scientific committee, and **Reyer Sjamaar** was one of five main speakers. Reyer's talk, *Convexity theorems for varieties invariant under a Borel subgroup*, was part of a program that focused on nonlinear analysis, differential geometry, and partial differential equations. Chepe's five Cornell graduate students partipated in the conference: Gonzalo Garcia (Universidad del Valle) was one of the organizers, and Henrique Araujo (Universidade Pernambuco), Nelia Charalambous (Irvine), Fernando Marques (IMPA), and Jean Cortissoz (Ohio) gave talks.

Faculty Leave Activities

Five faculty members spent their leaves of absence elsewhere this year. (Anil Nerode remained in residence, taking the opportunity to write.) Tara Holm delayed her arrival to spend the year at the University of Connecticut. Michael Nussbaum spent the spring semester at Technical University (TU) Berlin doing research on quantum statistics with R. Seiler and his research group of mathematical physics. Ravi Ramakrishna spent the spring at the University of Utah. Robert Connelly and Richard Durrett also spent their sabbaticals away. Here is what they report of their activities.

Robert Connelly

"I am in Cambridge, UK, from mid September 2005 until mid August 2006, visiting the Engineering Department and Simon Guest. We are writing a book about pin jointed frameworks and tensegrity structures, with the intention of providing a connection between the engineering and mathematical points of view as well as providing a description of how the representation theory of finite groups can be applied to symmetric structures. It has been fun being here. The banging and clanging adds to the ambience. My models fit right in, and the activity here is exciting and stimulating. But I will be ready to get back to Cornell and teach Calculus."

Richard Durrett

"I had a very productive sabbatical this year, enjoying traveling that my back did not allow me to do last year. I worked with Simon Levin in Princeton, Ed Perkins in Vancouver, and visited Berkeley and Stanford. I went to U of Rouen in France to be an external member for a thesis defense in September. It was interesting to see the considerably more formal French system. I was one of two referees on the seven-person jury. Although I can't say I understood every word of the closed-door discussion when we drafted a flowery paragraph to describe the candidate's performance, I did enjoy having a nice two-hour lunch before the defense, and champagne and cookies afterwards.

"I spent the month of February in Paris visiting Ecole Normale Superieure. Paris is warmer than Ithaca with temperatures about freezing, but some of this advantage is negated by the fact that I was walking instead of riding in my warm car. I gave three talks in Paris and two in Marseille, but in between these I had a lot of time to finish my 7th book *Random Graphs Dynamics*, which will be published by Cambridge University Press this summer.

"March 13-17 I made my first trip to South America giving a plenary lecture at the first International Congress on the Applications of Mathematics co-sponsored by SIAM, Latin American Mathematical Union (UMALCA), and the European Mathematical Society (EMS). Since I mostly attend probability conferences, it was interesting to hear lectures that covered a wide spectrum of topics including dynamical systems, partial differential equations, and mathematical biology. Chile is one time zone east of New York so you don't experience jet lag, just the loss of two nights' sleep on the plane. On the plus side, the temperature was 80, restaurants were inexpensive, and we had an excursion to the ocean to see the house of Pablo Neruda, Nobel Prize winner for his poetry."

Faculty Editorships

Dan Barbasch, editor of *Proceedings of the AMS*

Yuri Berest, editor of the *Journal of Nonlinear Mathematical Physics* (Sweden)

Louis Billera, member of the editorial boards of *Discrete and Computational Geometry* and the *Journal of Algebraic Combinatorics*

James Bramble, member of the editorial committees of *RAIRO, Numerical Functional Analysis and Optimization, Advances in Computational Mathematics,* and the *Panamerican Mathematical Journal*; editorial board member of *Communications in Applied Analysis*

Robert Connelly, editor of *Beiträge zur Algebra und Geometrie*

Richard Durrett, associate editor of *Notices of the American Mathematical Society, Stochastic Processes and their Applications*, and *Annals of Applied Probability*

Eugene Dynkin, member of the advisory boards of the *Journal of Stochastic Analysis and Applications* and *Mathematics in Operations Research, Probability Theory and its Applications*

Leonard Gross, member of the editorial boards of the *Journal of Functional Analysis*, *Reviews of Mathematical Physics*, *Potential Analysis*, the *Soochow Journal of Mathematics*, *Revista Colombiana de Matemàticas* and the advisory board of *Methods of Functional Analysis and Topology*

John Guckenheimer, editor of the *Journal of Experimental Mathematics*, the *SIAM Journal of Applied Dynamical Systems*, and the *International Journal of Bifurcation and Chaos*

Yulij Ilyashenko, member of the editorial boards of *Dynamical and Control Systems*, *Proceedings of the Moscow Mathematical Society* and *Mathematical Enlightenment*; member of the advisory boards of *Functional Analysis and its Applications* and *Ergodic Theory and Dynamical Systems;* and editor-in-chief of *Moscow Mathematical Journal*

Gregory Lawler, chief editor of the *Annals of Applied Probability*

Alvaro Lozano-Robledo, editor of the *Free Encyclopedia of Mathematics*

Anil Nerode, associate editor of the *Annals of Mathematics and Artificial Intelligence*; editor of *Computer Modeling and Simulation, Mathematics and Computer Modeling*, *Grammers*, *Documenta Mathematica*, and the *International Journal of Hybrid Systems*; member of the editorial board of the *Discrete Mathematics and Computer Science* series (Springer)

Michael Nussbaum, associate editor of *Annales de l'Institut Henri Poincaré* and *Statistics and Decisions*

Lawrence Payne, member of the editorial boards of *Glasgow Mathematical Journal, Applicable Analysis,* and *Mathematical Methods in the Applied Sciences*

Laurent Saloff-Coste, editor of *Mathematische Zeitschrift*; associate editor of *Probability Theory and Related Fields*, *Stochastic Processes and their Applications*, and the *Journal of Theoretical Probability*

Shankar Sen, member of the editorial board of the *Journal of the Ramanujan Mathematical Society*

Richard Shore, editor of *Studies in Logic and the Foundations of Mathematics* (North-Holland book series)

Reyer Sjamaar, managing editor of *Transformation Groups* (Birkhäuser)

Birgit Speh, editor of the *New York Journal of Mathematics* and the *Journal of Representation Theory*

Michael Stillman, algebraic geometry editor for the *Proceedings of the American Mathematical Society*; editor for *J. Math. Computation* (AMS)

Robert Strichartz, executive editor of *Journal of Fourier Analysis and Applications*

Lars Wahlbin, editor of *Mathematics of Computation*

James West, member of the editorial board of *Fundamenta Mathematicae*

2005-2006 Faculty Publications

Jeffrey Adams, **Dan Barbasch**, Annegret Paul, Peter Trapa, and David Vogan, *Shimura correspondences for split real groups*, Journal of the AMS (to appear).

Dan Barbasch and Dan Ciubotaru, *Spherical unitary principal series* (in honor of A. Borel), Quarterly J. of Math. **1** no. 4 (2005).

James Belk and **Kenneth Brown,** *Forest diagrams for elements of Thompson's group F*, Internat. J. Algebra Comput. **15** (2005), 815–850.

Yuri Berest and Oleg Chalykh, *A-infinity modules and Calogero-Moser spaces*, Crelle's Journal (to appear).

Yuri Berest and George Wilson, *Mad subalgebras of rings of differential operators on curves*, Adv. Math. (to appear).

James Bramble, Tzanio Kolev, and Joseph Pasciak, *The approximation of the Maxwell eigenvalue problem using a least squares method*, Math. Comp. 74 (2005), 1575–1598.

James Bramble, Tzanio Kolev, and Joseph Pasciak, *A least-squares method for the time-harmonic Maxwell equations,* J. Numer. Math. **13** (2005), 237–320.

Louis Billera, H. Thomas, and Stephanie van Willigenburg, *Decomposable compositions, symmetric quasisymmetric functions and equality of ribbon Schur functions*, Advances in Math. (to appear).

Louis Billera, Samuel Hsiao, and J. Scott Provan, *Enumeration in convex geometries and associated polytopal subdivisions of spheres*, Discrete and Computational Geometry (to appear).

Kenneth Brown, *The homology of Richard Thompson's group F;* in Topological and Asymptotic Aspects of Group Theory, Contemporary Mathematics **394** (2006), 47–59.

Kenneth Brown, Review of *The structure of spherical buildings* by Richard M. Weiss, Bull. AMS **42** no. 3 (2005), 395–400.

Hsiao-Bing Cheng, Li-Tien Cheng and Shing-Tung Yau, *Minimization with the affine normal direction*, Commun. Math. Sci. **3** no. 4 (2005), 561–574.

Robert Connelly, *Generic global rigidity,* Discrete and Computational Geometry **33** no. 4 (2005), 549–563.

Robert Connelly, Erik Demaine, Martin Demaine, Sándor Fekete, Stefan Langerman, Ares Rib'o, and Günter Rote, *Locked and unlocked chains of planar shapes*, Proceedings of ACM Symposium on Computational Geometry (to appear).

Richard Durrett, *Genome rearrangement*; in Statistical Methods in Molecular Evolution (R. Nielsen, ed.), Springer, 2005.

Jonah Blasiak and **Richard Durrett,** *Random Oxford graphs*, Stoch. Processes Appl. **115** (2005), 1257–1278.

Richard Durrett and Simon Levin, *Can stable groups be maintained by homophilous imitation alone?* Journal of Economic Behavior and Organization **57** (2005), 267–278.

Richard Durrett, Leonid Mytnik, and Edwin Perkins, *Competing super-Brownian motions as limits of interacting particle systems*, Electronic Journal of Probability **10** (2005), 1147–1220.

Richard Durrett and Jason Schweinsberg, *Random partitions approximating the coalescence of lineages during a selective sweep*, Ann. Appl. Probab. **15** no.3 (2005), 1591–1651.

Richard Durrett and Jason Schweinsberg, *A coalescent model for the effect of advantageous mutations on the genealogy of a population*, Stoch. Proc. Appl. **115** (2005), 1628–1657.

Richard Durrett and Jason Schweinsberg, *Power laws for family sizes in a gene duplication model*, Annals of Probability **33** (2006), 2094–2126.

Nathanael Berestycki and **Richard Durrett**, *A phase transition in the random transposition random walk*, Prob. Theory. Rel. Fields (to appear).

Benjamin Chan and **Richard Durrett**, *A new coexistence result for competing contact processes*, Annals of Applied Probability (to appear).

Richard Durrett, Rasmus Nielsen, Steven Tanksley, and Thomas York, *Bayesian and maximum likelihood estimation of genetic maps*, Genetics (to appear).

Richard Durrett, *Random Graphs Dynamics*, Cambridge University Press (to appear).

Eugene Dynkin, *On extreme X-harmonic functions,* Math. Research Letters **13** no. 1 (2006), 59–69.

Eugene Dynkin, *A note on X-harmonic functions*, Illinois J. Math. (to appear).

Eugene Dynkin, *An application of probability to nonlinear analysis*, Proceedings of the Second Abel Symposium (to appear).

Richard Casey, **John Guckenheimer**, and Eric Phipps, *Periodic orbits of hybrid systems and parameter estimation via AD*, Lecture Notes in Computational Science and Engineering **50** (2006), 211–224.

John Guckenheimer and Radu Haiduc, *Canards at folded nodes*, Moscow Mathematical Journal **25** (2005), 91–103.

Matthias Gruhn, **John Guckenheimer**, Ronald Harris-Warrick, and Bruce Land, *Dopamine modulation of two delayed rectifier potassium currents in a small neural network*, Journal of Neurophysiol., 94 (2005), 2888-2900.

Richard Casey, Marie Goeritz, **John Guckenheimer**, Ronald Harris-Warrick, Jason MacLean, Ricardo Oliva, and Yan Zhang, *Activity-independent coregulation of* N_A *and* N_h *in rhythmically active neurons*, J. Neurophysiol. **94** (2005), 3601–3617.

John Guckenheimer, Kathleen Hoffman, and Warren Weckesser, *Bifurcations of relaxation oscillations near folded saddles*, Int. J. Bif. Chaos **15** no. 11 (2005).

John Guckenheimer, Joseph Tien, and Allan Willms, *Bifurcations in the fast dynamics of neurons: implications for bursting*; in Bursting, The Genesis of Rhythm in the Nervous System (Stephen Coombes and Paul Bressloff, eds.), World Scientific, 2005, pp. 89–122.

John Guckenheimer, Martin Wechselberger and Lai-Sang Young, *Chaotic attractors of relaxation oscillators*, Nonlinearity **19** (2006), 701–720.

Robert Full, **John Guckenheimer**, Philip Holmes, and Dan Koditschek, *The dynamics of legged locomotion: models, analyses and challenges*, SIAM Review, in press.

Stephen Ellner and **John Guckenheimer**, *Dynamics Models in Biology*, Princeton University Press, 2006.

Allen Hatcher and Nathalie Wahl, *Stabilization for the automorphisms of free groups with boundaries*, Geometry and Topology **9** (2005), 1295–1336.

David Henderson and Daina Taimina, *How to use history to clarify common confusions in geometry;* a chapter in From Calculus to Computers: Using Recent History in the Teaching of Mathematics (A.Shell and B.Jardine, eds.), MAA Notes **68**, 2005, pp. 57–73.

David Henderson and Daina Taimina, *Geometry*, an invited signed article for the Hutchinson Encyclopedia of Mathematics (to appear).

Megumi Harada, Andre Henriques, and **Tara Holm**, *Computation of generalized equivariant cohomologies of Kac-Moody flag varieties*, Advances in Mathematics **197** no. 1 (2005), 198–221.

Megumi Harada and **Tara Holm**, *The equivariant cohomology of hypertoric varieties and their real loci*, Communications in Analysis and Geometry **13** no. 3 (2005), 527–559.

Jean-Claude Hausmann, **Tara Holm**, and Volker Puppe, *Conjugation spaces*, Algebraic and Geometric Topology **5** (2005), 923–964.

Victor Guillemin, **Tara Holm**, and Catalin Zara, *A GKM description of the equivariant cohomology ring of a homogeneous space*, Journal of Algebraic Combinatorics **23** no. 1 (2006), 21–41.

John Hubbard, *Hyperbolic structures on 3-manifolds that fiber over the circle*; in Lectures on Quasiconformal Mappings by Lars V. Ahlfors, 2^{nd} ed., American Mathematical Society, 2006.

John Hubbard, *Teichmüller Theory and Applications to Geometry, Topology and Dynamics; Volume 1: Teichmuller theory*, Matrix Editions (to appear).

J. T. Gene Hwang and Harrison Zhou, *Minimax estimation with thresholding and its application to wavelet analysis,* Annals of Statistics (2005), 101–125.

Rico Caldo, **J. T. Gene Hwang**, Dan Nettleton, and Roger Wise, *Estimating the number of true null hypotheses from a histogram of p-values*, J. of Agricultural, Biological and Environmental Statistics, to appear.

Anton Gorodetski, **Yulij Ilyashenko,** Victor Kleptsyn, and M. Nalski, *Non-removable zero Lyapnov exponents,* Functional Analysis and Appl. **39** no. 1 (2005), 27–38.

Gregery Buzzard, Suzanne Hruska, and **Yulij Ilyashenko,** *Kupka-Smale theorem for polynomial automorphisms of C^2 and persistence of heteroclinic intersections,* Invenciones Mathematicae **161** (2005), 45–89.

Alexey Glutsyuk and **Yulij Ilyashenko**, *Restricted infinitesimal Hilbert problem*, Doclady RAN **407** no. 2 (2006), 1–6.

Yulij Ilyashenko, *Attractors of dynamical systems and philosophy of generic position,* Images de Mathematique (to appear).

Paul Jung, *The critical value of the contact process with added and removed edges,* J. Theor. Prob. **18** (2005), 949–955.

Paul Jung, *The noisy voter-exclusion process,* Stochastic Processes and their Applications **115** (2005), 1979–2005.

Martin Kassabov, *Symmetric groups and expanders*, Electronic Research Announcements of AMS **11** (2005), 47–56.

Martin Kassabov, *Kazhdan constants for $SL_n(Z)$,* International Journal of Algebra and Computation **15** no. 5–6 (2005), 971–995.

Martin Kassabov, Alex Lubotzy, and Nikolay Nikolov, *Finite simple groups and expanders*, Proc. Nat'l Acad. Sci. **103** no. 16 (2006), 6116–6119.

Martin Kassabov and Nikolay Nikolov, *Universal lattices and property tau*, Inventiones Mathematicae DOI: 10.1007/s00222-005-0498-0.

Harry Kesten and Vladas Sidoravicius, *The spread of a rumor or infection in a moving population,* Ann. Probab. **33** (2005), 2402–2461.

Dexter Kozen, *Coinductive proof principles for stochastic processes*; in Proc. 21st Conf. Logic in Computer Science (LICS'06), IEEE, Seattle, WA, 2006.

Kamal Aboul-Hosn and **Dexter Kozen**, *Relational semantics for higher-order programs*; in Proc. Mathematics of Program Construction (MPC'06), 2006.

Dexter Kozen, Christoph Kreitz, and Eva Richter, *Automating proofs in category theory*; in Proc. 3rd Int. Joint Conf. Automated Reasoning (IJCAR'06), Seattle, WA, 2006.

Kamal Aboul-Hosn and **Dexter Kozen**, *KAT-ML: an interactive theorem prover for Kleene algebra with tests*, Journal of Applied Non-Classical Logics (2006).

Kamal Aboul-Hosn and **Dexter Kozen**, *Local variable scoping and Kleene algebra with tests*; in Proc. 9th Int. Seminar on Relational Methods in Computer Science and 4th Int. Workshop Applications of Kleene Algebra (Kleene/RelMiCS'06), 2006.

Lucja Kot and **Dexter Kozen**, *Kleene algebra and bytecode verification*; in Proc. 1st Workshop Bytecode Semantics, Verification, Analysis, and Transformation (Bytecode'05), (Fausto Spoto, ed.), Edinburgh, 2005, pp. 201–215.

Dexter Kozen, *Theory of Computation*, Springer, New York, 2006.

Gregory Lawler, *Conformally Invariant Processes in the Plane,* AMS (2005).

Gregory Lawler, *Estimates of random walk exit probabilities and application to loop-erased random walk*, Electron J. Probab. 44 (2005), paper no.44.

Gregory Lawler, *Stochastic Loewner evolution*, Encyclopedia of Mathematical Physics (to appear).

Gregory Lawler, *The Laplacian-b walk and the Schramm-Loewner evolution*, Illinois Journal of Mathematics, special issue in memory of J. Doob (to appear).

Alvaro Lozano-Robledo, *On elliptic units and p-adic Galois representations attached to elliptic curves*, J. of Number Theory **117** no. 2 (2006), 29 pages.

Alvaro Lozano-Robledo, *Buscando puntos racionales en curves elipticas: Metodos explicitos*; in La Gaceta de la Real Sociedad Matematica Espanola, J. of the Royal Mathematical Society of Spain **8** no. 2 (2005), 471–488 (in Spanish).

Alvaro Lozano-Robledo, *On certain closed subgroups of* $SL(2, Z_p[[X]])$, Revista Colombiana de Matematicas, **39** (2005), 13–19.

Alvaro Lozano-Robledo, *On the surjectivity of Galois representations attached to elliptic curves over number fields*, Acta Arithmetica **117** no. 3 (2005), 283–291.

James Michael, **Anil Nerode**, and Duminda Wijesekera, *An agent-based framework for assessing missile defense doctrine and policy*, POLICY (2005), 115–118.

Anil Nerode and Duminda Wijesekera, *Tableaux for constructive concurrent dynamic logic*, Ann. Pure Appl. Logic **135** (2005), 1–72.

Michael Jahnisch and **Michael Nussbaum,** *A functional Hungarian construction for the sequential empirical process*, C. R. Acad. Sci. Paris, Ser. I **341** (2005), 761–763.

Georgi Golubev, **Michael Nussbaum**, and Harrison Zhou, *Asymptotic equivalence of spectral density estimation and white noise*, Ann. Statist. (to appear).

Arpad Benyi, Karlheinz Grochenig, Christopher Heil, and **Kasso Okoudjou,** *Modulation spaces and a class of bounded multilinear pseudodifferential operators,* Journal of Operator Theory **54** no. 2 (2005), 389–401.

Kasso Okoudjou and **Robert Strichartz,** *Weak uncertainty principles on fractals,* Journal of Fourier Analysis and Applications **11** no. 3 (2005), 315–331.

Arpad Benyi, Loukas Grafakos, Karlheinz Grochenig, and **Kasso Okoudjou,** *A class of Fourier multipliers for modulation spaces*, Appl. Comput. Harmon. Anal. **19** no. 1 (2005), 131–139.

Matthew Fickus, Brody Johnson, Keri Kornelson, and **Kasso Okoudjou**, *Convolutional frames and the frame potential*, Appl. Comput. Harmon. Anal. **19** no. 1 (2005), 77–91.

Arpad Benyi and **Kasso Okoudjou**, *Modulation spaces estimates for multilinear pseudodifferential operators*, Studia Math. **172** no. 2 (2006), 169–180.

Elena Cordero and **Kasso Okoudjou**, *Multilinear localization operators*, J. Math. Anal. Appl. (to appear).

Lawrence Payne, Philip Schaefer and J. C. Song, *Some nonstandard problems in generalized heat conduction*, ZAMP **56** (2005), 931–941.

Lawrence Payne and J. C. Song, *Improved spatial decay bounds in generalized heat conduction*, ZAMP **56** (2005), 805–820.

Lawrence Payne, G. A. Philippin and Stella Vernier-Piro, *Decay bounds for solutions of second-order parabolic problems and their derivatives IV,* Applicable Analysis **85** (2006), 293–302.

Lawrence Payne, G. A. Philippin and Stella Vernier-Piro, *Blowup, decay bounds, and continuous dependence inequalities for a class of quasilinear parabolic problems,* Math. Meth. Appl. Sci. **29** (2006), 281–295.

Anders Bjorner, Jessica Sidman, and **Irena Peeva,** *Subspace arrangements defined by products of linear forms,* Journal of the London Math. Soc. **71** (2005), 273–288.

Jeffrey Mermin and **Irena Peeva**, *Lexifying ideals*, Math. Res. Letters (to appear).

Jean Jacod, Thomas Kurtz, Sylvie Meleard, and **Philip Protter**, *The approximate Euler method for Levy driven stochastic differential equations*, Annales of the Institut Henri Poincaré, special issue dedicated to the memory of P. A. Meyer (En Hommage à Paul-André Meyer) **41** (2005), 523–558.

Chandrashekhar Khare, Michael Larsen, and **Ravi Ramakrishna,** *Constructing Galois representations with very big image*, Canadian Journal of Mathematics (to appear).

Geoffrey Recktenwald and **Richard Rand**, *Coexistence phenomenon in autoparametric excitation of two degree of freedom systems*, International J. Nonlinear Mechanics **40** (2005), 1160–1170.

F. Dercole, K. Niklas, and **Richard Rand**, *Self-thinning and community persistence in a simple size-structured dynamical model of plant growth*, J. Math. Biology **51** (2005), 333–354.

Keith Aubin, Harold Craighead, Brian Houston, Jeevak Parpia, **Richard Rand**, Robert Reichenbach, and Maxim Zalalutdinov, *Third-order intermodulation in a micromechanical thermal mixer*, J. Microelectromechanical Systems **14** (2005), 1244–1252.

Timothy Riley, *Navigating in the Cayley graphs of* $SL_N(Z)$ *and* $SL_N(F_p)$*,* Geometriae Dedicata (to appear).

Sean Cleary and **Timothy Riley**, *A finitely presented group with unbounded dead-end depth*, Proc. Amer. Math. Soc. (to appear).

Steve Gersten and **Timothy Riley**, *Some duality conjectures for finite graphs and their group theoretic consequences*, Proc. Edin. Math. Soc. (to appear).

Steve Gersten and **Timothy Riley**, *The gallery length filling function and a geometric inequality for filling length*, Proc. London Math. Soc. (to appear).

Timothy Riley and Andrew Warshall, *The unbounded dead-end depth property is not a group invariant*, Int. J. Alg. Comp. (to appear).

Luke Rogers, *Degree-independent Sobolev extension on locally uniform domains*, J. Func. Anal. (to appear).

Alexander Grigor'yan and **Laurent Saloff-Coste,** *Stability results for Harnack inequalities,* Annales Inst. Fourier **55** (2005), 825–890.

Laurent Saloff-Coste, *On the regularity of sample paths of sub-elliptic diffusions on manifolds*, Osaka J. Math. **42** (2005), 677–722.

Laurent Saloff-Coste and Wolfgang Woess, *Transition operators on co-compact G-spaces*, Revista Matematica Iberoamericana (to appear).

Alexander Bendikov and **Laurent Saloff-Coste**, *Hypoelliptic bi-invarant Laplacians on infinite dimensional compact groups*, Canadian Journal of Mathematics (to appear).

Alfred Schatz, *Maximum norm error estimates allowing highly refined grids,* Contemporary Mathematics **383** (2005), 133–139.

Shankar Sen, *The Galois theory of the p-adic complex numbers*, JRMS (to appear).

C. T. Chong, **Richard Shore**, and Yue Yang, *Interpreting arithmetic in the r.e. degrees under $I\Sigma_4$-induction*; in Reverse Mathematics 2001 (S. Simpson, ed.), Lecture Notes in Logic **21**, Association for Symbolic Logic (2005), 120–146.

Richard Shore, *Boolean algebras, invariants and ACA^+_0*, Transactions of the Amer. Math. Soc. **358** (2006), 965–987.

Richard Shore and Theodore Slaman, *The $\forall\exists$-theory of $D(\leq,\vee,')$ is undecidable*; in Logic Colloquium '03 (V. Stoltenberg-Hansen and J. Väänänen eds.), Lecture Notes in Logic, ASL (to appear).

Barbara Csima, Antonio Montalban, and **Richard Shore**, *Boolean algebras, Tarski invariants and index sets*, Notre Dame Journal of Formal Logic (to appear).

Richard Shore, *Degree structures: Local and global investigations*, Bulletin of Symbolic Logic (to appear).

Victor Guillemin and **Reyer Sjamaar**, *Convexity properties of Hamiltonian groups actions*, CRM Monograph Series (2005), 145 pages.

Reyer Sjamaar, *A de Rham theorem for symplectic quotients*, Pacific J. Math. (to appear).

Jacques Hurtubise, Lisa Jeffrey, and **Reyer Sjamaar**, *Moduli of framed parabolic sheaves*, Ann. Global Anal. Geom. (to appear).

John Smillie, *Real polynomial diffeomorphisms with maximal entropy*, Ergodic Theory and Dynamical Systems (to appear).

John Smillie, *The Hénon family: the complex horseshoe locus and real parameter space*, Contemporary Mathematics volume of the AMS-IMS-SIAM Summer Research Snowbird Conference (to appear).

Birgit Speh and T. N. Venkataramana, *Construction of some modular symbols*, Pure and Applied Mathematics Quarterly **1** no.4 (2005), 737-754.

Michael Stillman, *Tools for computing primary decompositions and applications to ideals associated to Bayesian networks*; in Solving Polynomial Equations: Foundations, Algorithms, and Applications, (A. Dickenstein and I. Z. Emiris, eds.), Algorithms and Computation in Mathematics **14**, Springer (2005).

André Galligo and **Michael Stillman**, *Self intersections of bicubic surfaces*, MEGA conference (to appear).

Shawn Drenning, Judith Palagallo, Thomas Price, and **Robert Strichartz,** *Outer boundaries of self-similar tilings,* Experimental Mathematics **14** (2005), 199–209.

Robert Strichartz, *Laplacians on fractals with spectral gaps have nicer Fourier series,* Mathematical Research Letters **12** (2005), 269–274.

Robert Strichartz, *Solvability for differential equations on fractals*, Journal d'Analyse Mathematique 96 (2005), 247–267.

Nitsan Ben-Gal, Abby Shaw-Krauss, **Robert Strichartz**, and C. Young, *Calculus on the Sierpinski gasket II: point singularities, eigenfunctions, and normal derivatives of the heat kernel*, Transactions American Mathematical Society (to appear).

Robert Strichartz, *Convergence of mock Fourier series*, Journal d'Analyse Mathematique (to appear).

Robert Strichartz, *Differential Equations on Fractals, A Tutorial*, Princeton University Press (to appear).

Daniel Abrams, Bruno Eckhardt, Allan McRobie, Edward Ott, and **Steven Strogatz**, *Crowd synchrony on the millennium bridge*, Nature **438** (2005), 43–44.

Edward Swartz, *g-elements, finite buildings and higher Cohen-Macaulay connectivity*, JCT A (to appear).

James Conant, Ferenc Gerlits, and **Karen Vogtmann,** *Cut vertices in commutative graphs,* Quarterly J. Math **56** no. 3 (2005), 321–336.

Martin Bridson and **Karen Vogtmann**, *Automorphism groups of free groups, surface groups and free abelian groups*, Handbook of Questions Around the Mapping Class Group (B.Farb, ed.), to appear.

Karen Vogtmann, *The cohomology of automorphism groups of free groups*, Proceedings of International Congress of Mathematics, Madrid 2006 (to appear).

Teaching Program

During the 2005–2006 academic year, the Mathematics Department offered 126 courses in 219 lectures and 149 recitations to 5,897 students, generating 23,066 credit hours. While students were drawn from every college at Cornell, the majority came from the College of Agriculture & Life Sciences (14%), Arts & Sciences (32%), Engineering (42%), and the Graduate School (8%). (See pp. 20–21 for a complete list of courses with enrollments and credit hours.)

The Department of Theoretical & Applied Mechanics (T&AM) supported instructors for 12 lectures of the engineering calculus sequence. The remaining 207 lectures were supported by the Mathematics Department. The following faculty from T&AM and other scientific departments at Cornell contributed to the success of our teaching program in 2005–2006 by teaching lectures of engineering mathematics: from T&AM, K. Bingham Cady, James Jenkins, Subrata Mukherjee, Vijayanand Muralidharan, S. Leigh Phoenix, Andy Ruina, and Zheng Jane Wang; from Mechanical Engineering, P. C. Tobias de Boer; and from Chemical Engineering, T. Michael Duncan. Since T&AM shares the teaching of engineering calculus, they are accredited with 50% of the credit hours for MATH 190/191 in the fall and MATH 293-294 for the year, amounting to 3,794 credits for 2005–2006.

The 2005–2006 teaching program was supported by 99 teaching assistants and associates, who served as TA instructors for 33 lectures of MATH 103, 105, 111, 112, 171, and 191, as recitation TAs for our freshman- and sophomore-level courses, and as graders for our upper-level undergraduate and first-year graduate courses. The department received support for 8 full-time TAs from T&AM, 2 full-time TAs from the Center for Applied Mathematics (CAM), 1 half-time TA from the Knight Writing Program for our Writing-in-the-Major (WIM) course MATH 451, and 1 half-time TA from the Computer Science Department for MATH 335/COM S 480. The majority of our teaching assistants are mathematics graduate students, but in the 2005–2006 academic year 16 TAs were from CAM, 10 from T&AM, 6 from Statistics, 2 from Education, 1 from Biological Statistics & Computational Biology, and 1 from Computer Science.

During summer session 2005, the Mathematics Department offered 10 courses to 176 students, generating 670 credit hours. (Enrollments and credit hours are displayed in the table below.) The following short-term visitor taught during summer 2005: Thomas Pfaff (Ithaca College).

Visiting Program

Each year, the visiting program attracts mathematics professors on leave from small colleges around the country. Program participants are appointed half time to teach two (usually identical) courses each semester. While at Cornell, participants are free to attend classes, participate in seminars, conduct research and interact with Cornell faculty and students. Craig Johnson (Marywood University) and Thomas Stiadle (Wells College) participated in this year's visiting program. Craig taught Calculus for Engineers (MATH 192) to two small classes of about 30 students each in the fall and two large lectures of over 200 students each in the spring. Tom taught two lectures of Calculus I (MATH 111) in the fall, and one lecture each of Calculus III (MATH 213) and Linear Algebra with Applications (MATH 231) in the spring. We appreciate their efforts.

Summer Session 2005 Course Enrollment Statistics

Course and Title		Format	Instructor(s)	Enroll	Cr Hrs	Session
103	Mathematical Explorations	Lecture	M. Terrell	8	24	3-week
109	Precalculus Mathematics	Lecture	Alfors	12	36	6-week
111	Calculus I	Lecture	Meadows, Sinnott	18	72	6-week
135	The Art of Secret Writing	Lecture	Owens	14	42	6-week
171	Statistical Theory and Applications	Lecture	Pfaff	16	64	6-week
191	Calculus For Engineers	Lecture	Stiadle	28	112	6-week
192	Calculus For Engineers	Lecture	Jung	12	48	6-week
293	Engineering Mathematics	Lecture	Owens	22	88	8-week
294	Engineering Mathematics	Lecture	Back	36	144	8-week
336	Applicable Algebra	Lecture	R. Terrell	10	40	6-week

Teaching Awards

Recipients of three Department Teaching Awards were announced at the department's annual holiday party. **David Henderson** received the *Senior Faculty Teaching Award* for his dedication to teaching and to training and inspiring the next generation of mathematics teachers, and for developing innovative classroom methods and textbooks that have had a national impact on the teaching of geometry to prospective teachers.

Hsiao-Bing Cheng won the *Junior Faculty Teaching Award.* Students cite his "unmatched clarity and precision," his ability to "make difficult topics easy to grasp and to follow," as well as his skill at "providing a good challenge;" in addition, they find him "friendly and approachable both in class and out."

The *Graduate Student Teaching Award* was given jointly to **Melanie Pivarski** and **Treven Wall.** The selection committee was impressed by Melanie's patience and skill in guiding students at all levels to discover mathematics for themselves, and for her contributions to mentoring her fellow graduate students as TAs. They cited Treven's creativity and innovation in instruction that engages students in thinking about mathematical ideas in accessible and meaningful ways.

New Courses

MATH 201: Invitation to Higher Math: Algebra and Geometry

This course grew out of the idea that there should be other gateways into advanced mathematics besides the traditional route through calculus. There is, after all, much more to advanced mathematics than just "more calculus." Since algebra and geometry (broadly interpreted) are the other two main pillars of mathematics, the goal of the course was to illustrate how there is much more to algebra and geometry beyond what one typically sees in high school.

In this first running of the course the focus was on using geometry to illuminate some interesting topics in algebra, such as continued fractions, Pythagorean triples, Gaussian integers, quadratic forms, and quaternions. The geometry that came up included the non-Euclidean geometry of the hyperbolic plane.

The course was somewhat experimental, as very few colleges or universities seem to have courses of this type. The plan is to continue the experiment next year or the year after depending on course scheduling needs.

MATH 457/657: Computational Homology

In recent years, algebraic topology has emerged as a powerful tool for studying the structure of mathematical objects captured by large sets of numerical or physical data. In fall 2006, the department offered for the first time a course entitled *Computational Homology* with an emphasis on algebraic topology as a practical, computational tool. Unlike more traditional mathematics courses in algebraic topology, this course was aimed at students not only from mathematics, but also from engineering, computer science, physics, and other related sciences, and the prerequisites were minimal: a solid understanding of linear algebra and continuous functions.

This course, developed and taught by Sarah Day based on the text *Computational Homology* by Kaczcynski, Mischaikow, and Mrozek, covered some of the mathematical theory behind homology, efficient means of computation, and applications including computer-assisted proofs in nonlinear dynamics and the measurement of the global structure of patterns. The small group of participants included two undergraduate students, one graduate student, and a few faculty members. The students enrolled in MATH 457/657 also completed independent projects ranging from the numerical computation of the homology of non-orientable spaces to applications of computational homology to the study of nonlinear dynamical systems.

In Development for 2006-2007

The department plans to offer three new courses in the coming year. *Mathematics and Politics* has been so popular as a topic of MATH 103 that starting in the fall it will be offered each semester as MATH 134. In the fall, Irena Peeva will teach a new algebra course called *Computational Algebra* (MATH 437) for undergraduates who have taken a course in linear algebra. Mathematics majors may use this course as one of the program's two required courses in algebra. In addition, Allen Hatcher will introduce an alternate-year course in *Matrix Groups* (MATH 450), an undergraduate version of the *Lie Groups* course, MATH 650.

Calculus Experiment: MATH 111-112

This year we made an experimental change in the format of our standard first-year calculus sequence, MATH 111-112, in an effort to make these courses more attractive to both students and instructors. These courses are split into small classes of at most 25 students that in the past met four days a week with the principal instructor. The main feature of the experiment was to reduce the number of class meetings from four to three per week, with the fourth hour replaced by a combination of several other components. The first of these is an optional one-hour-a-week noncredit course, numbered 011 or 012, taught by lecturers from the Learning Strategies Center. These supplemental courses function somewhat like the fourth-hour TA recitation section in our other calculus courses such as MATH 221-222. They have existed for several years but are becoming increasingly popular and expanding in scope. A second additional component replacing the fourth hour of class consists of optional homework assistance sessions in the Tatkon Center near the dorms on the evenings before homeworks are due. Here the students work together on their problem sets, with an advanced undergraduate course assistant available to answer questions when necessary. The third addition to the course is an online component in which students take an online quiz after having read the section in the textbook to be covered in the next day's class meeting. The goal here is not to reach full comprehension of the new material just by reading it in advance, but rather to start the ball rolling so that students will be coming to class already warmed up to learn the new topic and perhaps have questions to ask about it. This allows for more efficient use of class time.

Enrollments in 111-112 rose 20% this year, and the new format undoubtedly played a significant role in this increase. Students find three meetings a week easier to fit into their schedules than the old arrangement of four classes, which essentially meant the course took up two time slots in their schedules. Surveys of students and instructors indicate strong overall satisfaction with the new arrangement. Pending college approval, the experiment will be made permanent beginning next year.

Web-Based Course Evaluations

The Mathematics Department utilized the Arts College's new web-based student course evaluation system this year, as an alternative to optically-scanned paper questionnaires that have been used in the department for many years. The web-based system was launched in spring 2005 and tested by the Economics Department. In September, the department's undergraduate coordinator, Michelle Klinger, joined a small committee composed of Arts & Sciences staff and faculty to advise the college programming staff on the continued development of the on-line course evaluation option. The result is a remarkably flexible system that allows departments to use multiple questionnaires, called templates, specify which courses are to be evaluated, and what templates are to be used. The student interface displays a list of the student's A&S courses with links to their forms.

Four department faculty members — Birgit Speh, Louis Billera, David Henderson, and Luke Rogers — formed a two-year teaching evaluation committee. Among their duties this first year was the adaptation of the department's paper evaluation form to the web-based system. The committee developed a group of core questions related to course, instructor, teaching assistant, and grader that expanded on those used on the paper forms. They also developed some questions specific to particular groups of courses. So far the online experiment has been successful. A large fraction of the students submitted their evaluations, and for the most part the data processing went smoothly.

Instructional Technology Support

The Instructional Technology Office completed its second year of operation under the direction of Maria Terrell. Graduate student Bryant Adams managed the lab, and trained and supervised undergraduate assistants. The Instructional Technology Office supported undergraduate mathematics instruction at Cornell in the following four core areas:

Hardware Loans

The IT Office has a variety of hardware available for use in providing technology components to seminars or class presentations. Laptops (five) and projectors (two) are available for computer presentations (whether Powerpoint-style presentations or displays that require more elaborate visualization hardware than a blackboard). Polling hardware (three sets) is generally used in MATH 111–112 (see below) along with the Good Questions material, and VHS video recorders (two) can be used for recording lectures, either for posterity or for teaching feedback and analysis.

Polling Systems

The IT Office provided support and training for the use of HiTT (HyperInteractive Teaching Technology) polling software. HiTT polling systems are used in MATH 111–112 to help instructors engage students in lively discussion and debate of mathematical concepts. In addition, ENGRI 131 was held in Malott Hall specifically because of the availability of our mobile polling equipment.

Development of Course Materials

The IT undergraduate assistants helped instructors with the development of technology-oriented course materials for ongoing use — chiefly the question bank creation process in MapleTA — and provided support to the MATH 111 and 112 undergraduate course assistants who worked with MapleTA and Blackboard. The use of emerging and innovative software such as MapleTA can support timely and frequent assessment of student learning and enhance how class time is spent. MapleTA allows instructors to expand their interaction with students outside the classroom by allowing them to pose mathematical questions to students through the web that can be automatically graded, and thereby give both faculty and students feedback on student learning outside of class time.

Development of Online Resources

The IT Office worked with the Engineering College, the Calculus Concept Inventory group, and the Mathematics Support Center to make existing paper-based evaluations (calculus placement testing, the Calculus Concept Inventory, and beginning-of-term diagnostic modules) available online. The online option allows evaluations to be delivered in a more timely manner (such as to incoming freshmen), with less complicated distribution lines — no need to distribute them to instructors of every class or go through an involved collection-and-return process — and statistics are immediately available without intermediate computer data entry.

Mathematics Support Center

An academic support wing of the Mathematics Department, the Mathematics Support Center (MSC) provides free one-on-one and small-group tutoring, workshops and review sessions on topics of common concern in mathematics, approximately fifty brief printed capsules on various mathematical topics, and advice, encouragement, and referrals for students. Although the center focuses on support of introductory courses, it employs both undergraduates and postgraduates (about eight each year) of diverse backgrounds and provides some limited tutoring even in upper-level courses.

During the 2005–2006 academic year, in addition to paid tutors, four volunteers donated their time and expertise: Professor Emeritus Roger Farrell, Harry Bowman, Jessie Degrado, and Matthew Thomas. Douglas S. Alfors directed the operations of the MSC and coordinated its efforts with the instructors of the introductory calculus sequence.

The MSC is located on a main thoroughfare of Malott Hall and is consequently quite visible and accessible to students. It has several tutoring areas that are sufficiently separated from one another to address privacy and noise issues; the reception area can adequately accommodate students who are waiting for their turn to be tutored, and there are a couple of sites that work nicely for small groups. Tutors and tutees can easily access the small library of texts that are maintained by the MSC, and mathematics computer programs provide additional support when needed.

During this past term, the Instructional Technology Office (ITO) assisted the MSC to cast several of the MSC written capsules into electronic format, suitable for web download and/or online diagnostic tools. This work will continue during the next school year.

The MSC maintains weekday hours of service (10:00 AM–5:00 PM), as well as Sunday hours (1:30–5:30 PM).

Learning Strategies Center

The Learning Strategies Center (LSC) provides academic support in a variety of subjects across campus, including biology, chemistry, physics, genetics, economics, writing, study skills, mathematics, and statistics. The mission of the LSC is to provide academic assistance to students during their transition from high school students to accomplished Cornell students. Studies have shown that students who successfully complete their freshman year generally go on to graduate from Cornell. Therefore, most of the LSC's efforts are directed to supporting large, primarily freshmen, courses.

In the 2005–2006 academic year, the LSC provided academic support for MATH 105, 106, 111, and 112. Support included respective supplemental courses MATH 005, 006, 011, and 012. Each supplemental course consisted of a 75-minute weekly lecture, offered during the late afternoon or evening (depending upon instructor), which reviewed material covered in the parent course, with an emphasis on problem solving and prelim preparation. In addition, the supplemental course instructors and their assistants provided extensive tutoring hours.

Under the direction of Patricia Alessi, the LSC Statistics Lab in the Center for Learning and Teaching provided support for MATH 171 and other undergraduate statistics courses. The tutor-staffed lab was open four evenings per week, equipped with statistical software and problem sets for the courses supported. During the 2006–2007 academic year, support will continue to be provided as described above for MATH 105, 106, 111, 112, and 171.

Academic Year Course Enrollment Statistics

Course and Title		Format	Faculty Instructor(s)	Enroll	Cr Hrs	Term
103	Mathematical Explorations	Lecture	Speh	62	186	Fall 2005
103	Mathematical Explorations	Lecture	Smillie	65	195	Spring 2006
105	Finite Mathematics for the Life and Social Sciences	Lecture	Kahn, Lind	111	333	Fall 2005
106	Calculus for the Life and Social Sciences	Lec/Sec	Vladimirsky	163	489	Spring 2006
111	Calculus I	Lecture	Ghate, C. Martin (czar), Stiadle	466	1,864	Fall 2005
111	Calculus I	Lecture	C. Martin, Morris	151	604	Spring 2006
112	Calculus II	Lecture	M. Terrell (czar)	174	696	Fall 2005
112	Calculus II	Lecture	Boulet, Gross (czar), Kim, Lozano-Robledo	226	904	Spring 2006
122	Honors Calculus II	Lec/Sec	Okoudjou, Ramakrishna	24	96	Fall 2005
135	The Art of Secret Writing	Lecture	J. West	18	54	Fall 2005
135	The Art of Secret Writing	Lecture	Morris	30	90	Spring 2006
171	Statistical Theory and Application in the Real World	Lec/Sec	Back, Hwang, Lawler, Nussbaum	87	348	Fall 2005
171	Statistical Theory and Application in the Real World	Lec/Sec	Back, Bock Stillman, White	124	496	Spring 2006
190	Calculus for Engineers	Lec/Sec	Schatz	63	252	Fall 2005
191	Calculus for Engineers	Lec/Sec	Muralidharan (T&AM), Rassart, Riley, Ruina (T&AM), Sen, Wahlbin, Z. Wang (czar; T&AM), Wilson	394	1,576	Fall 2005
191	Calculus for Engineers	Lec/Sec	Testa	14	56	Spring 2006
192	Calculus for Engineers	Lec/Sec	de Boer (M&AE), Cheng, Duncan (ChemE), Johnson, Mukherjee (T&AM), Saloff-Coste (czar), Sinnott, Testa	344	1,376	Fall 2005
192	Calculus for Engineers	Lec/Sec	Johnson	481	1,924	Spring 2006
201	Invitation to Higher Math: Algebra and Geometry	Lecture	Hatcher	9	27	Spring 2006
213	Calculus III	Lec/Sec	Berest	38	152	Fall 2005
213	Calculus III	Lec/Sec	Stiadle	37	148	Spring 2006
221	Linear Algebra	Lec/Sec	Boulet, Lozano-Robledo, Pantano, Vogtmann, White	116	464	Fall 2005
221	Linear Algebra	Lec/Sec	Billera, Kim	68	272	Spring 2006
222	Multivariable Calculus	Lec/Sec	Kim, Strichartz	26	104	Fall 2005
222	Multivariable Calculus	Lec/Sec	Back, Wilson	68	272	Spring 2006
223	Theoretical Linear Algebra and Calculus	Lec/Sec	Kemp	22	88	Fall 2005
224	Theoretical Linear Algebra and Calculus	Lec/Sec	Kemp	14	56	Spring 2006
231	Linear Algebra with Applications	Lecture	R. Terrell	15	45	Fall 2005
231	Linear Algebra with Applications	Lecture	Stiadle	24	72	Spring 2006
275	Living in a Random World	Lecture	Popovic	14	42	Spring 2006
293	Engineering Mathematics	Lec/Sec	Phoenix (T&AM), Stillman	410	1,640	Fall 2005
293	Engineering Mathematics	Lec/Sec	Muscalu	279	1,116	Spring 2006
294	Engineering Mathematics	Lec/Sec	Billera, R. Terrell	307	1,228	Fall 2005
294	Engineering Mathematics	Lec/Sec	Cady (T&AM), Jenkins (T&AM)	444	1,776	Spring 2006
304	Prove It!	Lecture	Kahn	16	64	Spring 2006
311	Introduction to Analysis	Lecture	Rogers	18	72	Fall 2005
311	Introduction to Analysis	Lecture	LaMar	19	76	Spring 2006
321	Manifolds and Differential Forms	Lecture	Jung	11	44	Fall 2005
323	Introduction to Differential Equations	Lecture	R. Terrell	23	92	Fall 2005
332	Algebra and Number Theory	Lecture	Kassabov	9	36	Fall 2005
335	Introduction to Cryptology	Lecture	Swartz	14	42	Fall 2005
335	Introduction to Cryptology	Lecture	Dennis	15	45	Spring 2006
336	Applicable Algebra	Lecture	Berest	17	68	Spring 2006
356	Groups and Geometry	Lecture	Calta	14	56	Spring 2006
401	Honors Seminar: Topics in Modern Mathematics	Seminar	Barbasch	3	12	Spring 2006
403	History of Mathematics	Lecture	Nerode	13	52	Spring 2006
408	Mathematics in Perspective	Lecture	Vogtmann	4	16	Spring 2006
413	Honors Introduction to Analysis I	Lecture	Ilyashenko, Okoudjou	43	172	Fall 2005
413	Honors Introduction to Analysis I	Lecture	Lawler	12	48	Spring 2006
414	Honors Introduction to Analysis II	Lecture	J. West	8	32	Spring 2006
418	Theory of Functions of One Complex Variable	Lecture	Barbasch	13	52	Spring 2006
420	Differential Equations and Dynamical Systems	Lecture	Hubbard	23	92	Fall 2005
420	Differential Equations and Dynamical Systems	Lecture	Day	22	88	Spring 2006
422	Applied Complex Analysis	Lecture	Schatz	26	104	Spring 2006
424	Wavelets and Fourier Series	Lecture	Okoudjou	12	48	Spring 2006
425	Numerical Analysis and Differential Equations	Lecture	Vladimirsky	5	20	Fall 2005
428	Introduction to Partial Differential Equations	Lecture	Wahlbin	9	36	Spring 2006
431	Linear Algebra	Lecture	Calta, Chase	46	184	Fall 2005
432	Introduction to Algebra	Lecture	Berest	27	108	Spring 2006
433	Honors Linear Algebra	Lecture	Michler, Sjamaar	34	136	Fall 2005
434	Honors Introduction to Algebra	Lecture	Dennis	23	92	Spring 2006
441	Introduction to Combinatorics I	Lecture	Billera	9	36	Fall 2005
442	Introduction to Combinatorics II	Lecture	Rassart	6	24	Spring 2006

Course and Title		Format	Instructor	Auditors	Enroll	Cr Hrs	Term
451	Euclidean and Spherical Geometry	Lecture	Henderson		12	48	Fall 2005
453	Introduction to Topology	Lecture	Hatcher		18	72	Fall 2005
454	Introduction to Differential Geometry	Lecture	Henderson		22	88	Spring 2006
457	Computational Homology	Lecture	Day	6	4	16	Fall 2005
471	Basic Probability	Lecture	Jung		32	128	Fall 2005
472	Statistics	Lecture	Hwang		14	56	Spring 2006
486	Applied Logic	Lecture	Arslanov		14	56	Spring 2006
490	Supervised Reading and Research	Ind Stud	varies		12	42	Fall 2005
490	Supervised Reading and Research	Ind Stud	varies		5	15	Spring 2006
505	Educational Issues in Undergraduate Mathematics	Lecture	Henderson		2	8	Spring 2006
507	Teaching Secondary Math: Theory and Practices	Lecture	Bock		9	36	Spring 2006
508	Mathematics for Secondary School Teachers	Lecture	Bock		0	0	Fall 2005
508	Mathematics for Secondary School Teachers	Lecture	Bock		6	6	Spring 2006
611	Real Analysis	Lecture	Strichartz	5	16	64	Fall 2005
612	Complex Analysis	Lecture	Strichartz		8	32	Spring 2006
615	Mathematical Methods in Physics	Lecture	L. Gross	2	11	44	Fall 2005
617	Dynamical Systems	Lecture	Smillie		3	12	Fall 2005
619	Partial Differential Equations	Lecture	Vladimirsky	6	8	32	Fall 2005
620	Partial Differential Equations	Lecture	Wahlbin		3	12	Spring 2006
621	Measure Theory and Lebesgue Integration	Lecture	Rogers		7	28	Fall 2005
622	Applied Functional Analysis	Lecture	Sjamaar	6	7	28	Spring 2006
628	Complex Dynamical Systems	Lecture	Ilyashenko		2	8	Fall 2005
631	Algebra	Lecture	Dennis		13	52	Fall 2005
632	Algebra	Lecture	Chase		7	28	Spring 2006
634	Commutative Algebra	Lecture	Stillman		9	36	Fall 2005
650	Lie Groups	Lecture	Barbasch	2	7	28	Fall 2005
651	Algebraic Topology I	Lecture	Vogtmann		19	76	Spring 2006
652	Differentiable Manifolds I	Lecture	J. West	1	6	24	Fall 2005
653	Differentiable Manifolds II	Lecture	Sjamaar	5	10	40	Spring 2006
671	Probability Theory I	Lecture	Dynkin	1	12	48	Fall 2005
672	Probability Theory II	Lecture	Dynkin	7	15	60	Spring 2006
674	Introduction to Mathematical Statistics	Lecture	Hwang		11	44	Spring 2006
681	Logic	Lecture	Shore	3	4	16	Spring 2006
711	Seminar in Analysis	Seminar	Muscalu	1	3	12	Fall 2005
712	Seminar in Analysis	Seminar	Rogers	1	3	12	Spring 2006
717	Applied Dynamical Systems	Lecture	Guckenheimer	5	5	20	Spring 2006
731	Seminar in Algebra	Seminar	Ramakrishna	4	2	8	Fall 2005
732	Seminar in Algebra	Seminar	Michler	3	2	8	Fall 2005
735	Topics in Algebra	Lecture	Swartz	6	13	52	Fall 2005
735	Topics in Algebra	Lecture	Sen		4	16	Spring 2006
737	Algebraic Number Theory	Lecture	Sen	3	3	12	Fall 2005
739	Topics in Algebra	Lecture	Pantano	4	6	24	Spring 2006
751	Seminar in Topology	Seminar	Kassabov		4	16	Fall 2005
752	Seminar in Topology	Seminar	Riley	2	5	20	Spring 2006
755	Topology and Geometric Group Theory Seminar	Seminar	N/A		1	4	Fall 2005
756	Topology and Geometric Group Theory Seminar	Seminar	N/A		2	8	Spring 2006
757	Topics in Topology	Lecture	Thurston	8	5	20	Fall 2005
758	Topics in Topology	Lecture	Thurston		3	12	Spring 2006
761	Seminar in Geometry	Seminar	Hubbard	5	9	36	Fall 2005
762	Seminar in Geometry	Seminar	Hubbard		8	32	Spring 2006
767	Algebraic Geometry	Lecture	Testa	4	10	40	Spring 2006
771	Seminar in Probability and Statistics	Seminar	N/A		2	8	Fall 2005
772	Seminar in Probability and Statistics	Seminar	N/A		3	12	Spring 2006
774	Topics in Statistics	Lecture	Nussbaum		6	24	Fall 2005
777	Stochastic Processes	Lecture	Lawler	6	13	52	Fall 2005
778	Stochastic Processes	Lecture	Saloff-Coste	9	8	32	Spring 2006
781	Seminar in Logic	Seminar	Khoussainov	4	4	16	Fall 2005
782	Seminar in Logic	Seminar	Shore	7	5	20	Spring 2006
783	Model Theory	Lecture	Arslanov	3	10	40	Spring 2006
784	Recursion Theory	Lecture	Shore	1	6	24	Fall 2005
788	Topics in Applied Logic	Lecture	Khoussainov	3	7	28	Fall 2005
790	Supervised Reading and Research	Ind Stud	varies		15	87	Fall 2005
790	Supervised Reading and Research	Ind Stud	varies		20	100	Spring 2006

* The Department of Theoretical and Applied Mechanics shares in the teaching of engineering calculus and is accredited with 50% of the credit hours for MATH 190/191 in the fall and MATH 293 and 294 for the year; the remainder is accredited to Mathematics.

TOTALS	Courses	Enroll	Dept* Cr Hrs	Total Cr Hrs
Fall Semester	61	3,179	10,169	12,517
Spring Semester	65	2,718	9,103	10,549
Academic Year	126	5,897	19,272	23,066

Graduate Program

Cornell's Graduate Program in Mathematics has been ranked as one of the top ten in the country for many years. The Ph.D. program included 74 graduate students during the 2005–2006 academic year, including one non-degree student. Class representatives were:

- **Franco Saliola** (sixth and seventh year),
- **Henri Johnston** (fifth year),
- **Bradley Forrest** (fourth year),
- **Jonathan Needleman** (third year),
- **Ingvar Sigurjonsson** (second year),
- **Marisa Belk** (first year).

Treven Wall served as the graduate and professional student representative.

Graduate students play an essential role in all aspects of the department: teaching, research, mentoring of undergraduates, and community outreach programs.

Graduate Student Recruitment

The Mathematics Department was again awarded six one-year fellowships from the Graduate School. These fellowships were offered to the top-ranking applicants for their first year of study. Our goal remains to offer all of our students at least two years free of teaching duties. We will continue to work with the Graduate School towards this goal.

Mia Minnes, **Jennifer Biermann**, **Bastian Laubner**, **Gregory Muller**, **Joshua Bowman**, and **Gwyneth Whieldon** planned and executed a very successful Prospective Graduate Student Weekend March 3–5, 2006. All of the graduate students played a very important role in hosting and meeting with the visiting students. Nine prospective students attended the weekend activities, which included meetings with faculty and students, attending classes and lectures, and many special events. Everyone agrees that it is well worth the effort and resources. Four of the nine visiting students will join the Ph.D. program next year.

The entering class this fall will consist of fifteen new Ph.D. students. Seven students are entering with a one-year Graduate School fellowship:

- **Juan Alonso**, University of the Republic of Uruguay;
- **Mihai Bailesteanu**, University Bremen;
- **Mingzhong Cai**, Fudan University;
- **Igors Gorbovickis**, Moscow State University;
- **Kristine Jones**, University of Chicago;
- **Ho Hon Leung**, Imperial College London;
- **Benjamin Lundell**, University of Illinois.

The following seven students will be supported as teaching assistants:

- **Youssef El Fassy Fihry**, Ecole des Mines de Paris;
- **Yasemin Kara**, Bogazici University;
- **Samuel Kolins**, Bowdoin College;
- **Fatima Mahmood**, Union College;
- **Eyvindur Palsson**, University of Iceland;
- **Corinne Sheridan**, University of South Carolina,;
- **Paul Young**, Cornell University.

Santi Tasena from Chiang Mai University will attend on a scholarship from Thailand. We are pleased to welcome all of these students to the Ph.D. program.

The department will host one non-degree student for the academic year 2006–2007: **Thien Tam Tran** from University of Paris VII. Thien is participating in the Cornell Abroad program.

Graduate Student Awards

Guan-Yu Chen was awarded the 2006 Liu Memorial Award, established by friends and colleagues in memory of the late Professor Ta-Chung Liu and his wife. Awards are based on demonstrated academic ability and performance, with some consideration given to character and financial need. In keeping with the endowment, preference is given to students of Chinese descent regardless of citizenship.

The *Robert John Battig Graduate Prize* was awarded to **Sarah Koch** and **Andrei Maxim**. Recipients of the Battig Prize are graduate students in mathematics at Cornell who have passed the A exam (typically in their second year of study). Any such graduate student is eligible regardless of social or financial background. Sarah is a student of John Hubbard. Her research is in the area of complex dynamics. Andrei works with Lars Wahlbin in the area of numerical solutions of partial differential equations. They are both outstanding researchers and excellent students.

Hutchinson Fellowships were awarded to **Henri Johnston** and **Mauricio Velasco**, providing one semester of relief from teaching to allow them to work on their thesis problems. Established in 1947 by Genevra Barrett Hutchinson to honor her husband John Irwin Hutchinson and his long teaching career in the Mathematics Department, Hutchinson fellowships are awarded annually to mathematics graduate students who have done outstanding work as teaching assistants or as students in the graduate program. Accordingly, it is given to students who have completed three years of study and are not in their final year. Henri works with Ravi Ramakrishna in algebraic number theory, and Mauricio with Mike Stillman in the area of commutative algebra and effective algebraic geometry. Both students are outstanding researchers and instructors.

The *Eleanor Norton York Award* was awarded to **David Rothstein** in Astronomy and **Guan-Yu Chen** in Mathematics. The York Award was established by friends of Eleanor York, who died of cancer in 1993. Each year a student in the Mathematics Department and a student in the Astronomy Department, in which Eleanor was employed, are selected to receive this award. Recipients are chosen from those in the middle of their graduate education on the basis of their achievements to date to encourage them to have even more success in the future. Guan-Yu is a second-year student with Laurent Saloff-Coste.

The *Graduate Student Teaching Award* was presented to **Melanie Pivarski** and **Treven Wall** at the Mathematics Department's annual holiday party. Melanie is a seventh-year student working with Laurent Saloff-Coste, and Treven is a fifth-year student with Leonard Gross. (For more information, see page 19.)

Department Colloquia

Devoted to expository talks on current research areas, the Olivetti Club is organized entirely by graduate students, and most of the speakers are graduate students. **Joshua Bowman** and **Gregory Muller** served as organizers in the fall and **Timothy Goldberg** and **Matthew Noonan** organized talks in the spring. In addition, **Jeffrey Mermin** organized the Number Theory and Algebraic Geometry Seminar, and **Mia Minnes** and **Kristin Camenga** conducted the Teaching Seminar. In all, 30 graduate students gave 93 talks in department seminars this year. (See Department Conferences and Seminars for a list of talks, pp. 40–48.)

Preparing Future Faculty

The Preparing Future Faculty program continues to prepare graduate students for the professorate while attracting attention from outside administrative agencies. The College of Arts and Sciences Dean's Office provided funding for the program this year, and Dr. Maria Terrell served as director.

Cornell graduate students gave talks to mixed audiences of faculty and students at nearby colleges and universities, an experience that afforded participants the opportunity to talk about their work in ways that anticipate both professional meetings and job searches, while providing understandable and enjoyable colloquia for undergraduates in our region. The graduate student speakers were also able to see firsthand how faculty roles and student expectations at other campuses can vary widely from those here at Cornell. Graduate students **Edoardo Carta** and **Sarah Koch** coordinated the speakers' bureau.

Selected Talks

Kristin Camenga: *A tale of two proofs* (Hobart and William Smith College); *A new angle on Euler's formula* (Houghton College)

Matthew Noonan: *Our symmetric universe* (Wells College)

Jessica Zuniga: *Finite projective planes and straight lines* (Ithaca College)

Outreach Activities

Graduate students play a key role in the department's outreach activities. (See also Community Outreach, pp. 49–51.)

Kristin Camenga gave the talk *Making writing in mathematics instruction practical* at Cornell's Educator Professional Development Day and the Minnesota Council of Teachers of Mathematics Conference. She is also involved in the mentoring of new teaching assistants with **Melanie Pivarski**, **Mia Minnes**, and others.

Several graduate students gave talks at area schools during Mathematics Awareness Month. **Melanie Pivarski** gave an interactive talk at Newfield Middle School on binary numbers and codes to four classes, and **David Biddle** spoke to students at Chenango Forks High School about *Magic toruses and torus knots*. In addition, **Josh Bowman**, **Jeff Mermin**, and **Jonathan Needleman** gave talks at Dryden High School, while **Paul Shafer** gave a talk at Ithaca High School, and **Kristin Camenga** gave a presentation to fifth graders at Cayuga Heights Elementary School.

Expanding Your Horizons was organized and run by the following team of graduate students: **Jennifer Biermann**, **Benjamin Chan**, **Evgueni Klebanov**, **Jonathan Needleman**, and **Melanie Pivarski.** They worked with a group of 7th, 8th, and 9th grade girls in a workshop on combinatorial games. **Mia Minnes** and **Treven Wall** also participated in the planning.

Jeffrey Mermin, **Matthew Noonan**, and **Jay Schweig** organized the Ithaca High School Senior Seminar under the direction of Ed Swartz. The three graduate students led workshops on notions of infinity, voting issues, and ideas related to combinatorics and topology.

David Biddle, **Sarah Koch**, **Andrei Maxim**, **Radu Murgescu**, and **Jessica Zuniga** participated in Math Explorer's Club. The group explored various topics related to games and magic tricks, geometry, probability, and problem-solving strategies.

Other Graduate Student Activities

Graduate students were active in attending conferences and giving off-campus research presentations at meetings and specialized conferences. What follows is a small sampling of these activities:

David Biddle gave several talks, including *Using mathematics to help students explore their writing skills* at the MAA Seaway section's spring meeting; and *The homology of homotopy 2-types* at Binghamton University. He ran an independent Spectral Sequences seminar from the middle of June to the beginning of August 2005 for an audience of faculty, graduate students, and REU students and worked with an undergraduate on a research problem. David was also responsible for inviting Peter Hilton to give a special Oliver Club this spring and took care of many of the associated administrative duties.

Kristin Camenga was a TA for the Banff International Research Station Summer School *Computing the Continuous Discretely: Integer-point enumeration in polyhedra*. She participated in the SUNY Binghamton combinatorics seminar and gave the following talks: *Angle sums on polytopal complexes* and *A classification of secondary mathematics writing tasks* at the Joint Mathematics Meetings; and *Connecting Gram's relation for angle sums of polytopes to the Euler characteristic* at the University of Louisville.

Benjamin Chan attended the Spatial Ecology workshop of the Mathematical Biosciences Institute at Ohio State for a week. He will return this summer (2006) for their Summer Education program. Ben also did a little acting on the side; he performed in a skit at the Hong Kong Student Association's Cultural Show.

Melanie Pivarski attended the Northeast Probability Seminar in New York and gave the talk *Heat kernel asymptotics on Euclidean polytopal complexes* at the AMS/MAA joint meetings.

Artem Pulemotov gave a talk at the International Workshop on Operator Theory and Applications, University of Connecticut at Storrs.

Franco Saliola gave several talks at universities: *The face semigroup algebra of a hyperplane arrangement*, University of New Brunswick, MIT, University of British Columbia, and the Pacific Institute for the Mathematical Sciences; *Descent algebras via hyperplane arrangements*, UQAM; and *Hyperplane arrangements and Koszul algebras*, Syracuse University. He also gave the talk *Geometry and algebra associated to hyperplane arrangements* at a special session on discrete and computational geometry at the CMS Summer 2005 Meeting at the University of Waterloo.

John Workman attended the NSF FRG Conference on Interactions between Harmonic Analysis and Partial Differential Equations in Columbia, Missouri (March 2006) and will attend the ICM Satellite Conference on Harmonic and Geometric Analysis with Applications to Partial Differential Equations in Seville, Spain (August 2006). His joint work with Suzanne Lenhart, *An introduction to optimal control applied to immunology problems*, was presented by Lenhart in the AMS Short Course on Modeling and Simulation of Biological Networks at the Joint Math Meetings.

Graduate Student Publications

Kristin Camenga, *Vector spaces spanned by the angle sums of polytopes*, Beiträge zur Algebra und Geometrie (to appear).

Benjamin Chan and Richard Durrett, *A new coexistence result for competing contact processes*, Annals of Applied Probability (to appear).

Henri Johnston, *On the trace map between absolutely Abelian number fields of equal conductor*, Acta Arithmetica **122** no.1 (2006), 63–74.

Jeffrey Mermin and Irena Peeva, *Lexifying ideals*, Math. Res. Letters (to appear).

Paul Shafer, Timothy Isganitis, and Golan Yona, *Hubs of knowledge: using the functional link structure in Biozon to mine for biologically significant entities*, BMC Bioinformatics 7 no. 71 (2006).

Paul Shafer, David M. Lin, and Golan Yona, *EST2Prot: Mapping EST sequences to proteins*, BMC Genomics 7 no. 41 (2006).

S. Lenhart, V. Protopopescu, and **John Workman**, *Minimizing transient times in a coupled solid-state laser model*, Mathematical Methods in the Applied Sciences **29** no. 4 (2006), 272–286.

Doctoral Degrees — August 2005

Maria Belk

Applications of Stress Theory: Realizing Graphs and Kneser-Poulsen

M.S. Special (2002), Cornell University
B.A. (1999), Carleton College
Committee: Connelly, Billera, Stillman
First Position: Postdoc, Texas A&M University

Abstract: We use the ideas of stress theory and tensegrities to answer some questions in discrete geometry. In particular, we classify 3-realizable graphs, and we show some results related to the Kneser-Poulsen conjecture in hyperbolic space.

A graph is *d-realizable* if, for every configuration of its vertices in $\mathbb{E}_N$, there exists another corresponding configuration in $\mathbb{E}_d$ with the same edge lengths. A graph is 2-realizable if and only if it does not have K_4 as a minor. We show that a graph is 3-realizable if and only if it does not have K_5 or $K_{2,2,2}$ as a minor.

Kneser and Poulsen independently conjectured that the volume of the union of balls in Euclidean space will not decrease under an expansion. Csikós proved that this is true in Euclidean space under a continuous expansion, and Connelly and Bezdek proved it for the Euclidean plane (not necessarily a continuous expansion). It is still an open question for higher dimensions. The conjecture can also be stated for balls in hyperbolic space. Csikós proved that it is true under a continuous expansion in hyperbolic space, but it is still an open question for a non-continuous expansion in hyperbolic space. We show that the conjecture holds for 4 balls in 3-dimensional hyperbolic space.

Nathanael Berestycki

Phase Transitions for the Distance of Random Walks with Applications to Genome Rearrangements

D.E.A./Masters (2002), University of Paris 6
Maitrise/B.S. (2001), University of Paris 7
Committee: Durrett, Saloff-Coste, Lawler
First Position: Postdoc, University of British Columbia

Abstract: We study phase transition phenomena for the distance of random walks on graphs. In particular, we show how this question relates to the theory of random graphs and to stochastic processes of coalescence and fragmentation. This question is also intimately connected to some problems in genome rearrangement.

Lee Gibson

The Number of Sites Visited By a Random Walk on an Infinite Graph

M.S. Special (2002), Cornell University
M.S. (1999), University of Louisville
B.S. (1998), University of Kentucky
Committee: Saloff-Coste, Durrett, Brown, Lawler
First Position: Assistant professor, Univ. of Louisville

Abstract: The research contained in this dissertation develops the most specific knowledge to date regarding the logarithmic asymptotic behavior of the negative exponential moments of the number of sites visited by a random walk on an infinite graph. Due to the relationship between this quantity and the survival time of a random walk among i.i.d. Bernoulli traps at the vertices of the graph, the accomplishment is achieved by first adapting and then applying Sznitman's method of enlargement of obstacles to the graph context. For Cayley graphs of finitely generated groups with polynomial volume growth, it is shown that the upper and lower limits of the logarithmic quantity are bounded above and below, respectively, by the upper and lower limits of a variational formula on sets in the graph which balances the volume of the set and the least non-zero Dirichlet eigenvalue of the generator of the random walk restricted to the set. It is known that for the simple random walk on $\mathbb{Z}^d$, these upper and lower limits match to yield a precise limit, and progress is reported here regarding the possibility that these limits will also match for the Heisenberg group and others of similar nature.

Radu Haiduc

Horseshoes in the Forced van der Pol Equation

M.S./B.Sc. (1998), Babes-Bolyai University (Romania)
Committee: Guckenheimer, Vavasis, Ilyashenko
First Position: Associate at Credit Suisse First Boston

Abstract: The forced van der Pol equation was introduced in the 1920's as a model of an electrical circuit. Cartwright and Littlewood established the existence of invariant sets with complex topology in this system. This paper contains, for the first time, a full description of the nonwandering set for an open set of parameters near the singular limit of the forced van der Pol equation. In particular, we prove the existence of a hyperbolic chaotic invariant set. We also prove that the system is structurally stable. The analysis is conducted from the perspective of the geometric singular perturbation theory. Verifying the hypothesis is done by implementing self-validating numerical algorithms.

Spencer Hamblen

Lifting n-dimensional Galois Representations

B.S. (1998), Amherst College
Committee: Ramakrishna, Sen, Stillman
First Position: Postdoc, Queens University

Abstract: We investigate the problem of deforming n-dimensional mod p Galois representations to characteristic zero. Taylor and Ramakrishna have proven the existence of 2-dimensional deformations under certain conditions by allowing ramification at additional primes in order to annihilate a dual Selmer group. We use the same general methods to prove the existence of n-dimensional deformations.

We then examine under which conditions we may place restrictions on the shape of our deformations at p, with the goal of showing that under the correct conditions, the deformations may have locally geometric shape. We also use the existence of these deformations to prove the existence as Galois groups over Q of certain infinite subgroups of p-adic general linear groups.

Christopher Hardin

The Horn Theory of Relational Kleene Algebra

M.S. Special (2005), Cornell University, Computer Science
M.S. Special (2002), Cornell University, Mathematics
B.A. (1998), Amherst College
Committee: Kozen, Shore, Nerode
First Position: Visiting asst. professor, Smith College

Abstract: Kleene algebra arises in many areas of computer science. In particular, Kleene algebra with tests provides an algebraic way of representing and studying programs. When using Kleene algebra for this purpose, one generally wishes to restrict attention to algebras built from binary relations on some set of states, since they capture a common model for computation; such algebras are called relational Kleene algebras.

The equivalence of two programs, which is useful for verifying program correctness or compiler optimizations, can be expressed as an equation in Kleene algebra. The equational theory of relational Kleene algebra is already well understood, and decidable. One often needs to reason about programs under certain hypotheses about the semantics of individual program fragments, however, and this requires the use of Horn formulas.

We show that the Horn theory of relational Kleene algebra is Pi-1-1-complete (highly undecidable). We then exhibit special types of Horn formulas for which the complexity is much lower. We give an infinitary proof system for the Horn theory of relational Kleene algebra that is sound and complete, along with a closely related system that is sound and complete for the Horn theory of *-continuous Kleene algebras. Despite being infinitary, these systems have practical applications; in particular, we give new decidability results that follow from proof-theoretic arguments over the systems.

Todd Kemp

Hypercontractivity in Non-commutative Holomorphic Spaces

M.S. Special (2002), Cornell University
B.Sc. (Hon, 2000), University of Calgary
Committee: Gross, Saloff-Coste, Sjamaar, Hubbard
First Position: Escobar Assistant Professor, Cornell University

Abstract: In this dissertation, non-commutative holomorphic spaces $\mathbf{H}_q$ (for $-1 \le q \le 1$) are introduced. These spaces naturally generalize the algebra of entire functions (identified with $\mathbf{H}_1$) in the context of the q-Gaussian von Neumann algebras Γ_q of Bozejko and Speicher. A non-commutative Segal-Bargmann transform S_q — an isometric isomorphism

$$L^2(\Gamma_q) \to L^2(\mathbf{H}_q)$$

which commutes with the number operator N_q, and which canonically generalizes the classical Segal-Bargmann transform — is constructed. The following theorem, which is the main result, is proved: for even integers r, the semigroup generated by N_q is a contraction

$$L^2(\mathbf{H}_q) \to L^r(\mathbf{H}_q) \text{ precisely when } e^{-2t} \le 2/r.$$

This strong hypercontractivity theorem generalizes (a special case of) the complex hypercontractivity result of Janson to the algebras $\mathbf{H}_q$.

Antonio Montalban

Beyond the Arithmetic

M.S. Special (2002), Cornell University
B.S. (2000), Universidad de la Republica
Committee: Shore, Kozen, Nerode
First Position: Postdoc, University of Chicago

Abstract: Various results in different areas of Computability Theory are proved. First we work with the Turing degree structure, proving some embeddability and decidability results. To cite a few: we show that every countable upper semilattice containing a jump

operation can be embedded into the Turing degrees, of course, preserving jump and join; we show that every finite partial ordering labeled with the classes in the generalized high/low hierarchy can be embedded into the Turing degrees; we show that every generalized high degree has the complementation property; and we show that if a Turing degree a is either 1-generic and delta-zero-one, 2-generic and arithmetic, n-REA, or arithmetically generic, then the theory of the partial ordering of the Turing degrees below a is recursively isomorphic to true first order arithmetic.

Second, we work with equimorphism types of linear orderings from the viewpoints of Computable Mathematics and Reverse Mathematics. (Two linear orderings are equimorphic if they can be embedded in each other.) Spector proved in 1955 that every hyperarithmetic ordinal is isomorphic to a recursive one. We extend his result and prove that every hyperarithmetic linear ordering is equimorphic to a recursive one. From the viewpoint of Reverse Mathematics, we look at the strength of Fraïssé's conjecture. From our results, we deduce that Fraïssé's conjecture is sufficient and necessary to develop a reasonable theory of equimorphism types of linear orderings. Other topics we include in this thesis are the following: we look at structures for which Arithmetic Transfinite Recursion is the natural system to study them; we study theories of hyperarithmetic analysis and present a new natural example; we look at the complexity of the elementary equivalence problem for Boolean algebras; and we prove that there is a minimal pair of Kolmogorov-degrees.

Roland Roeder

Topology for the Basins of Attraction of Newton's Method in Two Complex Variables

M.S. Special (2003), Cornell University
B.A. (2000), University of California at San Diego
Committee: Hubbard, Smillie, Hatcher
First Position: Postdoc, Fields Institute

Abstract: In a recent paper, John H. Hubbard and Peter Papadopol study the dynamics of the Newton map, $N:\mathbf{C}^2 \to \mathbf{C}^2$, for finding the common zeros of two quadratic equations $P(x, y) = 0$ and $Q(x, y) = 0$. The map N has points of indeterminacy, critical curves, and invariant circles that are non-uniformly hyperbolic. Most of the work in their paper is spent resolving the points of indeterminacy of N, and creating a compactification of $\mathbf{C}^2$ in a way that is both compatible with the dynamics of N and that has "tame" topology. This part of their work requires two very technical tools called Farey blow-ups and real-oriented blow-ups. In a different direction, Hubbard and Papadopol show that the basin of attraction for each of the four common zeros of P and Q is path connected. However, most further questions about the topology of these basins of attraction remain a mystery.

The dynamics of N is much simpler if the common roots of P and Q lie on parallel lines, for instance when

$$P(x, y) = x(x-1) = 0 \text{ and } Q(x, y) = y^2 + Bxy - y = 0.$$

The first component of N depends only on x, while the second component depends on both x and y. Many of the complexities described by Hubbard and Papadopol disappear: one must still do an infinite sequence of blow-ups in order to make N a well defined dynamical system, but one can avoid the Farey blow-ups and the real-oriented blow-ups.

Let r_1 and r_2 be the roots in the line $x = 0$ and r_3 and r_4 be the roots in the line $x = 1$ and let $W(r_1)$, $W(r_2)$, $W(r_3)$ and $W(r_4)$ be the corresponding basins of attraction of under iteration of N after this infinite sequence of blow-ups has been performed. There is a symmetry exchanging r_1 with r_2 and exchanging r_3 with r_4, but for a given B the pair (r_1, r_2) behaves differently from the pair (r_3, r_4). More specifically, one pair "attracts" the points of indeterminacy of N, and the other does not. We consistently make the restriction that

$$B \in \Omega = \{|1 - B| < 1\},$$

which guarantees that the pair (r_1, r_2) attracts the points of indeterminacy.

We will prove that

$$H_1\left(\overline{W(r_1)}\right) \text{ and } H_1\left(\overline{W(r_2)}\right)$$

are infinitely generated for every $B \in \Omega$. There is an invariant circle within the line $x = 1$ that is super-attracting in the x-direction and hyperbolically repelling in the line $x = 1$. Let W_1 be the super-stable "manifold" corresponding to this invariant circle. For the values of $B \in \Omega$ for which W_1 intersects the critical value parabola $C(x, y) = 0$,

$$H_1\left(\overline{W(r_3)}\right) \text{ and } H_1\left(\overline{W(r_4)}\right)$$

are infinitely generated. For all other $B \in \Omega$,

$$H_1\left(W(r_3)\right) \text{ and } H_1\left(W(r_4)\right)$$

are trivial.

In addition, for the parameter values B that are not in the bifurcation locus — which is exceptional in the sense of Baire's Theorem — the statements above remain true if we replace the closures of the basins with the basins themselves.

Hasanjan Sayit
Realistic No Arbitrage Condition

M.S. Special (2004), Cornell University
Diplom (1998), Xinjiang University (China)
Committee: Protter, Durrett, Jarrow
First Position: Visiting assistant professor, University of Houston

Sergey Slavnov
Semantic Investigations of Linear Logic

M.S. Special (2004), Cornell University
Spetzialist (2000), Moscow State University
Committee: Nerode, Morley, Ilyashenko
First Position: Postdoctoral researcher, University of Ottawa Department of Mathematics and Statistics

Abstract: We consider semantics of Linear Logic, mainly of its multiplicative fragment. We construct a model, based on ideas of geometric quantization and semiclassical approximation, where formulas are interpreted as symplectic manifolds (phase spaces of physical systems), and proofs are interpreted as Lagrangian submanifolds (approximate localization of quantized systems in classical phase spaces). Physically this corresponds to the setting of semiclassical approximation of quantum mechanics. In our model we consider the extra structure of coherence (technically — a conic subset of the tangent bundle) on a symplectic manifold, which specifies a class of "coherent" Lagrangian submanifolds. Connectives of Linear Logic obtain very natural interpretation as operations on coherences. We show that the above category (category of coherent phase spaces) is a sound and complete in some strong sense model of the multiplicative fragment of Linear Logic. We also try to understand if our coherences and operations on them have any physical meaning.

In parallel we consider another model of the multiplicative fragment, where formulas are interpreted as compact oriented manifolds and proofs are interpreted as manifolds with boundary (bordisms or space-times). Similarly to the previous model we introduce coherences for bordisms, which allows us again to interpret logical connectives as very natural operations on coherences. Furthermore, this formalism, being essentially a generalization of the well-known formalism of proof-nets, allows us to formulate an alternative syntax of multi-dimensional proof-nets, uncovering a geometric meaning of multiplicative connectives of Linear Logic. Finally, following ides of topological field theory, we discover interesting connections between the two models.

In the last part of the dissertation we attempt to extend the symplectic interpretation to larger fragments of Linear Logic, namely to the exponential and the unital fragments. A correct generalization is the category of coherent prequantum spaces, based on prequantum, rather than symplectic, manifolds. Although the resulting model remains, in some aspects, heuristic, as far as the unital fragment is concerned, we obtain a completely rigorous new interpretation.

José Antonio Trujillo Ferreras
The Random Walk Loop Soup and the Expected Area of the Brownian Loop in the Plane

M.A. (2001), Duke University
Licenciado (1999), Universidad Autonoma de Madrid
Committee: Lawler, Durrett, Saloff-Coste
First Position: Research associate, ETH Zurich

Abstract: The Brownian loop soup introduced in [BLS] is a Poissonian realization from a σ-finite measure on unrooted Brownian loops. This measure is one of the important recent developments in a large program for understanding scaling limits in two dimensions. In this thesis, we present a random walk loop soup and show that it converges to the Brownian loop soup. The type of convergence that we establish is a strong approximation and makes use of a strong approximation result of the type derived by Komlós, Major, and Tusnády. A detailed proof of the variation of their result that we need is included.

We also study the following problem. Let B_t, $0 \le t \le 1$ be a planar Brownian loop (a Brownian motion conditioned so that $B_0 = B_1$). We consider the compact hull obtained by filling in all the holes, i.e., the complement of the unique unbounded component of $\mathbf{C} \setminus B[0,1]$. We show that the expected area of this hull is $\pi / 5$. We also use a result of Yor about the law of the index of a Brownian loop to show that the expected areas of the regions of index (winding number)

$$n \in \mathbf{Z} \setminus \{0\} \quad \text{are} \quad \frac{1}{2\pi n^2}.$$

As a consequence, we find that the expected area of the region of index zero inside the loop is $\pi / 30$. The proof uses the Schramm Loewner Evolution (SLE).

[BLS] Gregory F. Lawler and Wendelin Werner, *The Brownian loop soup*, Probab. Theory Related Fields **128** (2004), 565–588.

Russell Woodroofe
Shelling the Coset Poset

M.S. Special (2002), Cornell University
B.S. (1998), University of Michigan
Committee: Brown, Dennis, Billera
First Position: Teaching Assistant, Weill Cornell Medical College at Qatar

Abstract: It is shown that the coset lattice of a finite group has shellable order complex if and only if the group is complemented. It is also shown that the order complex is Cohen-Macaulay under the same circumstances. The group theoretical tools used are relatively elementary, and avoid the classification of finite simple groups and of minimal finite simple groups.

Doctoral Degrees — January 2006

Steven Morris
Four- and Six-Dimensional Nilmanifolds and Symplectic Forms

B.S. (1998), University of Oregon
Committee: Sjamaar, Hatcher, Kahn
First Position: Escobar Assistant Professor, Cornell University

Abstract: In this thesis we study four- and six-dimensional nilmanifolds using their associated rational Lie algebras and minimal models. We show that all four-dimensional nilmanifolds have symplectic structures. We then show that there exists a family of four-dimensional nilmanifolds, non-diffeomorphic to the Kodaira-Thurston manifold, which fibrate symplectically as torus bundles over tori. Using similar methods we also investigate which six-dimensional nilmanifolds possess symplectic structures. Our last result concerns symplectic torus actions. We show that the Duistermaat-Heckman function defined on a torus is a piecewise trignometric polynomial. We present examples of torus valued moment maps on a family of symplectic manifolds studied by Cordero, Fernandez and Gray.

Yan Zeng
Compensators of Stopping Times

M.S. Special (2004), Cornell University
B.Sc. (1999), Peking University
Committee: Protter, Durrett, Jarrow, Guo
First Position: Visiting assistant professor, University of Florida

Abstract: Let $\left(\Omega,\left(\mathscr{F}_t\right)_{t\geq 0},\mathscr{F},P\right)$ be a filtered probability space satisfying the usual hypotheses. Suppose τ is a stopping time and $N_t = 1_{\{\tau\leq t\}}$ is the associated point process. We consider when the Doob-Meyer decomposition of N has a compensator whose sample paths are a.s. absolutely continuous with respect to the Lebesgue measure. We prove a decomposition theorem which uniquely decomposes any totally inaccessible stopping time into two parts, such that one part has an absolutely continuous compensator and the other part has a singular compensator. We also characterize an absolutely continuous space, in which any totally inaccessible stopping time has an absolutely continuous compensator. A criterion of Ethier and Kurtz for the existence of an absolutely continuous compensator is extended, a corollary of which is that the absolute continuity of a compensator is preserved under filtration shrinkage.

We then define locally jumping filtrations and calculate the compensators of jump times. This result is applied to the filtration generated by a family of first passage times. Robustness of compensators is also considered in this specific setting. We then propose two formulations of filtration shrinkage and we prove they are different in general. After that, we calculate the compensators of first hitting times under various filtrations, including the natural filtration of a Hunt process or a semimartingale and the progressive expansion of shrunk filtrations. Finally, we conclude by a discussion of various computation methodologies for calculating compensators of stopping times.

Doctoral Degrees — May 2006

Jeffrey Abraham Mermin
Lexicographic Ideals

B.S. (2000) Duke University
Committee: Stillman, Peeva, Sen
First Position: Postdoc at the University of Kansas

Abstract: Macaulay proved in 1927 that every Hilbert function in the polynomial ring $R = k[x_1,\ldots,x_n]$ is attained by a lexicographic ideal. We study the combinatorial and homological properties of lexicographic ideals and identify other settings in which lexicographic ideals attain every Hilbert function and other classes of ideals with similar properties. We develop the theory of compression, which makes many of our arguments possible and leads to shorter new proofs of results of Macaulay, Bigatti, Hulett, and Pardue. Using compression, we extend results of Green and Clements-Lindstrom and prove a special case of Evans' Lex-Plus-Powers conjecture.

John Thacker
Properties of Brownian and Random Walk Loop Soups

M.S. Special (2005), Cornell University
B.S. (2001) Duke University
Committee: Lawler, Saloff-Coste, Durrett
First Position: Northrop Grumman IT TASC, Mathematician 4

Abstract: The Brownian loop soup introduced by Lawler and Werner is a Poissonian realization from a particular σ-finite measure on loops in $\mathbb{C}$. This measure satisfies conformal invariance and a restriction property. The random walk loop soup introduced by Lawler and Trujillo Ferreras is a realization from a similar measure on random walk loops in $\mathbb{C}$ and converges to the Brownian loop soup. In this dissertation, we present several results on Brownian loop soup and random walk loop soup. First, we show that the complement of the Brownian loop soup (i.e., the set of points not surrounded by any loop) has a Hausdorff dimension of $2-\lambda/5$, where λ is the intensity of the loop soup. Next, we extend the definitions of Brownian and random walk loop soup to arbitrary higher dimension and show that the random walk loop soup can also be considered a measure on continuous time random walk loops. We then give a strong approximation that shows that the random walk loop soup converges to the Brownian loop soup in any dimension, making use of the strong approximation result of Komlós, Major, and Tusnády.

Master of Science Special Degrees*

Effective January 2004

Hway Kiong Lim, Mathematics
B.S. (Hons) (1997), National University of Singpore
Committee: Hatcher, Barbasch, West

August 2005

David D. Biddle, Mathematics
M.A. (2002), SUNY at Binghamton
B.S. (2001), SUNY at Binghamton
Committee: Vogtmann, Hatcher, Brown, Henderson

Bradley T. Forrest, Mathematics
B.S. (2002), Harvey Mudd College
Committee: Vogtmann, Hatcher, Brown

January 2006

Nikolai Dimitrov, Mathematics
M.S. (2001), Sofia University
Committee: Ilyashenko, Sjamaar, Hubbard

Andrei Maxim, Mathematics
B.Sc. (2002), West University of Timisoara (Romania)
Committee: Wahlbin, Protter, Schatz

Radu Andrei Murgescu, Mathematics
B.A. (2002), Ohio Wesleyan University
Committee: Ramakrishna, Sen, Stillman

May 2006

Andrew W. Cameron, Mathematics
B.S./B.A. (2002), University of Virginia
Committee: Schatz, Vavasis, Wahlbin

Alimjon Eshmatov, Mathematics
B.A. (2003), National University of Uzbekistan
Committee: Sjamaar Barbasch, Berest

Timothy E. Goldberg, Mathematics
B.A. (2002), Bard College
Committee: Sjamaar, Speh, Berest

Mia Minnes, Mathematics and Computer Science
B.A./B.Sc.E. (2003), Queen's University
Committee: Nerode, Shore, Halpern, Kozen

Francesco Matucci, Mathematics
B.Sc. (2002), University of Firenze (Italy)
Committee: Brown, Vogtmann, Dennis

Matthew E. Noonan, Mathematics
B.A. (2003), Hampshire College
Committee: Hubbard, Thurston, Hatcher

* No thesis required.

Undergraduate Program

The Cornell undergraduate program in mathematics accepted 53 new majors in the academic year 2005–2006 and conditionally accepted 10 students, sustaining our program at 135 majors and 9 provisional majors just prior to commencement. Among these students are 65 double majors, 5 triple majors, 1 *quadruple* major, and 3 dual-degree Engineering students.

Receptions for Current and Prospective Majors

Fall and spring receptions were held shortly before the undergraduate pre-enrollment period to advertise our course offerings and highlight opportunities available to current and prospective majors. They began with some formal presentations followed by a chance to chat informally with faculty about courses planned for the following term. At the fall reception, John Hubbard gave brief "inspirational" presentations aimed at showing students that math is a vibrant field that is very much alive. Bob Strichartz discussed REU opportunities. Yulij Ilyashenko discussed the Math in Moscow program, and Ravi Ramakrishna spoke about the Budapest Semesters in Math program. Kasso Okoudjou spoke about the Math Modeling contest, while Dave Bock spoke about opportunities in education, and the Math Club president talked to students about the club. The program in the spring varied slightly. Recent participants **Kelly Bowen** and **Tom Church** talked about their experiences in the Budapest Semesters in Math Program and the Math in Moscow program, respectively. These receptions are useful as recruiting tools and may have played some positive role in the recent increase of our majors.

Student Feedback

In April, we held our first feedback session for majors to hear their thoughts on the strengths of our program and where we might make improvements. Attendance was small at this first meeting, about a dozen majors, but the students shared some valuable ideas with the majors committee. Three specific suggestions emerged:

- Require one course in geometry or topology for the mathematics concentration.
- Add some fast-track courses for students coming out of MATH 223–224. In particular, these students found MATH 413–414 repetitive and slow-moving.
- Offer a 1- or 2-credit 100-level "gems of math" course to entice students to major in mathematics. Engineering 150 would be a model for such a course.

In addition, twenty-seven majors completed an online survey. Responses were mainly positive. Students made the following requests:

- More computers in the library.
- Change the day of the Math Club talks.
- More courses in number theory and mathematical physics.
- Add an education concentration.
- Reduce the gap between honors and nonhonors courses.
- Offer more varied Math Club activities.

We hope to be able to report next year on our progress in implementing some of these ideas.

Kieval Lecture: Persi Diaconis

Persi Diaconis of Stanford University delivered a magical Kieval Lecture on September 14, 2005, to a mixed crowd that spilled out into the halls. Persi threw a deck of cards into the packed auditorium and asked an audience member to cut the deck and select a card, then pass the deck around the crowd until five people held cards. He then instructed the participants to stand up if they were holding a red card and correctly predicted what cards four out of five audience members were holding. The audience was impressed!

But Persi proceeded to break the first rule of magic: never reveal your secret. He explained that he had accurately guessed the cards using mathematical probability patterns with binary triples. Persi said this sequence is also found in random number generation, repeated measurement, and even robotic vision. It can also be used to manipulate DNA strand reading.

According to Persi, magic and math are similar. "For both," he said, "you're constantly solving problems under constraints. In magic, you want to solve a problem without the audience knowing how. In math, you need to solve problems following set rules." On the other hand: "Professors are treated with respect, but magicians may not be," he said. "It's a hard life."

In addition to his post at Stanford, Persi has served as a research staff member at AT&T Bell laboratories, a professor at Harvard, and he was Cornell's David Duncan Professor of Mathematics, 1996–1998. He has given many lectures at Cornell and is a very popular speaker.

Persi offered the following advice to the students in the audience: "When you're studying a subject, find another way to learn it [other than courses]," he said. "Get interested in something and just think about it. Learn about things you don't take classes in."

Undergraduate Mathematics Club

The undergraduate Mathematics Club, under the leadership of president **Peng Zhao '08**, organized a series of talks by Cornell faculty and a graduate student.

Allen Hatcher, *Symmetries of surfaces*

Craig Johnson, *Applications of number theory and groups in music*

Alexander Vladimirsky and **Kasso Okoudjou,** *Mathematical models: the good, the bad, and the ugly*

Reyer Sjamaar, *Differential equations and Lie's theory of continuous groups*

Robert Strichartz, Sarah Day, and **Edward Swartz,** *Summer research opportunities for undergraduates*

Daina Taimina, *Mysteries of the hyperbolic plane*

David Henderson, *What is straight?*

Matthew Noonan, *How to count*

Todd Kemp, *Random matrices, random graphs, and King Arthur's court*

Attendance at the talks averaged 20 people (and frequently more), primarily undergraduates but also faculty and graduate students. The Math Club also organized and supported the Kieval lecture and co-sponsored with the department a graduate school information session, two receptions for current and prospective majors, and a feedback session, followed by pizza and games.

Undergraduate Awards and Honors

The *Harry S. Kieval Prize in Mathematics* for 2006 was awarded to **Thomas Church** and **Wai Wai Liu.** The prize is named for Dr. Harry S. Kieval '36, a generous man who fervently believed in undergraduate education. He established the Kieval Prize in 1983 to provide an annual award for outstanding graduating senior mathematics majors, and upon his death in 1994 he left an endowment to support the continuation of the prize. The department's honors committee chooses the recipients on the basis of academic performance, the quality and variety of mathematics courses taken, and faculty recommendations.

Thomas Church is a student of Robert Strichartz. He spent the fall semester at the Independent University of Moscow under a Math in Moscow scholarship and wrote a senior thesis entitled *The Magnus Representation of the Torelli Group* $\mathcal{I}_{g,1}$ under the direction of Karen Vogtmann. Tom will attend graduate school in mathematics at the University of Chicago.

Wai Wai Liu is a student of Richard Shore. Wai Wai wrote his senior thesis, *The Logarithmic Sobolev Constant of Some Finite Markov Chains*, under Laurent Saloff-Coste and served as degree marshal for the College of Arts and Sciences in this year's commencement procession because he had one of the highest GPAs in the college. He will attend graduate school in statistics at Stanford University under a VIGRE fellowship.

Matthew LaBoda '06 was named a *Cornell Merrill Presidential Scholar*. Merrill Scholars are graduating seniors who have demonstrated outstanding scholastic achievement, strong leadership ability and potential for contributing to society. Matthew was also inducted into the Phi Beta Kappa Society, the nation's oldest and largest academic honor society.

Nicholas Flanders '08 was selected to study next year at L'Institut des Sciences Politiques, the renowned school of international relations and political science in Paris. Although he probably won't be doing much math there, it is a great honor. Nicholas is a double major in mathematics and economics with a concentration in international relations.

Peng Zhao '08 was awarded the Frank and Emily Wood Scholarship for Study Abroad during the 2006–2007 academic year. He will study mathematics and physics at Cambridge University in England.

Study Abroad

Four of our juniors and two seniors took advantage of Cornell's Study Abroad program this year, and two students went abroad over the summer. **Mark Steadman '07** spent the academic year at the University of Durham studying complex analysis and linear algebra. **Evan Marshak '07** spent the fall in Washington doing policy research as part of the Cornell-in-Washington program, and **Brian London '07** studied mathematics, Spanish, and Argentinian literature and culture in Argentina this spring.

In the fall, **Thomas Church '06** studied at the Independent University of Moscow (IUM) under a *Math in Moscow* scholarship. IUM is a small, elite institution of higher learning focusing primarily on mathematics. Discovering mathematics under the guidance of an experienced teacher is the central principle of the Math in Moscow program, which emphasizes in-depth understanding of carefully selected material rather than broad surveys of large quantities of material. The program provides a fifteen-week-long research experience for students (in the spirit of an REU, but with broader representation from the international community), with other mathematically talented and highly motivated undergraduates as well as some of the world's leading mathematicians. **Keith Thomas '07** and **Jia-Young Michae Fu '07** also participated in the Math in Moscow program in the spring.

In addition, **Shane Sniffen '07** went to Shanghai, China in summer 2005 on a grant from the Asian Studies Department to study Mandarin Chinese. **Margarita Echavarria '07** traveled to Russia during the summer, where she took a one-on-one E&M course and history course at Moscow State University.

Student Research and Activities

Last fall, a group of six undergraduate students, including **Alexandra Brodski '06**, **Margarita Echavarria '07**, **David Eisler '07**, **Katya Isichenko '06**, and **Peter Maceli '06** participated in a research and reading seminar (MATH 490) under the supervision of Prof. Yuri Berest. The aim of the seminar was twofold: (1) to learn some basic algebraic geometry and some of its applications and (2) to practice using computer algebra software in mathematical research. The main texts were M. Reid's book *Undergraduate Algebraic Geometry* and S. Coutinho's *A Primer on Algebraic D-modules*. Every student gave at least three (1.5 hour) presentations and worked out numerous homework problems (some of which were rather testing). In the end an attempt was made to find new examples of commuting differential operators related to higher genus curves ($g > 1$) with the help of *Mathematica* software. The students wrote an algorithm (and the actual computer code), which turned out to be quite efficient: essentially all examples known from the literature were verified, and in a few cases mistakes were spotted.

Shane Sniffen '07 did a project with a psychology professor (Shimon Edelman) on quantifying the learning rate of his natural language grammar-learning algorithm on Chinese relative to English and another with a neurobiology professor (Christiane Linster) on quantifying the degree of synchrony of neurons in a population (computational neuroscience).

Matthew Fontana '07 did an independent study project in dynamical systems with John Guckenheimer, resulting in a final paper (unpublished) titled *An exploration of the unforced FitzHugh Nagumo equations*. Matthew also wrote some MATLAB code for plotting the solutions to the dynamical system, which he reports was a good learning experience.

Rafael Frongillo '07 participated in the 2005 REU at Ithaca College. Professor David A. Brown led the project, which involved exploring the tip sets of fractal trees in 3 dimensions. The goal was to find conditions on the parameters of a tree for the tip set to be connected. The group found curves in the parameter space describing the trees with connected tip sets (mostly numerically, although with some exact results). In addition, Rafael personally found a family of trees that fill a box in n-dimensional space. The group's results will appear in the journal *Chaos, Solitons, and Fractals*. Rafael has also been coaching the Ithaca High School Math Team.

Sherry Wu '07 participated in an REU program at Williams College.

Thomas Church '06 participated in the 2005 Cornell REU under Tara Brendle, working on mapping class groups with Aaron Pixton. He continued his research during the spring semester under the supervision of Karen Vogtmann.

Last summer and continuing on into this year, **David Lawrie '07** was involved in biological research focusing on the evolution of transcription factor binding sites in humans and chimpanzees. More recently that work has involved creating a mathematical definition for radical changes in transcription factor binding sites.

Nikhil Revankar '07 participated in an REU program last summer at the University of Arkansas in the Department of Space and Planetary Sciences. He worked under the supervison of Dr. Julia Kennefick in the Department of Astronomy, and his work involved the recovery of classification of quasars with $3.0 < z < 3.5$ using an automated telescope in New Mexico that the university is looking to use in the future in the classroom. Nikhil collected images over a period of 45 days in blue, red, and green filters. After stacking the images together, he used software to obtain magnitudes, from which he was able to obtain two colors, namely B-V and V-R. Once plotted against each other, the quasars stood apart from the general stellar locus.

For one semester, **Matthew LaBoda '06** examined overfitting in machine learning, under Professor John Hopcroft. Overfitting in machine learning is a phenomenon where a computer trying to learn a task actually begins to perform less well as it gains information. The problem is that the machine begins to value the details of the specific examples too highly, rather than learning general patterns. Matthew tried to develop a simple two-dimensional model and corresponding learn algorithm such that overfitting was the only phenomenon of interest occuring in the experiment. The next step was to analyze the model to learn more about overfitting. Much to the surprise of both student and advisor, this proved to be very complicated, and there was insufficient time in the semester to fully analyze the results.

Junping Shao '06 studied nanotechnology, statistical physics, biochemistry, statistical thermodynamics, and biophysics while on leave in the fall through the University of Leiden's International Exchange program.

Putnam Competition

The 66th William Lowell Putnam Mathematics Competition was held on December 3, 2005. A total of 3,545 students from 500 colleges and universities in Canada and the United States participated, spending 6 hours (in two sittings) trying to solve 12 problems, such as this one:

> Show that every positive integer is a sum of one or more numbers of the form $2^r 3^s$, where r and s are nonnegative integers and no summand divides another. (For example, 23 = 9 + 8 + 6.)

One Cornell student, freshman Julius Poh, scored among the top 75 and received an honorable mention award. Four other Cornell students placed among the top 200, and five more in the next 300.

Cornell's team of sophomores — Anand Bhaskar, Hyun Kyu Kim, and Kun Hyong Kim — was ranked 20th nationally. (Team rank is based on the sums of the individual ranks, not scores, of the team members.) A three-person team must be chosen well in advance for the competition, and like those at many universities, our team consisted of the three highest scorers from the previous year.

The Putnam committee tried some innovative methods during the fall semester weekly Putnam preparation sessions. Particularly well received were guest sessions by Prof. Greg Lawler (who had coached a 1st place Putnam team from Duke in the mid nineties) and graduate student Pavel Gyrya who had been among the top 25 in a recent competition. Students also greatly appreciated the department's financial help in purchasing a problem book. Interestingly, many of our students expressed enthusiasm for an open team selection competition early in the fall. This will be brought to the attention of the next Putnam committee.

Mathematical Contest in Modeling

The Mathematical Contest in Modeling (MCM) is an international team competition, in which each team of three undergraduates chooses one of two open-ended "real-world" problems, builds a mathematical model, obtains a solution based on it, and writes a detailed paper proving the feasibility of the team's model and solution, all in less than four days. This year MCM attracted 748 submissions from 9 countries. Four teams represented Cornell, and the solutions of two of them were designated meritorious (thus placing them in the top 15% of participants). The first team was formed by Eric Angle, Ian Duke, and Philip Owrutsky, who also submitted a meritorious solution in the previous year. Matthew Naides, Jeff Parker, and Edgar Peralta formed the second meritorious team. More information about Cornell's participation in MCM is available at www.math.cornell.edu/~mcm. This year's problems are described at www.comap.com/undergraduate/contests/mcm/contests/2006/problems/.

Senior Theses

Three graduating majors submitted senior theses this year. They will be added to the Mathematics Library's collection of senior theses.

Thomas Franklin Church (joint with Aaron Pixton)
The Magnus Representation of the Torelli Group $\mathcal{I}_{g,1}$
Supervisor: Karen Vogtmann

Abstract: The Magnus representations r_k are defined on the Johnson filtration of the mapping class group. We focus on $r_2 : \mathcal{I}_{g,1} \to \mathrm{GL}_{2g}(\mathbb{Z}[H])$, where $\mathcal{I}_{g,1}$ is the Torelli subgroup of the mapping class group and $H = H_1(S_{g,1})$ is the first homology of the surface. After restricting r_2 to the Johnson kernel $\mathcal{K}_{g,1}$, we classify all relations between pairs of Dehn twists in the image.

Wai Wai Liu, *The Logarithmic Sobolev Constant of Some Finite Markov Chains*
Supervisor: Laurent Saloff-Coste

Abstract: We prove the log-Sobolev constant α of the simple random walk on the 5-cycle and the spectral gap λ satisfy $\alpha = \lambda / 2$, and show some examples on the 3-point space with the exact value of α found.

Philip Daniel Owrutsky, *Orthogonal Polynomials with Respect to Self-Similar Measures*
Supervisor: Robert Strichartz

Bachelor of Arts Degrees

Bachelors' degrees in mathematics were awarded to 54 students this year, including one in August and seven in January. This graduating class was outstanding. We had two Kieval winners this year. Honors were awarded to 18 students:

- Thomas Church and Wai Wai Liu graduated summa cum laude.
- Prakash Balachandran, Philip Owrutsky, and Navin Sivakumar graduated magna cum laude.
- Dionysios Anninos, Jonathan Bergknoff, Jason Chlipala, Yuantian Leslie Huang, Nabil Iqbal, Max Kaplan, Matthew Kaschalk, Matthew LaBoda, Jay Lu, Peter Maceli, Jessica Nadel, Yash Parghi, and Noah Spies graduated cum laude.

At least 25 of our graduates are going on to graduate school in mathematics, physics, biology, computer science, economics, and statistics at Yale, Stanford, Chicago, Columbia, Harvard, MIT, Cornell, and other top schools. Following is a list of students awarded a Bachelor of Arts in mathematics at Cornell this year.

August 2005

Eli Terry Brown

January 2006

Andrew Justin Butts
Max Isaac Kaplan,† *Cum Laude in Mathematics*
Peter Lawson Maceli, *Cum Laude in Mathematics*
Jason Robert Neuswanger
Elizabeth Elaine Smoot,† *Magna Cum Laude in Archeology*
Sunghwan Austin Yi†
John Ligeng Zhang

May 2006*

Dionysios Theodoros Anninos,† *Cum Laude in Mathematics* and *Summa Cum Laude in Physics*
Quinn Allen Arntsen
Prakash Balachandran,† *Magna Cum Laude in Mathematics* and *Cum Laude in Physics*
Angela Susan Barclay
Jonathan Ariel Bergknoff,† *Cum Laude in Mathematics*
Joseph James Boccuzzi
Kelly Lynn Bowen
Dwayne Craig Bowles
Alexandra Brodski, *Cum Laude in Economics*
Zachary Callaghan Burns
Daniel Abraham Carlton
Jason Chlipala,† *Cum Laude in Mathematics*
Thomas Franklin Church,† *Summa Cum Laude in Mathematics* and *Kieval Prize in Mathematics*
William Alden Cross
Zachary Alexander Fischer†
Daniel Goldburt
Michael Colin Henderson
Michael B Holzwarth
Yuantian Leslie Huang,† *Cum Laude in Mathematics*
Nabil Iqbal,† *Cum Laude in Mathematics* and *Summa Cum Laude in Physics*
Yekaterina Isichenko
Christopher Arthur Kakovitch
Matthew Stephen Kaschalk,† *Cum Laude in Mathematics*
Paul Brian Kelleher
Benjamin Lewis Kirk
Gregory Jackson Konover
Matthew Allen LaBoda,† *Cum Laude in Mathematics* and *Summa Cum Laude in Computer Science*
Wai Wai Liu,† *Summa Cum Laude in Mathematics* and *Kieval Prize in Mathematics*
Jay Lu,† *Cum Laude in Mathematics*
Yulia Mikhaylova
Patrick Elliot Mutch
Caitlin Jean Myles
Jessica Shannon Nadel,† *Cum Laude in Mathematics*
Philip Daniel Owrutsky,† *Magna Cum Laude in Mathematics*
Oya Paksoy†
Yash Ajay Parghi,† *Cum Laude in Mathematics*
Esther Polevoy, *Cum Laude in Astronomy*
Austin Sands
Navin Sivakumar,† *Magna Cum Laude in Mathematics*
Noah Walter Benjamin Spies,† *Cum Laude in Mathematics*
Michael Allen Taylor
Matthew David Thomas
Thitidej Tularak
Kevin Patrick Wallace†
Ann Karen Zatsman
Jeffery Zhang

* Students who completed their degree requirements by May 28, 2006 may yet be added to the May 2006 degree list.

† Distinction in all subjects

2005 Research Experiences for Undergraduates Program

The Department of Mathematics has run a Research Experiences for Undergraduates (REU) Program, sponsored by the National Science Foundation, every summer since 1994. This program brings talented students here from across the country to work on research projects directed by Cornell faculty members.

A lively and productive group of fifteen students battled with challenging problems and made many interesting discoveries in the following areas:

- Analysis on Fractals — directed by program director **Robert Strichartz** and assisted by graduate student **Jessica Zuniga**;
- Mapping Class Groups and Topology of Surfaces — directed by **Tara Brendle** and assisted by graduate student **Heather Armstrong**;
- Expander Graphs and Groups — directed by **Martin Kassabov** and assisted by graduate student **Francesco Matucci**.

Two of the student participants came with funding from their home colleges, and our department supported one student. Many of the students will continue to work on their projects, and several papers reporting the results are in the works.

Analysis on Fractals

The fractals group arrived a week early to attend the Conference on Analysis and Probability on Fractals for a crash course on the subject and a quick glimpse of some of the accomplishments of previous groups of REU students who have been working in this area since 1996. With this head start, they were able to jump into work on four topics.

Continuing work done by REU students from 2003, **Carlos Avenancio-Leon** (U. of Puerto Rico-Humacao) studied local properties of harmonic functions on the Sierpinski gasket (SG) in a neighborhood of a periodic point, covering the case when a certain matrix has complex conjugate eigenvalues.

Jonas Azzam (U. of Nebraska-Lincoln) and **Michael Hall** (U. of Maryland) began work on understanding the analog of conformal geometry in the fractal setting. They were able to compute the spectrum of some conformal Laplacians on SG and found a very beautiful differential equation satisfied by effective resistances for conformal energies. This differential equation involves energy measures, so their work turned in another direction and led to an interesting linear algorithm for computing these measures. (The definition involves quadratic expressions.)

Mihai Cucuringu (Hiram College) studied an infinitesimal version of the effective resistance metric on SG. He was able to construct and analyze a dynamical system that models this problem, and so prove existence and find an algorithm to compute this metric. He also studied a related problem, how to describe all self-similar energies on SG. C. Sabot solved this problem in 1997 in a long paper with a very complicated solution. Mihai showed that by adding some twists to the definition of self-similarity, the solution becomes much simpler.

Tyrus Berry (U. of Virginia) worked on a new approach to computing the spectrum of a fractal Laplacian called "outer approximation." The idea is to approximate the fractal by a sequence of domains in the plane that contain it, and then take a renormalized limit of the spectra of the ordinary Laplacians on the domains. Along the way, Tyrus made a remarkable serendipitous discovery. While looking at the eigenfunctions of the Laplacian on a rather simple sawtooth-shaped domain (approximating an interval), he noticed that some of them appeared to be highly localized to one of the teeth, and close to zero on the other teeth. (Of course, it cannot be identically zero.) The existence of localized eigenfunctions of fractal Laplacians has been one of the surprising features of the theory. It is interesting that it spills over to ordinary Laplacians on domains that are very far from being fractal.

Mapping Class Groups and Topology of Surfaces

Tara Brendle's group worked on three different projects, all related to the Torelli group of a surface (the subgroup of the surface mapping class group acting trivially on homology) and a certain subgroup of Torelli known as the Johnson subgroup.

Two students — **Thomas Church** (Cornell) and **Aaron Pixton** (Princeton) — studied the Magnus representation of the Torelli group. In particular, they generalized and gave new proofs of some results of Suzuki that interpret the Magnus representation topologically in terms of "higher intersection forms" on the relative homology of the universal abelian cover of a surface. Their results appear to give a new abelian quotient of the Johnson kernel, whose abelianization is currently unknown.

Three other students worked on another homomorphism of the Torelli group known as the Birman-Craggs-Johnson homomorphism. **Tova Brown** (UC Santa Cruz) worked on finding a new topological characterization of the kernel of this map. **Peter Maceli** (Cornell) and **Vijay Ravikumar** (Amherst College) studied the action on second homology groups induced by the BCJ map, in particular using the method of abelian cycles. This yielded an improvement on known lower bounds for the rank of the second homology of the Torelli group. Vijay also studied the cokernel of this induced map, suggesting a new characterization of elements "missed" by the abelian cycles method.

Expander Graphs and Groups

Finite graphs with nice properties like symmetry, low diameter, and high connectivity have many applications. Such graphs are called expanders and they are often used as basic building blocks of various computer and communication networks. Typically one is looking for graphs with many vertices (large networks), and as few edges as possible (low cost).

The students — **Mihai Cucuringu** (Hiram College), **Alina Florescu** (Mount Holyoke College), **James Davis** (North Carolina State), **John Hegeman** (Stanford), **Hyun Kyu Kim** (Cornell), and **Lauren Susoeff** (Beloit College) — worked together on several projects using various methods from group theory to construct and study interesting examples of finite graphs.

One of the projects focused on studying the diameters of Cayley graph. The students learned many combinatorial tools and successfully applied them to several problems. The work on this project led to fast algorithms for finding short paths in some Cayley graphs of finite simple groups. These algorithms are likely to be used in many practical applications of these graphs in theoretical computer science.

Another project was aimed at understanding the Kazhdan constants of finite groups with respect to different generating sets. The project started with a mini-course in representation theory. The students not only understood several recent results, but they were also able to generalize a theorem of Alon-Roichman about existence of small expanding generating sets in groups.

Summer 2006

The REU program continues in summer 2006 with projects in analysis on fractals (Robert Strichartz), dynamical systems (Sarah Day), and geometric combinatorics (Ed Swartz).

Department Conferences and Seminars

Summer School in Probability

July 10-22, 2005

The first Cornell Summer School in Probability was held July 10–22, 2005, sponsored by a National Science Foundation grant through Cornell University. Three main speakers — Richard Durrett (Cornell), Jean Francois Le Gall (Paris), and Russell Lyons (Indiana) — each gave a nine-hour mini-course. In addition, participants gave many research talks. The majority of the 100 participants, including 80 nonCornellians, were graduate students, post-docs, or other junior faculty. See www.math.cornell.edu/~durrett/CPSS2006/ for news of the second summer school, held June 26–July 7, 2006.

Chelluri Lecture Series

April 6, 2006

The Chelluri Lecture Series is offered in memory of Thyagaraju (Raju) Chelluri, a brilliant student, a gifted scholar and a wonderful human being who died on August 21, 2004 at the age of 26. Raju graduated magna cum laude from Cornell in 1999 with a B.A. in mathematics and was awarded a Ph.D. posthumously from Rutgers University.

Dan Goldston of San Jose State University gave the inaugural lecture, *Are There Infinitely Many Twin Primes?* Twin primes are pairs of primes that differ by 2. Thus the first five pairs of twin primes are: 3 and 5, 5 and 7, 11 and 13, 17 and 19, and 29 and 31. Are there infinitely many twin primes? And can we prove it? This talk provided a convincing answer to the first question. As for the second question, up to now proofs have never been in sight, but recent work of the speaker with Pintz and Yildirim has maybe changed this situation. At present their method, while not producing twin primes, is able to prove that there are pairs of primes very close together compared to the average distance between consecutive primes. This talk explained their knowledge of twin primes and discussed the new method in a fairly non-technical fashion.

The lecture series opened with a public reception in Malott Hall's faculty lounge. Following the lecture, family, invited guests, and members of the department gathered at the Hilton Garden Inn for a special dinner and jazz performance.

Stochastic Models in Cell Biology

April 9-11, 2006

The workshop focused on stochastic models for chemical reaction networks arising in cellular processes, and the goal was to discuss participants' ongoing work and identify the main concerns for future direction in the area. Invited lecturers included:

- Gheorghe Craciun, University of Wisconsin;
- Dan Gillespie;
- Jonathan Mattingly, Duke University;
- Tom Kurtz, University of Wisconsin;
- Linda Petzold, U. C. Santa Barbara;
- Lea Popovic, Cornell University;
- Mike Reed, Duke University;
- Greg Rempala, University of Louisville.

Sophus Lie Days at Cornell

April 22-23, 2006

Familiarity with the basic principles and results of Lie theory is profitable for many mathematics and science students. For this reason, Professors Dan Barbasch, Yuri Berest, Tara Holm, Ravi Ramakrishna, Reyer Sjamaar, and Birgit Speh organized the first *Sophus Lie Days at Cornell*, a 2-day conference for undergraduate and graduate students, and invited students not only from mathematics but also from the natural sciences and applied mathematics.

The speakers — Eugene Dynkin (Cornell), Alexander Veselov (Loughborough University, U.K.) and Roger Howe (Yale) — presented an introduction to Lie theory and its applications to differential equations and physics to about 40 students from Cornell and a few from Syracuse. *Sophus Lie Days* is intended to become an annual event with increased attendance by students from other universities in the Northeast. The provost funded this year's conference. Future support is being sought through an NSF Research Training Grant (pending approval).

Mini-workshop on Mathematics of Schramm-Loewner Evolution and Loop Measures

May 5-6, 2006

This was one of the "hot topics" workshops sponsored by a special NSF grant to the probability group at Cornell. The workshop was opened by an introductory talk given by Greg Lawler as part of the Oliver Club. Research lectures were given by:

- Chuck Newman, Courant Institute;
- Robert Bauer, University of Illinois at Urbana;
- Scott Sheffield, Courant Institute;
- Nam-Gyu Kang, MIT;
- Michael Kozdron, University of Regina;
- John Cardy, Oxford University;
- Denis Bernard, SACLAY, Paris;
- Vincent Beffara, ENS Lyons;
- Steffen Rohde, University of Washington;
- Bertrand Duplantier, SACLAY, Paris.

Cornell Topology Festival

May 18-21, 2006

The topology/geometry group of the Mathematics Department hosted the forty-fourth annual Cornell Topology Festival this year. Now an internationally known event, the festival was founded by Paul Olum in 1963 as a small regional conference that celebrated the return of spring and reviewed the outstanding results in topology during the preceding year. The subject of topology has exploded in the intervening years, and the festival now covers a broad spectrum of topics.

The 2006 festival featured eleven one-hour invited talks, a table for preprints, and much opportunity for conversation. Several speakers were selected from a special area of emphasis, *algebraic topology and its applications*, and Gunnar Carlsson and Jesper Grodal gave workshop lectures in this area. In addition, the speakers held a panel discussion on recent developments in topology. Notes on the panel discussion are posted on the Festival web page, at www.math.cornell.edu/~festival.

Social activities included an opening reception, a banquet at an Italian restaurant, two working luncheons, and a picnic featuring lamb roasted over an open barbeque pit. Travel grants were available to young mathematicians, women and minorities, and a significant number took advantage of these. Ninety-six mathematicians attended the festival.

This year's featured speakers and their talk titles were:

Noel Brady, University of Oklahoma: *Perron-Frobenius eigenvalues, snowflake groups and isoperimetric spectra*
Gunnar Carlsson, Stanford University: *Algebraic topology and high dimensional data*
Thomas Farrell, Binghamton University: *Some applications of topology to geometry*
Soren Galatius, Stanford University: *Stable homology of automorphisms of free groups*
Robert Ghrist, University of Illinois at Urbana-Champaign: *Homological sensor networks*
Jesper Grodal, University of Chicago: *From finite groups to infinite groups via homotopy theory*
Maurice Herlihy, Brown University: *Topological methods in distributed and concurrent computing*
Tara Holm, Connecticut and Cornell University: *Orbifold cohomology of abelian symplectic reductions*
Martin Kassabov, Cornell University: *Kazhdan property T and its applications*
Lee Mosher, Rutgers University: *Axes in outer space*
Nathalie Wahl, University of Chicago: *Mapping class groups of non-orientable surfaces*

The forty-fifth Cornell Topology Festival is planned for May 2007.

Summer Math Institute

June 17-August 6, 2006

The Summer Mathematics Institute at Cornell is a seven-week program aimed at strengthening the backgrounds of undergraduates from underrepresented groups (e.g., women and minorities). Ten strong students, mostly juniors, who have all expressed an interest in continuing in mathematics, will participate in SMI 2006. Their home institutions range from Agnes Scott College to the University of the Virgin Islands.

Coursework will include a rigorous analysis course at the level of MATH 413-414, usually not available at the students' home institutions. Taught by Sharad Goel, a 2005 CAM Ph.D, this course will help prepare them to succeed in standard first-year courses when they enter a graduate program. Emilia Huerta-Sanchez and Erik Sherwood will support this course as teaching assistants. Students will also work in groups on research projects in *Dynamical Systems and Neurobiology* and *Random Graphs and Algorithms* under the direction of CAM graduate students Joe Tien and Yannet Interian.

The idea for SMI was conceived by graduate students in the Center for Applied Mathematics. The effort was bolstered by the involvement of several faculty members in CAM and Mathematics, including Ken Brown, Rick Durrett, John Guckenheimer, Ravi Ramakrishna, Steve Strogatz, and Maria Terrell. SMI 2006 is supported by the Sloan Foundation (1/3), the Provost (1/3), the Mathematics Department (1/6), and the Engineering Dean (1/6). Ravi Ramakrishna and Steve Strogatz are co-directors.

Algebraic Geometry Seminar

All speakers are from Cornell unless otherwise indicated.

September 2005

Steven Sinnott: *Ideals and varieties*
Jeffrey Mermin: *The Zariski topology*
Zachary Scherr: *Monomial orderings and Gröbner bases*

October 2005

Steven Sinnott: *Gröbner bases*
Jeffrey Mermin: *Regular functions and morphisms*
Jeffrey Mermin: *Rational functions*

November 2005

Steven Sinnott: *Dimension theory* (in two parts)
Zachary Scherr: *Projective space*
Steven Sinnott: *New varieties from old*

February 2006

Jeffrey Mermin: *Compression*
Steven Sinnott: *Algebraic geometry, Bayesian networks, and phylogenetic trees*

March 2006

Achilleas Sinefakopoulos: *Cellular resolutions of powers of the maximal ideal*

April 2006

Jeffrey Mermin: *The Eliahou-Kervaire resolution is cellular*
Susan Cooper, Syracuse University: *The lex-plus-powers conjecture for points*

Analysis Seminar

September 2005

Todd Kemp, Cornell University: *Log-subharmonic functions and hypercontractivity*
Camil Muscalu, Cornell University: *A simple proof of Coifman-Meyer theorem*
Brett Wick, Vanderbilt University: *Bounded analytic projections and the Corona problem*
Robert Strichartz, Cornell University: *Spectral properties of Laplacians on Euclidean domains and fractals*

October 2005

Laurent Saloff-Coste, Cornell University: *Lie groups with property RD*
Brian Hall, Notre Dame University: *Analytic continuation and cancellation of singularities*
Christoph Thiele, UCLA: *Carleson's theorem and applications to scattering and ergodic theory*
Mauro Maggioni, Yale University: *Diffusion wavelets for multiscale analysis on manifolds and graphs: constructions and applications*

November 2005

Gady Kozma, Institute for Advanced Study: *Analytic uniqueness theory*
Dmitri Beliaev, Institute for Advanced Study: *Harmonic measure on random fractals*
Kasso Okoudjou, Cornell University: *Unimodular Fourier multipliers*
P. Batchourin, Princeton University: *Multidimensional dispersing billiards: singularity manifolds and the fundamental theorem*

December 2005

Melanie Pivarski, Cornell University: *Heat kernel asymptotics on Euclidean polytopal complexes*

January 2006

Todd Kemp, Cornell University: *A new Haagerup inequality for the free group*

February 2006

Artem Pulemyotov, Cornell University: *Maximum principles for parabolic systems*
Xiaodong Cao, Columbia University: *The Ricci flow on manifolds with positive curvature operator*
Robert Strichartz, Cornell University: *Energy forms on the Sierpinski gasket*
Luke Rogers, Cornell University: *Two proofs of a Borel-type theorem on the Sierpinski gasket*

March 2006

Jean Steiner, New York University: *Hide-and-seek and spectral invariants on surfaces and Markov chains*
Ioan Bejenaru, UCLA: *On Schrödinger maps*
Stefan Kroemer, University of Augsburg: *Nonconvex variational problems with radial symmetry*
Laurent Saloff-Coste, Cornell University: *Ultracontractivity and embedding property from Markov semigroups*

April 2006

Piotr Hajlasz, University of Pittsburgh: *Sobolev extensions and restrictions*

Alex Powell, Vanderbilt University: *The Balian-Low uncertainty principle: sharpness, non-symmetry, and other extensions*
Natasa Pavlovic, Princeton University: *On a periodic nonlinear Schrödinger equation*
Diego Maldonado, University of Maryland: *A geometric approach to the Monge-Ampere equation and applications*

May 2006
Jani Onninen, Syracuse University: *Deformations of finite energy*
Dominique Bakry, Université Paul Sabatier: *From Log-Sobolev inequalities to Li-Yau's parabolic Harnack ones*

Commutative Algebra and Algebraic Geometry Seminar

All speakers are from Cornell unless otherwise indicated.

September 2005
Damiano Testa: *Rationally connected varieties - examples, really!*
Damiano Testa: *Irreducibility of some mapping spaces*

October 2005
John Hubbard: *Brauer-Severi varieties and the Brauer group*
Mauricio Velasco: *Mori's bend-and-break lemmas*

November 2005
Mauricio Velasco: *Fano varieties are covered by rational curves*
Greg Muller: *The irreducibility of the moduli space of curves*

January 2006
John Hubbard: *Rings of integers in number fields and the etale topology* (in two parts)

February 2006
John Hubbard et al: *Further topics on the etale topology of number fields*
Michael Stillman: *Computing sheaf cohomology* (in two parts)

March 2006
Damiano Testa: *The Brauer group of* Q_p
Yuri Berest: *An invitation to noncommutative projective geometry*

April 2006
Mauricio Velasco: *Cox rings for del Pezzo surfaces*

Computational and Commutative Algebra Seminar

September 2005
Mauricio Velasco, Cornell University: *New monomial ideals associated to finite simplicial complexes*
Mauricio Velasco, Cornell University: *Does every minimal monomial free resolution admit a cellular structure?*

February 2006
Jeffrey Mermin, Cornell University: *Compression* (in two parts)
Mauricio Velasco, Cornell University: *Minimal monomial ideals*
Michael Stillman, Cornell University: *Computing sheaf cohomology*

March 2006
Achilleas Sinefakopoulos, Cornell University: *Borel ideals* (in two parts)

April 2006
Mauricio Velasco, Cornell University: *CW-resolutions*
Steven Sinnott, Cornell University: *Algebraic statistics*
Susan Cooper, Syracuse University: *The Eisenbud-Green-Harris conjecture*
Jeffrey Mermin, Cornell University: *A cellular structure on the Eliahou-Kervaire resolution*

May 2006
Steven Sinnott, Cornell University: *Bayesian networks and computational algebra*

Discrete Geometry and Combinatorics Seminar

September 2005
Cilanne Boulet, Cornell University: *A combinatorial proof of the Rogers-Ramanujan and Schur identities*
Bridget Tenner, MIT: *Reduced decompositions and permutation patterns*
Louis Billera, Cornell University: *Identities on ribbon Schur functions and Littlewood-Richardson coefficients*

October 2005
Helge Tverberg, University of Bergen: *Glimpses of an ongoing long story, starting with Radon's theorem*
Richard Ehrenborg, University of Kentucky: *Counting pattern avoiding permutations via integral operators*
Etienne Rassart, Cornell University: *A chamber complex for Kostka numbers*
Drew Armstrong, Cornell University: *Partial orders on Coxeter groups*

November 2005

Franco Saliola, Cornell University: *Left regular bands in combinatorics*

Christopher Hanusa, Binghamton University: *A Gessel-Viennot-type method for counting disjoint unions of cycles in a graph*

January 2006

Danh N. Tran: *On Kruskal-Katona type theorems for integer vectors*

February 2006

Megan Owen, Cornell University: *Combinatorics in information theory*

Todd Kemp, Cornell University: *Partitions, central limit theorems, and free probability*

Todd Kemp, Cornell University: *Free cumulants and the lattice of non-crossing partitions*

March 2006

Kenneth Brown, Cornell University: *Buildings as metric spaces*

Kristin Camenga, Cornell University: *Complexes with alternating angle sums half the Euler characteristic*

Louis Billera, Cornell University: *A quasisymmetric function for matroids*

Francesco Brenti, University of Rome: *Diamonds, Kazhdan-Lusztig polynomials, and Hecke algebra representations*

April 2006

Isabella Novik, University of Washington: *How neighborly can a centrally symmetric polytope be?*

Kalle Karu, University of British Columbia: *The combinatorics of the strong factorization conjecture for toric varieties*

Stephanie van Willigenburg, University of British Columbia: *Coincidences amongst skew Schur functions*

Thomas Zaslavsky, SUNY Binghamton: *The algebraic foundation of weak Tutte functions*

May 2006

Louis Billera, Cornell University: *Kazhdan-Lusztig polynomials and the cd-index*

Dynamical Systems Seminar

September 2005

Sarah Koch, Cornell University: *Moving in herds: critical points of the Hénon map*

Christiane Rousseau, University of Montreal: *The finiteness part of Hilbert's 16th problem for quadratic vector fields*

Zin Arai, Kyoto University: *On the hyperbolicity of the real and complex Hénon map*

October 2005

Yulij Ilyashenko, Cornell University: *Topological properties of polynomial foliations*

Sebastian van Strien, University of Warwick: *Density of hyperbolicity*

Stefano Luzzatto, Imperial College: *The boundary of hyperbolicity for Hénon-like maps*

Robert Devaney, Boston University: *McMullen domains and their environs*

Xavier Buff, Université Paul Sabatier: *Quadratic Julia sets with postive area*

November 2005

Madhusudhan Venkadesan, Cornell University: *Dexterous manipulation in humans: characterizing a noisy dynamical system*

Arnd Scheel, University of Minnesota: *Following coherent structures*

Drew LaMar, Cornell University: *Modeling the inner ear*

Araceli Medina-Bonifant, University of Rhode Island: *Elementary maps on P^2 and their intermingled basins*

December 2005

Joshua Bowman, Cornell University: *Veech groups of flat surfaces*

Yoav Naveh, Ben Gurion University of the Negev: *Upper bounds on the number of invariant components on Abelian differentials*

January 2006

Jean-Philippe Lessard, Georgia Institute of Technology: *Parallel continuation for equilibria of PDEs*

March 2006

W. Patrick Hooper, Yale University: *Stable billiards in triangles*

April 2006

Adam Epstein, Warwick Mathematics Institute: *Teichmüller theory of Riemann surfaces and solenoids*

Roland Roeder, Fields Institute, Toronto: *Linking with currents to study the topology of basins of attraction*

Dierk Schleicher, International University Bremen: *Newton's method for finding roots of complex polynomials (with a view towards transcendental functions)*

Johannes Rueckert, International University Bremen: *Newton's method for transcendental functions*

Umberto Pesavento, Cornell University: *Unsteady aerodynamics of falling plates: experiments, simulations, and bifurcation analysis*

Mitsuhiro Shishikura, Kyoto University: *The renormalization for parabolic fixed points and their perturbations*

May 2006

Victor Matveev, New Jersey Institute of Technology: *Multistability in a two-cell inhibitory network with T-like currents and synaptic facilitation*

Educational Mathematics Seminar

October 2005

Kristin Camenga, Cornell University: *A classification of secondary mathematics writing tasks*

December 2005

Aaron Weinberg, Ithaca College: *Revising process-object models of mathematical learning*

Lie Groups Seminar

September 2005

F. Alberto Grunbaum, University of California at Berkeley: *Matrix valued orthogonal polynomials arising from representations of SU(N)*

Wook Kim, Cornell University: *Standard module conjecture for GSpin groups*

George Wilson, Oxford University and Cornell University: *Mad subalgebras of rings of differential operators on curves*

Dan Edidin, University of Missouri at Columbia: *Non-abelian localization in equivariant K-theory*

October 2005

Farkhod Eshmatov, Cornell University: *DG models and Nakajima quiver varieties*

Wai Ling Yee, University of Alberta: *Signatures of invariant Hermitian forms*

Alexander Varchenko, University of North Carolina at Chapel Hill: *The flag variety structure of solutions to the Bethe ansatz equations*

November 2005

Jonathan Weitsman, University of California at Santa Cruz: *Measures on Banach manifolds, random surfaces, and nonperturbative string theory*

Thomas Nevins, University of Illinois at Urbana-Champaign: *Difference modules and Hilbert schemes*

December 2005

Liat Kessler, New York University: *Holomorphic shadows in the eyes of model theory*

February 2006

Damiano Testa, Cornell University: *Rational curves on the quintic threefold*

Farkhod Eshmatov, Cornell University: *Quantized Kleinian singularities and Nakajima quiver varieties*

March 2006

Freydoon Shahidi, Purdue University: *Stability of root numbers with applications to functoriality*

Alimjon Eshmatov, Cornell University: *Lie group valued moment maps*

Alessandra Pantano, Cornell University: *On the complementary series of the double cover of F4*

April 2006

Dan Goldston, San Jose State University: *Primes in tuples* (The Chelluri Lecture)

John Millson, University of Maryland: *The toric geometry of polygons in Euclidean space*

Eckhard Meinrenken, University of Toronto: *Twisted K-homology and Lie groups*

Logic Seminar

September 2005

Bakhadyr Khoussainov, University of Auckland and Cornell University: *Some topics in computable model theory and algebra*

Pavel Semukhin, University of Auckland and Cornell University: *On Pi_1 presentations of algebras* (in two parts)

Michael O'Connor, Cornell University: *Effective completeness theorem*

Michael O'Connor, Cornell University: *Effective omitting types theorems*

Mia Minnes, Cornell University: *Weighted finite-state transducers and applications to speech recognition*

Pavel Semukhin, University of Auckland and Cornell University: *Decidable prime models* (in two parts)

Sasha Rubin, Auckland University: *Automata-theoretic approach to verification: introduction*

October 2005

Sasha Rubin, Auckland University: *S1S with extended predicates*

Sasha Rubin, Auckland University: *Alternating automata*

Jiamou Liu, University of Auckland and Cornell University: *Parity games*

November 2005

Pavel Semukhin, University of Auckland and Cornell University: *Decidable saturated models*

Walker White, Cornell University: *What's next? Models of time event systems* (in two parts)

Mia Minnes, Cornell University: *Ash-Nerode theorem*
Mia Minnes, Cornell University: *Intrinsically computable sets and forcing*
Michael O'Connor, Cornell University: *Completeness results for properties of computable models* (in two parts)
James Worthington, Cornell University: *Computable isomorphism types of linear orders and Boolean algebras* (in two parts)

January 2006
Richard Shore, Cornell University: *Hyperarithmetic theory: an introduction*
Wojtek Moczydlowski, *Cornell University: Normalization of IZF* (in two parts)

February 2006
Marat Arslanov, Kazan State University and Cornell University: *N-c.e. degrees structures*
Wojtek Moczydlowski, Cornell University: *Ordinal notations and effective transfinite recursion*
Barbara Csima, University of Waterloo: *Effectiveness properties of Fraisse limits*
James Worthington, Cornell University: *Recursive ordinals and Pi-1-1 sets* (in two parts)
Bryant Adams, Cornell University: *Basic logic of quantum computation*
William Calhoun, Bloomsburg University: *Degrees of monotone complexity*

March 2006
Mia Minnes, Cornell University: *Hyperarithmetic = Delta-1-1*
Marat Arslanov, Kazan State University and Cornell University: *Completeness criteria for strong reducibilities*
Mia Minnes, Cornell University: *Selection, separation and reduction*
Bryant Adams, Cornell University: *Gurevich's abstract state machine thesis*
Michael O'Connor, Cornell University: *Pi-0-2 singletons; hyperarithmetic reducibility*
Andre Nies, University of Auckland: *Automata presentable groups*
James Worthington, Cornell University: *Incomparable hyperdegrees via measure theoretic arguments*

April 2006
Andre Nies, University of Auckland: *Computability and randomness* (in two parts)
Michael O'Connor, Cornell University: *The hyperjump*
Vivienne Morley, Ithaca, NY: *Basis theorems*
Vivienne Morley, Ithaca, NY: *Hyperarithmetic quantifiers*
Joseph Mileti, University of Chicago: *Effective ring theory*
Joseph Mileti, University of Chicago: *The strength of the Rainbow Ramsey Theorem*

May 2006
Michael O'Connor, Cornell University: *Applications of strong normalization of Heyting arithmetic*
Mia Minnes, Cornell University: *Automata and automatic structures*

Number Theory Seminar

August 2005
Ravi Ramakrishna, Cornell University: *Recent progress on Serre's conjecture* (in two parts)

September 2005
Alvaro Lozano-Robledo, Cornell University: *Elliptic units and Galois representations*
Ralph Greenberg, University of Washington: *The structure of some modules occurring in number theory*
Eknath Ghate, Tata Institute and Cornell University: *On the local behavior of ordinary Galois representations*

October 2005
Henri Johnston, Cornell University: *Galois module structure of rings of integers*
Jason Martin, Cornell University: *Building infinite 2-ray class towers of number fields with specified signature and bounded root discriminant*
Shankar Sen, Cornell University: *On some aspects of Galois representations*
Alina Cojocaru, Princeton University: *Effective versions of Serre's theorem for elliptic curves*

November 2005
David Rohrlich, Boston University: *Root numbers*
Farshid Hajir, University of Massachusetts: *Post-critically finite polynomials and iterated monodromy representations*
Anupam Srivastav, University at Albany: *Normal integral basis and swan modules*
Keith Conrad, University of Connecticut: *Root numbers and ranks in positive characteristic*

January 2006
Henri Johnston, Cornell University: *Galois module structure and change of base field*

February 2006
Alvaro Lozano-Robledo, Cornell University: *A conjectural geometric description of principal congruence subgroups*
Radu Murgescu, Cornell University: *On class numbers*

Alvaro Lozano-Robledo, Cornell University: *Bernoulli numbers, Hurwitz numbers, p-adic L functions and Kummer-type criteria* (in three parts)

March 2006
Henri Johnston, Cornell University: *Basics of Iwasawa theory*

April 2006
Alvaro Lozano-Robledo, Cornell University: *Trivial bounds and elliptic curves of maximal rank*

Oliver Club

September 2005
F. Alberto Grunbaum, University of California at Berkeley: *Differential operators with matrix coefficients: a collection of open problems in algebra and (maybe) non-commutative algebraic geometry*
Alexander Vladimirsky, Cornell University: *Going with the (information) flow: on efficient computations and boundary-value problems*
Persi Diaconis, Stanford University: *From characterization to algorithm*
Christiane Rousseau, University of Montreal: *The root extraction problem for a germ of holomorphic diffeomorphism* $f : (\mathbf{C}, 0) \to (\mathbf{C}, 0)$
Dan Edidin, University of Missouri at Columbia: *Grassmanians, frames, and signal reconstruction*

October 2005
Eknath Ghate, Tata Institute and Cornell University: *Modular endomorphism algebras*
Peter Hilton, Binghamton University: *Breaking high-grade German ciphers in World War II*
Terence Tao, UCLA: *Long arithmetic progressions in the primes*
Alexander Varchenko, University of North Carolina, Chapel Hill: *The* (gl_n, gl_k)*-duality and critical points of master functions*

November 2005
Xavier Buff, Université Paul Sabatier: *Quadratic Julia sets with positive area*
Jonathan Weitsman, University of California at Santa Cruz: *Measures on Banach manifolds and supersymmetric quantum field theory*
Michael Yampolsky, University of Toronto: *Computability and computational complexity of Julia sets*
Thomas Nevins, University of Illinois at Urbana-Champaign: *Chern classes of algebraic varieties*

December 2005
Jeff Viaclovsky, MIT: *Moduli spaces in Riemannian geometry*

January 2006
Damiano Testa, Cornell University: *Rationally connected varieties*

February 2006
Martin Kassabov, Cornell University: *Small presentations of finite simple groups*

March 2006
Freydoon Shahidi, Purdue University: *Lattice point problems, Galois representations and Langlands functoriality conjecture*
Andrew Odlyzko, University of Minnesota: *Zeros of the Riemann zeta function: computations and implications*
George Willis, University of Newcastle (Australia): *Almost normal subgroups of* $SL_n(\mathbf{Z})$
Francesco Brenti, University of Rome: *On the combinatorial invariance conjecture for Kazhdan-Lusztig polynomials*

April 2006
Dan Goldston, San Jose State University: *Are there infinitely many twin primes?*
Kalle Karu, University of British Columbia: *The geometry of the cd-index*
John Millson, University of Maryland: *The generalized triangle inequalities in symmetric spaces and buildings with applications to representation theory*
Eckhard Meinrenken, University of Toronto: *Pure spinors on Lie groups*

May 2006
Gregory Lawler, Cornell University: *The Schramm-Loewner evolution: an introduction*

Olivetti Club

All speakers are from Cornell unless otherwise indicated.

August 2005
Jonathan Needleman: *An exceptional talk*

September 2005
Michael Robinson: *Studying the bifurcation behavior of a nonlinear PDE*
Melanie Pivarski: *Poincaré inequalities: pleasant, yet informative*
Joshua Bowman: *Translation with a capital T, and that rhymes with B, and that stands for billiards!*
Matthew Noonan: *Dividing by small numbers*

October 2005
Greg Muller: *Knots, physics, and the Jones polynomial*
Timothy Goldberg: *The Lie bracket and the commutator of flows*

November 2005

Peter Samuelson: *What non-positive curvature means to me*
Abra Brisbin: *The (nucleo)tides of time: probability and population genetics*
Treven Wall and Sarah Koch: *Minimum Sudoku sets: a problem-solving session*
Jim Pivarski: *Why stuff is hard*

January 2006

Greg Muller: *Fun with cobordisms*
Timothy Goldberg: *A little Lie algebra cohomology, if you please*

February 2006

Jonathan Needleman: *I challenge you to a unitary dual!*
Will Gryc: *Why the Sobolev function couldn't get a date for Valentine's day*
Treven Wall: *Thirteen ways of looking at a Sobolev space*

March 2006

Matthew Noonan: *Matt Noonan's magic mystery talk: nonlinear mathematics*
Melanie Pivarski and Kristin Camenga: *Mathematical cousins*
Drew Armstrong: *Euler's (other) constant*
Michael O'Connor: *Ordinals, proofs, and programs*

April 2006

Joshua Bowman: *Pseudo-Anosov maps of a surface-ally docious (If you say it loud enough you'll always sound precocious)*
Benjamin Chan: *The way Google makes its money*
Michael Robinson: *Tug-of-war: how nonlinearity and the Laplacian interact*
Greg Muller: *Greg Muller strikes back*

May 2006

Sarah Koch: *Some secrets of the Mandelbrot set and a glimpse of dynamics in C^2*

Probability Seminar

September 2005

Gregory Lawler, Cornell University: *Conformal invariance and two-dimensional polymers*
Joan Lind, Cornell University: *The geometry of Loewner evolution*
David White, Cornell University: *Processes with inert drift*
Josh Rushton, Cornell University: *A Chung-type functional LIL for alpha-stable processes, and related invariance results*

October 2005

Paul Jung, Cornell University: *The contact process on non-amenable graphs*
Lea Popovic, Cornell University: *Continuum trees from catalytic population models*
Raazesh Sainudiin, Cornell University: *A randomized enclosure algorithm: Moore rejection sampling*
Kazumasa Kuwada, Kyoto University and Cornell University: *Large deviations for random currents induced from stochastic line integrals*

November 2005

Gady Kozma, Institute for Advanced Study: *The scaling limit of loop-erased random walk in three dimensions*
Julien Dubedat, Courant Institute: *Commutation of Schramm-Loewner evolutions*
Richard Durrett, Cornell University: *Waiting for ATCAAAG*

January 2006

Nicolas Lanchier, Rouen and Minnesota: *Stochastic spatial models for host-symbiont interactions*
Anja Sturm, University of Delaware: *Spatial coalescents with multiple mergers*
Serge Cohen, Toulouse: *Gaussian approximation of multivariate Lévy processes*

February 2006

Antar Bandyopadhyay, Chalmers University (Sweden): *Random walk in dynamic Markovian random environment*
Davar Khoshnevisan, Utah: *A coupling and the Darling-Erdos conjectures*

March 2006

Ted Cox, Syracuse University: *Renormalization of a stochastic Lotka-Volterra model: the two-dimensional case*
Mihai Sirbu, Columbia University: *On the two-times differentiability of the value functions in the problem of optimal investment in incomplete markets*
X. Chen, Tennessee: *Large deviations for Brownian intersection local times and related problems*
Jason Schweinsberg, University of California at San Diego: *The loop-erased random walk and the uniform spanning tree on the four-dimensional discrete torus*

April 2006

Benedek Valko, University of Toronto: *Limits of random trees from real-world networks*
Michael Reed, Duke University: *Why cell biology needs mathematicians*
Joe Yukich, Lehigh University: *Limit theory for some problems in geometric probability — an overview*

Michael Roeckner, Purdue University: *Stochastic porous media and fast diffusion equations*

May 2006

Dominique Bakry, Université Paul Sabatier: *From Log-Sobolev inequalities to Li-Yau's parabolic Harnack ones*

Teaching Seminar

All speakers are from Cornell unless otherwise indicated.

August 2005

Preparing for the first day of class: some ideas, examples, and a chance to plan

September 2005

Kristin Camenga, Mia Minnes, Melanie Pivarski: *Groupwork: advantages, disadvantages, and tips*

Louis Billera, Kenneth Brown, Kariane Calta, Sarah Day, Stephen Hilbert (Ithaca College), Luke Rogers: *Applying for postdocs and teaching jobs*

October 2005

Kristin Camenga: *Using good questions*

Treven Wall: *Math anxiety in the classroom — how to deal*

November 2005

Jonathan Needleman and Matthew Noonan: *The overall structure of calculus*

Bryant Adams: *The Instructional Technology Office and how it can help you*

Melanie Pivarski: *Ice-breakers and other first day of class activities*

February 2006

Todd Kemp and Treven Wall: *Term projects for math courses*

David Bock: *Preparing for Math Awareness Month*

March 2006

How to write good questions (panel discussion)

Kristin Camenga: *Ideas for writing assignments in math*

April 2006

Mia Minnes: *The Good Questions archive and database: how to use this TA tool*

Robert Strichartz, Craig Johnson (Marywood University), Thomas Church: *Facilitating research by undergraduates: a panel discussion*

May 2006

Jobs panel: where graduate students found positions and how they did it (tips about the job search)

Topology and Geometric Group Theory Seminar

September 2005

Francesco Matucci, Firenze and Cornell University: *The simultaneous conjugacy problem for Thompson's group F is solvable*

Edward Swartz, Cornell University: *f-vectors and manifolds*

Craig Johnson, Marywood & Cornell University: *A computer search for free actions on orientable surfaces*

October 2005

Jason Behrstock, University of Utah: *Relative hyperbolicity and the mapping class group*

Ross Geoghegan, SUNY at Binghamton: *Associativity and Thompson's group*

Mikhail Ershov, Yale University and IAS: *Finite presentations of pro-p groups and Lie algebras*

November 2005

Matthew Horak, Trinity College: *Group actions on order trees*

Marc Lackenby, Oxford University: *Counting covering spaces and subgroups in dimension 3*

Michael Handel, CUNY: *The commensurator group of* $Out(F_n)$

Andrzej Zuk, University of Paris 7 and Institute for Advanced Study: *Automata groups*

Collin Bleak, SUNY at Binghamton: *Solvability in groups of piecewise-linear homeomorphisms of the unit interval*

December 2005

Seonhee Lim, Yale University: *Minimal volume entropy on graphs and buildings*

January 2006

Ruth Charney, Brandeis: *Outer space for right-angled Artin groups*

Pedro Ontaneda, SUNY Binghamton: *Ricci flow and negative curvature in higher dimensions*

February 2006

Josep Burillo, Universitat Politècnica de Catalunya: *The braided Thompson's group*

James Conant, University of Tennessee at Knoxville: *The rational unstable homology of automorphism groups of free groups*

Tom Stiadle, Wells College and Cornell University: *Characterizing centers of graphs of groups*

Tara Brendle, Louisiana State University: *The Johnson filtration of the mapping class group and Heegaard splittings of 3-manifolds*

March 2006

Zoran Sunik, Texas A&M University: *Hanoi towers, Schreier graphs, iterated monodromy groups and Julia sets*

Donald Cartwright, University of Sydney: *Groups acting simply transitively on the vertices of a building*

Udo Baumgartner, University of Newcastle, Australia: *Flat rank as a geometric invariant of totally disconnected, locally compact groups*

Vladimir Shpilrain, City College of New York: *Densities in free and free abelian groups*

Nikolay Nikolov, Oxford University: *Counting primes, groups, and manifolds*

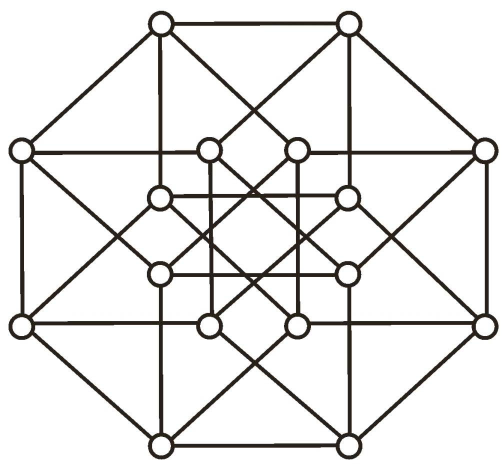
April 2006

Craig Johnson, Marywood and Cornell University: *An obstruction to embedding a simplicial n-complex into a 2n-manifold*

Francesco Matucci, Firenze and Cornell University: *On trivalent directed graphs and conjugacy classes of Thompson's group F*

May 2006

Stefan Wenger, New York University: *Isoperimetric inequalities of Euclidean and sub-Euclidean type in metric spaces*



Think Outside the Box

Math Awareness Month 2006

Ithaca High School and Cornell University™

Community Outreach

Math Explorer's Club

Five Cornell graduate students supervised weekly after-school meetings of the Math Explorer's Club throughout the year at Ithaca High School. Sarah Koch began with the game of Set, then challenged students to find strategies for fair cake division, and demonstrated De Bruijn sequences using the same magic trick that Persi Diaconis performed at the Kieval lecture. (See p. 31.) Sarah was followed by Jessica Zuniga, who presented the club with a number of activities, problems, and puzzles involving probability.

After the winter break, David Biddle started with magic squares as viewed from a torus and continued with a geometric theme. The group looked at tesselations of the plane as an introduction to curvature, a variety of knot related subjects, including the short film *Not Knot*, and concluded with a discussion of what the "shape of space" really means. Radu Murgescu turned the students' attentions to a number of different problem-solving strategies, including the pigeonhole, invariance, and extremal principles. The group applied these ideas to situations that ranged from analyzing combinatorial situations as found in Nim, Bachet's game, or graph theory to deriving analytic formulas for the Fibonacci numbers. Andre Maxim wrapped up the year with coloring problems, inequalities, induction, sequences, and brain-teasers.

Ithaca High School Senior Seminar

About ten Ithaca High students attended this year's senior seminar, organized by Cornell graduate students Matt Noonan, Jeff Mermin, and Jay Schweig.

Matt taught the first module on various notions of infinity, starting with uncountability in set theory and using the continuum hypothesis to start thinking about other models of the *standard* mathematical universe. This led to a discussion of nonstandard reals and later hyperbolic and projective geometry (as *nonstandard* models of Euclid's first four axioms). The group talked about the quaternions so they could comb the 3-sphere. Other geometric ideas, such as the Banach-Tarski paradox, which linked back to the axioms of set theory, were also discussed. They saw how infinite techniques could be applied to finite problems in combinatorics through the theory of structure types, which seem to have fractional (or even complex!) cardinality.

Jeff discussed a variety of subjects revolving around voting issues. He started with flaws in the existing voting systems used in American elections, instant runoff voting (used in municipalities and foreign countries), and Borda count (widely used in sports). Afterwards he proved Arrow's Impossibility Theorem, which states that every voting system is flawed, and examined measurements of voting power and issues of apportionment.

Jay introduced the students to a number of ideas related to combinatorics and topology, especially simplicial complexes. The module began with graph coloring, flows, and how these ideas are connected via duality, eventually leading to the more general notion of matroids. He also examined the connections between these concepts and face counts of simplicial complexes, shellings, Euler characteristic, and enumeration on partially ordered sets.

The students finished the year by researching and presenting a topic of their choice with the help of one of the organizers. Project topics included: connections between chip-firing and network reliability, cellular automata and Conway's game of life, the matrix-tree theorem, and maze generation algorithms.

Saturday Workshops for Teachers

The Department again hosted a series of four full-day workshops for area secondary mathematics teachers, continuing a program begun in 1985. These workshops were planned and led by **David Bock**, the department's K-12 education and outreach coordinator. Participants investigated the role of technology in teaching mathematics and explored math history and concepts related to the topics they teach. About 25 people attended each of the four full-day sessions, collectively involving 40 different teachers from 20 schools in central New York.

These sessions were greatly enhanced by the participation of faculty members **John Hubbard**, **Todd Kemp**, and **Ravi Ramakrishna**, graduate student **Sarah Koch**, undergraduate math major **Leslie Huang**, and the Theory Center's Susan Kolodziej.

Curriculum Development for Robert Moses' Algebra Project

David Henderson was supported once again by the department and the associate provost to continue as a member of the high school curriculum development team for Robert Moses' Algebra Project. Robert Moses, the well-known 1960s civil-rights leader, has been working on what he calls the new civil-rights goal of "raising the floor" by educating under-served students to want to learn mathematics and providing them with the education they need to be successful in mathematics in terms of passing state exams and entering college without taking remedial courses. Moses' key pedagogic idea is that mathematical meanings come from human experiences and then reflection on those experiences. Besides working on a new high school geometry curriculum, Professor Henderson is also assisting the Ithaca school district to incorporate different aspects of the Algebra Project into its mathematics programs.

Educational Outreach Through a Digital Library of Printable Mechanisms

Senior Research Associate **Daina Taimina** and **David Henderson** have been working with the Cornell University Libraries, Department of Mechanical Engineering, and the Museum of Science in Boston on a project supported by grants from the Institute for Museum and Library Services (IMLS) and the National Science Foundation (NSF). Project research has investigated the use of mechanical artifacts and their digital representations in two distinct learning environments (middle school classroom and museum), as well as the management of digital representations of physical objects in a library context. The work of the project can be found at the website kmoddl.library.cornell.edu, an open-access resource for teaching and learning about the history and theory of machines.

Taimina and Henderson have been responsible for describing (through on-line tutorials and workshops) the interactions between mathematics and mechanical mechanisms for students and teachers. This year, they included their work in three national workshops for mathematicians who teach teachers and in two book chapters. In addition, Taimina taught a short course for middle school students at Ithaca's Lehman Alternative Community School.

CU Math/Science Professional Development Day

On March 24, 2006, over 1200 teachers attended workshops at Cornell during a conference day coordinated with most of the regional school districts. This ambitious outreach effort involved teachers at all grade levels and in all disciplines, the largest such professional development activity ever mounted by an American university. The feedback was enthusiastically positive, and this will surely become an annual event.

Math teachers chose two offerings from a total of 14 sessions. Presenters included: faculty members **Dave Bock**, **Craig Johnson**, **Alvaro Lozano-Robledo**, and **Bob Strichartz**; graduate students **Kristin Camenga** and **Jeff Mermin**; education professor Susan Piliero; and six other math educators from SUNY Binghamton, SUNY College at Cortland, and Ithaca College.

Mathematics Awareness Month At Area Schools

The Cornell Mathematics Department again participated in the American Mathematical Society and Mathematical Association of America's annual Mathematics Awareness Month, this year focusing on the mathematics of Internet security. Graduate students made well-received presentations in area classrooms: **Josh Bowman**, **Jeff Mermin**, and **Jonathan Needleman** at Dryden High School; **Melanie Pivarski** at Newfield High; **Paul Shafer** at Ithaca High; and **Kristin Camenga** in a 5th grade class at Cayuga Heights Elementary School.

Again this year the department sponsored a T-shirt design contest, won by Ithaca High student Joshua Katz. (Josh's winning design is pictured on page 48.) The departments of mathematics at Cornell University and Ithaca High School underwrote the cost of producing 125 shirts. Most were given to Ithaca High students as prizes for solving daily math problems; shirts were also available to the school's math teachers as well as Cornell staff and students.

Newsletter for Math Teachers

About 2–3 times a month **Dave Bock** emails a math newsletter to about 300 central New York math teachers. The content includes announcements of upcoming talks and workshops, pedagogical suggestions, recent math-related news stories, the latest information from the NYS Education Department, as well as pointers to valuable books, articles, weblinks, and other resources.

Freshman Math Prize Exam

The seventh annual Freshman Math Prize Exam, organized by **Paul Jung**, **Martin Kassabov**, and **Allen Back**, was held on March 29, 2006. This is a challenging prize exam open to all freshmen at Cornell. Although the problems do not require any mathematics beyond elementary calculus, many do require intuition, ingenuity and persistence. Here is a sample question:

> The UN invited $2n$ diplomats for a dinner. Each of them has at most $n - 1$ enemies. Show that you can seat them at a round table so that nobody sits next to an enemy. (We assume that being an enemy is symmetric: if A is an enemy of B, then B is an enemy of A.)

This and other sample problems from recent exams, along with this year's exam, may be found at the following web site:

www.math.cornell.edu/~putnam/freshman_prize

Four students were declared winners this year. First place went to **Julius Poh**, second to **Daniel Goldfein**, third to **Adam Neumann**, and fourth to **Vincent Chan**. They received cash prizes from an endowment originally funded by Putnam team winnings in the mid nineties.

Expanding Your Horizons

On April 29, 2006, members of the Cornell Mathematics Department participated in a day of hands-on workshops in mathematics for 7th, 8th, and 9th grade girls, featuring a workshop on combinatorial games, in particular the game of Nim. The workshop was run and planned by several members of the department, and some math teachers who were looking for new classroom activities observed. Graduate students **Jennifer Biermann**, **Benjamin Chan**, **Evgueni Klebanov**, **Jonathan Needleman**, and **Melanie Pivarski** worked with a group of girls and three large bags of M&M's to determine optimal strategies for the game Nim. **Mia Minnes** and **Treven Wall** assisted in the planning.

The group began by playing the "subtraction game." Starting with the number 20, players take turns subtracting a number from 1 through 4 until someone reaches the number zero and wins. After solving the subtraction game and some of its variants, we moved on to the game of Nim. Nim is a game consisting of two players and some number of piles. Players take turns taking as many objects as they want from any *one* pile, and the player who takes the last object wins. The girls split up in pairs and explored 2-pile Nim, using piles of M&M's, then 3-pile Nim. While 3-pile Nim proved more challenging, many pairs made good progress toward a solution before eating all of their playing pieces! In the end the girls had a very fulfilling experience.

Expanding Your Horizons is a national program aimed at encouraging middle-school girls' interest in math and science and motivating them to continue taking math and science courses throughout high school. Organized and run primarily by women in mathematics and science, it is held in over 100 locations nationwide. To learn more, visit www.expandingyourhorizons.org.

Mathematics Awareness Month Public Lecture

On April 26th, Graeme Bailey (Computer Science) gave the 2006 Mathematics Awareness Month lecture to a mix of Cornell staff and students, as well as teachers and students from Ithaca High School and other schools as far away as Elmira.

Bailey's talk — *Keeping and Sharing Secrets* — was in keeping with this year's theme, *Mathematics of Internet Security*. He gave a quick introduction to some of the mathematical ideas used in sharing secrets in both good and hostile communities and showcased recent work done by some Cornell undergraduates in this area.

Michael D. Morley Ithaca High School Prize in Mathematics

Ed Swartz presented the 2006 Michael D. Morley Ithaca High School Prize in Mathematics jointly to **Greg Durrett** and **Ben Zax** on June 8th at Ithaca High School. Formerly known as the Ithaca High School Senior Prize, it is funded largely by faculty contributions. The selection committee — Ed Swartz and Graeme Bailey — interviewed finalists chosen by faculty at Ithaca High School, and they were equally impressed with Greg and Ben, though for different reasons. The finalists were given two problems to solve. Ben went after the solutions with overpowering accuracy and killer ability, while Greg took an impressive — and equally successful — route outside of the box, showing creativity and a willingness to take risks.

Mathematics Library

The Mathematics Library continues to have a high level of use that often finds most of the library computers and many seats full. While scholarly journals are moving online, books remain in the paper world and the total use of the print collection continues to grow. Paintings and items of interest are on display in the library. Most notable is a collection of oil paintings of early faculty of the Mathematics Department, including a large portrait of James Edward Oliver, who started the department colloquium series in 1891.

The Mathematics Library collection at Cornell is one of the finest in the nation and supports research and instruction in mathematics and statistics for the Cornell community. The research collection consists of works on mathematics, statistics, applied mathematics, mathematics education, and the history of mathematics. For undergraduates with an interest in mathematics, the library is a wonderful resource for materials to support instructional and career needs as well as expository and recreational reading. The library collection has great historic depth and breadth and includes materials from around the world in many languages.

Gifts to the library endowment have made endowment income the primary source of funds for the purchase of books. Thanks to the generous gifts of our donors, endowment principle grew significantly in the last year. An anticipated larger endowment payout next year will be a tremendous help. Gifts are the difference between an excellent library and a mediocre one. Our endowments purchase essentially all the monographs we order individually.

The university appropriated budget for the library continues to grow, but not as fast as the cost of journals from a few large commercial publishers. In stark contrast, independent, society, university press, and not-for-profit journals are *not* increasing prices at an unsustainable rate. The majority of our appropriated budget is consumed by relatively few titles from a few large commercial publishers.

The library subscribes to 640 journals. About 240 of these titles are now available online only, but an equal number are still only available in paper form. Another 150 journals are available both on paper in the library and online to all Cornell users. The University Library has emphasized moving to online-only access whenever possible to achieve savings, and the library has negotiated site license contracts that provide archival reliability. This year was a big changeover, and in the coming year we will see more titles go to online-only access; however, most of the dual access titles either do not have online-only subscriptions available or the reliability of the online access is in question. Online journals are important but they are generally not much less expensive than the printed resources they will eventually replace. A crisis in scholarly communications is looming, largely because commercial publishers are pushing up the prices of their journals at a rate that it is not sustainable. For more information: www.library.cornell.edu/scholarlycomm/.

The Mathematics Library encourages and welcomes all patrons in the Cornell community to use its resources. Reciprocal interlibrary loan agreements with other institutions make Cornell's resources available throughout the world and open the world to Cornell researchers. The need for quantification, analysis and more mathematical sophistication in the social, biological, and engineering sciences attracts a spectrum of patrons from across the campus and generates frequent use of the collection. A full range of reference, circulation, printing, and photocopy services are available in person and via phone, e-mail, or the web.

The library staff consists of Steven Rockey, director of the library, Natalie Sheridan, branch manager, and approximately a dozen part-time undergraduate student employees. The veteran professional staff and the competent student employees are always ready to serve the public, and they welcome feedback. A primary goal is to make the library experience for the staff and patrons interesting, productive, and enriching in a small and personal environment.

The Mathematics Library's home page has been redesigned and relocated: www.library.cornell.edu/math/. It has information about the Mathematics Library, including services, hours of operation, pointers to bibliographic indexes such as MathSciNet and our locally created bibliography of "collected works" of mathematicians, links to other mathematical science resources, etc. Library personnel are always adding new and relevant links to this home page. Visit our library, our home page, or contact us electronically or by telephone to find out how the Mathematics Library can serve you.

Cornell is involved in a number of digitization projects relating to mathematics. An overview of worldwide mathematics digitization efforts is available at: www.library.cornell.edu/math/digitalization.php. Here are some project highlights.

Project Euclid

projecteuclid.org

Project Euclid is Cornell University Library's electronic publishing initiative in mathematics that is now fully functional and has grown to 40 titles. Project Euclid is a user-centered initiative to create an environment for the effective and affordable distribution of serial literature in mathematics and statistics. The journal publishers join forces and participate in an online presence with advanced functionality, without sacrificing their intellectual or economic independence or commitment to low subscription prices. Full-text searching, reference linking, interoperability through the Open Archives Initiative, and long-term retention of data are all-important components of the project.

Cornell Historical Math Monographs Collection

historical.library.cornell.edu/math/

This is a collection of 576 digitized books that were scanned from originals held by the Mathematics Library. The titles can be viewed electronically, and the Mathematics Library also does a brisk business selling bound paper facsimiles to libraries and individuals. The Math Books collection is mostly composed of old books that are out of copyright but still mathematically relevant.

Digital Mathematics Library (DML)

www.ceic.math.ca/WDML/index.shtml

The successful Cornell-coordinated planning of the DML has resulted in the ongoing World DML project coordinated under the auspices of the International Mathematical Union. See www.mathematik.uni-bielefeld.de/~rehmann/DML/dml_links.html for a current list of retrodigitized mathematics.

Electronic Mathematics Archives Initiative (EMANI)

www.emani.org

This is a collaborative effort between the German scientific publisher Springer and the libraries at Cornell, Göttingen, Tsinghua (Beijing), and NUMDAM (Grenoble). EMANI will focus on the archiving of digital mathematics literature, and also addresses repository and dissemination issues. Springer wishes to establish its reputation as a leader in digital archiving in a public-spirited fashion and hopes to benefit from the good will this can generate. Springer also hopes that a systematic and collaborative approach to digital archiving will speed their transition to electronic-only publishing. EMANI is expected to be an important component in the broader Digital Math Library initiative if Springer can in fact offer a model for other publishers of an open and collaborative approach to issues of archiving and access provision.

Faculty Research Areas in the Field of Mathematics

Dan M. Barbasch, Professor; Ph.D. (1976) University of Illinois; Representation theory of reductive Lie groups

Yuri Berest, Assistant Professor; Ph.D. (1997) Université de Montreal (Canada); Mathematical physics and algebraic geometry

Louis Billera, Professor; Ph.D. (1968) City University of New York; Geometric and algebraic combinatorics

Kenneth S. Brown, Professor and Chair; Ph.D. (1971) Massachusetts Institute of Technology; Algebra, topology, group theory

Stephen U. Chase, Professor; Ph.D. (1960) University of Chicago; Non-commutative algebra, homological algebra, Hopf algebras, group theory

Robert Connelly, Professor; Ph.D. (1969) University of Michigan; Discrete geometry, computational geometry and the rigidity of discrete structures

R. Keith Dennis, Professor; Ph.D. (1970) Rice University; Commutative and non-commutative algebra, algebraic K-theory, group theory, mathematical bibliography

Richard Durrett, Professor; Ph.D. (1976) Stanford University; Problems in probability theory that arise from ecology and genetics

Eugene B. Dynkin, A. R. Bullis Chair and Professor; Ph.D. (1948), Dr. of Science (1951) Moscow University; Probability theory, Lie groups

Leonard Gross, Professor; Ph.D. (1958) University of Chicago; Functional analysis, constructive quantum field theory

John M. Guckenheimer, Professor; Ph.D. (1970) University of California at Berkeley; Dynamical systems

Allen Hatcher, Professor; Ph.D. (1971) Stanford University; Geometric topology

Timothy Healey, Professor and Chair of Theoretical and Applied Mechanics; Ph.D. (1985) University of Illinois; Nonlinear elasticity, nonlinear analysis, partial differential equations

David W. Henderson, Professor; Ph.D. (1964) University of Wisconsin; Educational mathematics, geometry

John H. Hubbard, Professor; Doctorat d'Etat (1973) Université de Paris Sud; Analysis, differential equations, differential geometry

J.T. Gene Hwang, Professor; Ph.D. (1979) Purdue University; Statistics, confidence set theory

Yulij Ilyashenko, Professor; Ph.D. (1969) Moscow State University; Dynamical systems

Peter J. Kahn, Professor; Ph.D. (1964) Princeton University; Symplectic topology/geometry

Dexter Kozen, Professor of Computer Science; Ph.D. (1977) Cornell University; Computational theory, computational algebra and logic, logics and semantics of programming languages

Gregory Lawler, Professor; Ph.D. (1979) Princeton University; Probability, statistical physics

Camil Muscalu, Assistant Professor; Ph.D. (2000) Brown University; Harmonic analysis and partial differential equations

Anil Nerode, Goldwin Smith Professor; Ph.D. (1956) University of Chicago; Mathematical logic, computability theory, computer science, mathematics of AI, control engineering

Michael Nussbaum, Professor; Ph.D. (1979) Academy of Sciences Berlin (Germany); Mathematical statistics

Irena Peeva, Assistant Professor; Ph.D. (1995) Brandeis University; Commutative algebra and algebraic geometry

Philip Protter, Professor of Operations Research and Industrial Engineering; Ph.D. (1975) Univ. of California at San Diego; Probability theory, stochastic calculus, stochastic differential equations, stochastic numerical methods, mathematical finance theory, credit risk

Ravi Ramakrishna, Associate Professor; Ph.D. (1992) Princeton University; Algebraic number theory

Richard Rand, Professor of Theoretical and Applied Mechanics; Sc.D. (1967) Columbia University; Nonlinear dynamics

James Renegar, Professor of Operations Research and Industrial Engineering; Ph.D. (1983) University of California at Berkeley; Optimization algorithms

Laurent Saloff-Coste, Professor; Ph.D. (1983) and Doctorat d'Etat (1989) Université Paris VI; Analysis, potential theory, stochastic processes

Alfred H. Schatz, Professor; Ph.D. (1964) New York University; Numerical solutions of partial differential equations

Shankar Sen, Professor; Ph.D. (1967) Harvard University; Algebraic number theory

Richard A. Shore, Professor; Ph.D. (1972) Massachusetts Institute of Technology; Mathematical logic, recursion theory, set theory

Reyer Sjamaar, Associate Professor; Ph.D. (1990) Rijksuniversiteit te Utrecht (RUU), the Netherlands; Symplectic geometry

John Smillie, Professor; Ph.D. (1977) University of Chicago; Dynamical systems

Birgit E. Speh, Professor; Ph.D. (1977) Massachusetts Institute of Technology; Lie groups, automorphic forms, representation theory

Michael E. Stillman, Professor; Ph.D. (1983) Harvard University; Algebraic geometry, computational algebra

Robert S. Strichartz, Professor; Ph.D. (1966) Princeton University; Harmonic analysis, partial differential equations, analysis on fractals

Steven H. Strogatz, Professor; Ph.D. (1986) Harvard University; Applied mathematics

Edward Swartz, Assistant Professor; Ph.D. (1999) University of Maryland at College Park; Combinatorics and discrete geometry

William Thurston, Professor; Ph.D. (1972) University of California at Berkeley; Topology

Alexander Vladimirsky, Assistant Professor; Ph.D. (2001) University of California at Berkeley; Numerical methods, dynamical systems, nonlinear PDEs, control theory

Karen Vogtmann, Professor; Ph.D. (1977) University of California at Berkeley; Topology, geometric group theory

Lars B. Wahlbin, Professor; Ph.D. (1971) University of Göteborg, Sweden; Numerical solutions of partial differential equations

James E. West, Professor; Ph.D. (1967) Louisiana State University; Geometric topology, infinite-dimensional topology

Faculty Profiles

Allen Back

Senior Lecturer of Mathematics

My original training was primarily in differential geometry and secondarily in topology. The most interesting portion of my earlier work was related to the role of compact Lie group actions in differential geometry, especially curvature realizability questions. I've been impressed by a variety of recent progress in this area (e.g. Einstein metrics and positive Ricci curvature on many cohomogeniety one manifolds) and have been working on what further directions may now be fruitful.

Besides equivariant differential geometry, other areas of past work and interest include transformation groups, homotopy theory, dynamical systems, some parts of mathematical physics, geometric modeling and robotics. My work as director of the Instructional Computing Lab meshed with a long-standing interest in the use of computers for mathematical enrichment.

Selected Publications

Rational Pontryagin classes and killing forms, J. Diff. Geom. **16** no. 2 (1981), 191–193.

Pontryagin forms on homogeneous spaces, Comment. Math. Helv. **57** no. 3 (1982), 349–355.

Equivariant geometry and Kervaire spheres (with Wu Yi Hsiang), Trans. AMS **304** no. 1 (1987), 207–227.

dstool: Computer assisted exploration of dynamical systems (with J. Guckenheimer, M. Myers, F.J. Wicklin and P. Worfolk), Notices AMS **39** (1992), 303–309.

Mathematics and tensegrity (with R. Connelly), American Scientist March-April (1998), 142–151.

Dan Barbasch

Professor of Mathematics

My research is in the field of representation theory of reductive Lie groups. I am particularly interested in the classification of the unitary dual for groups over local fields, and its relation to the orbit structure of the Lie algebra. Furthermore I am interested in the relation of these representations to problems arising from number theory, more precisely automorphic forms.

Selected Publications

Unitary spherical spectrum for split classical p-adic groups, Acta Applicandae Mathematicae **44** (1996).

Local character expansions (with A. Moy), Ann. Sci. de L'Ecole Norm. Sup. (1997).

The associated variety of an induced representation (with M. Bozicevic), Proc. AMS (1998).

The spherical dual for p-adic groups (with A. Moy), Proc. of Conf. in Cordoba, Argentina.

The associated variety of unipotent representations, preprint.

Yuri Berest

Associate Professor of Mathematics

My research interests include mathematical physics, algebraic geometry and representation theory. I am particularly interested in various interactions between these fields. Some of my recent work is related to noncommutative geometry, integrable systems, differential operators on algebraic varieties, representation theory of Cherednik algebras, and the theory of invariants of finite reflection groups.

Selected Publications

A-infinity modules and Calogero-Moser spaces (with O. Chalykh), J. Reine Angew. Math. (to appear).

Mad subalgebras of rings of differential operators on curves (with G. Wilson), Advances in Math. (to appear).

Quasi-invariants of complex reflection groups (with O. Chalykh), preprint, 45 pp.

Louis J. Billera

Professor of Mathematics

For some time, my research has centered on combinatorial properties of convex polytopes and, more generally, to algebraic approaches to combinatorial problems arising in geometry. Some questions are related to the facial structure of polytopes, for example, the enumeration of faces by dimension. Others have to do with subdivisions of polytopes.

A common theme in much of this has been the construction of polytopes to given specifications: for example the construction with Carl Lee of polytopes satisfying the conditions of McMullen's *g*-conjecture, showing these conditions to be sufficient to describe the enumeration of faces of all simplicial convex polytopes, or the construction with Bernd Sturmfels of fiber polytopes, showing that certain sets of polyhedral subdivisions of polytopes themselves have the structure of convex polytopes. In addition, we have used some of these ideas in the study of questions arising in biology concerning the structure of the space of all phylogenetic trees.

More recently, I have been studying algebraic structures underlying the enumeration of faces and flags in polytopes and posets. This has led to the study of connections with the theory quasisymmetric and symmetric functions and has had application to enumeration in matroids and hyperplane arrangements and to a representation of the Kazhdan-Lusztig polynomials of Bruhat intervals in a Coxeter group.

Selected Publications

Generalized Dehn-Sommerville relations for polytopes, spheres, and Eulerian partially ordered sets (with M. M. Bayer), Inv. Math. **79** (1985), 143–157.

Homology of smooth splines: generic triangulations and a conjecture of Strang, Trans. Amer. Math. Soc. **310** (1988), 325–340.

Fiber polytopes (with B. Sturmfels), Annals of Math. **135** (1992), 527–549.

Geometry of the space of phylogenetic trees (with S. Holmes and K. Vogtmann), Advances in Applied Mathematics **27** (2001), 733–767.

Peak quasisymmetric functions and Eulerian enumeration (with S. K. Hsiao and S. van Willigenburg), Advances in Mathematics **176** (2003), 248–276.

David Bock

Senior Lecturer of Mathematics and K-12 Education and Outreach Coordinator

I am generally interested in the teaching and learning of mathematics. I coordinate Mathematics Department outreach efforts that bring department members together with K–12 students for enrichment activities and with teachers for professional development opportunities. I also lead workshops for current and pre-service teachers and teach a graduate course for prospective secondary math teachers. Currently I am active in the development of pedagogical initiatives for undergraduate statistics and have co-authored three textbooks. My most recent presentations at the Annual NCTM Meeting (National Council of Teachers of Mathematics) and at the Advanced Placement National Conference addressed strategies for teaching statistical inference.

Selected Publications

How to Prepare for the AP Calculus Examination (with S. Hockett), Barron's, 2005 (8th ed.), 620 pages.

Is That an Assumption or a Condition?, paper posted by The College Board at their APCentral website.

Why Variances Add — And Why It Matters, paper posted by The College Board at their APCentral website.

Intro Stats (with R. DeVeaux and P. Velleman), Addison-Wesley, 2003 (2nd ed.), 677 pages.

Stats: Data and Models (with R. DeVeaux and P. Velleman), Addison-Wesley, 2004, 743 pages.

Stats: Modeling the World (with R. DeVeaux and P. Velleman), Prentice Hall, 2007 (2nd ed.), 680 pages.

James H. Bramble

Professor Emeritus of Mathematics

For the past 25 years I have been interested in the development of the theoretical foundation of finite-element methods for the approximation of solutions of elliptic and parabolic partial differential equations. Recently I have concentrated on questions concerning rapid solution of large-scale systems that result from such approximations. Such a question is: Among all the theoretically good approximations to a general class of problems, are there some that can be solved efficiently by taking advantage of modern computer architectures such as parallelism? Answers to questions like this one can bring many problems into the realm of practical feasibility. My current research interest is the design of approximations to solutions to problems in partial differential equations that adequately describe the problem and that can be efficiently solved using modern computing power. In particular, I have been most recently interested in Maxwell's Equations and acoustics, including scattering problems.

Selected Publications

A new approximation technique for div-curl systems (with J. E. Pasciak), Math. Comp. **73** (2004), 1739–1762.

Analysis of a finite PML approximation for the three dimensional time-harmonic Maxwell and acoustic scattering problems (with J. E. Pasciak), Math. Comp. (to appear).

The approximation of the Maxwell eigenvalue problem using a least squares method (with T. Kolev and J. E. Pasciak), Math. Comp. (to appear).

Nathan Broaddus

H. C. Wang Assistant Professor of Mathematics

I am interested in the topology and geometry of 3-manifolds. In particular I am interested in algorithmic problems arising from 3-manifolds.

Selected Publications

Noncyclic covers of knot complements, Geometriae Dedicata (to appear).

Kenneth Brown

Professor and Chair of Mathematics

My main interests have been algebra and topology. I have especially enjoyed using topological methods to study infinite discrete groups. In some of my early work, for instance, I studied Euler characteristics of groups. I obtained formulas relating the Euler characteristic (a topological concept) to purely algebraic properties of groups. When applied in special cases, these formulas unexpectedly led to new results in algebraic number theory. Later, I found topological methods for studying two interesting families of groups: infinite simple groups, and groups that can be presented by means of a complete rewriting system.

My work has recently had unexpected applications to probability theory. I have used methods of algebra and topology to analyze an interesting family of random walks.

Selected Publications

Euler characteristics of discrete groups and G-spaces, Invent. Math. **27** (1974), 229–264.

Cohomology of Groups, Graduate Texts in Mathematics **87**, Springer-Verlag, New York, 1982.

Buildings, Springer-Verlag, New York, 1989.

Semigroups, rings and Markov chains, J. Theoret. Probab. **13** (2000), 871–938.

Forest diagrams for elements of Thompson's group F (with James Belk), Internat. J. Algebra Comput. **15** (2005), 815–850.

Kariane Calta

H. C. Wang Assistant Professor of Mathematics

My research involves the dynamics of the geodesic flow on translation surfaces, i.e. 2-manifolds whose transition functions are translations. I am also interested in the orbit structures of these surfaces in the moduli space of abelian differentials. Some of my research has applications to the study of billiards.

Selected Publications

Veech surfaces and complete periodicity in genus two, JAMS **17** no. 4 (2004), 871–908.

Xiaodong Cao

Assistant Professor of Mathematics

My research has been concentrated on the study of geometric evolution equations and their applications to differential geometry. I am especially interested in the Ricci flow, its singularities, long time existence and convergence.

Selected Publications

Isoperimetric estimate for the Ricci flow on $S^2 \times S^1$, Communications in Analysis and Geometry **13** no. 4 (2005), 1–13.

Eigenvalues of $(-\Delta + R/2)$ *on manifolds with nonnegative curvature operator* (submitted).

Compact gradient shrinking Ricci solitons with positive curvature operator (submitted).

Dimension reduction under the Ricci Flow on manifolds with nonnegative curvature operator, preprint (2005).

Stephen U. Chase

Professor of Mathematics

With the exception of my early work on module theory, homological algebra, and abelian groups, the enduring theme of my mathematical interests and research has been the Galois theory of rings and fields, and variations of these theories in which the role of the classical Galois group is played by some related algebraic structure such as a restricted Lie algebra, group scheme, Hopf algebra, or groupoid. This work impinges upon and utilizes techniques from other areas in which I also have strong interests, such as category theory and homological algebra, group theory, group schemes and Hopf algebras, representation theory, algebraic *K*-theory, and algebraic number theory.

Following a period in my career in which the main focus of my research was the Galois module structure of algebraic integers, I have returned to investigations in pure algebra; these involve primarily Hopf algebras (especially quantum groups and Tannakian reconstruction) and, more recently, finite groups (especially the structure of *p*-groups).

Selected Publications

Galois theory and Galois cohomology of commutative rings (with D. K. Harrison and A. Rosenberg), Amer. Math. Soc. Memoir **52** (1965).

Hopf algebras and Galois theory (with M. E. Sweedler), Lecture Notes in Math **97**, Springer-Verlag, 1969.

Infinitesimal group scheme actions on finite field extensions, Amer. J. Math. **98** (1976), 441–480.

Ramification invariants and torsion Galois module structure in number fields, J. Algebra **91** (1984), 207–257.

Hsiao-Bing Cheng

VIGRE Assistant Professor of Mathematics

I am primarily interested in the study of parabolic geometric flows, and in particular, the Ricci and Mean Curvature flows. Much like the heat flow, these flows often have a "smoothing" effect and can thus be used to help find "simple" or canonical geometries on a given space.

Parabolic flows are also used extensively for numerical computations which are geometric in nature.

Marshall M. Cohen

Professor Emeritus of Mathematics

I am a geometric topologist and a combinatorial group theorist. Much of my work has dealt with the introduction of combinatorial and algebraic themes into geometric problems or geometric themes into combinatorial and algebraic problems. Over the years this work has involved the intermingling of topological manifolds, combinatorial topology, the foundations of piecewise linear topology, simple-homotopy theory, automorphisms of free groups, spaces of length functions on groups and equations over groups. Currently the second best description of me is as a geometric group theorist.

The title I most covet is that of teacher. The writing of a research paper and the teaching of freshman calculus, and everything in between, falls under this rubric. Happy is the person who comes to understand something and then gets to explain it.

In addition to research and teaching I deeply enjoy my role as faculty advisor to undergraduates. These days research, teaching and advising are done in my position as Visiting Professor at Morgan State University, the Urban University of Maryland and one of the classic HBCU's (Historically Black Colleges and Universities).

Selected Publications

Simplicial structures and transverse cellularity, Annals of Math. (2) **85** (1967), 218–245.

A Course in Simple-Homotopy Theory, Graduate Texts in Mathematics **10**, Springer Verlag, 1973.

On the dynamics and the fixed subgroup of a free group automorphism (with Martin Lustig), Inv. Math. **96** (1989), 613–638.

Very small group actions on R-trees and Dehn twist automorphisms (with Martin Lustig), Topology **34** (1995), 575–617.

The surjectivity problem for one-generator, one-relator extensions of torsion-free groups (with Colin Rourke), Geometry and Topology **5** (2001), 127–142.

Ode to geometric group theory, American Mathematical Monthly (Aug/Sept 2005), to appear.

Robert Connelly

Professor of Mathematics

Discrete geometry, with emphasis on the geometry of rigid and flexible structures, is my main area of interest. A tensegrity is a structure composed of sticks held in mid-air with strings that, nevertheless, holds its shape. This can be modeled very nicely as a configuration of points with upper and lower bounds on the distances between certain pairs of points. This in turn leads to interesting problems in, and applications to, distance geometry and the theory of packings and coverings of spheres as well as applications to robotics, protein folding, motion planning and percolation problems in physics and probability.

Another subject of interest is the theory of flexible surfaces. There are triangulated surfaces that flex, keeping their edges at a fixed length, and it has recently been shown that such surfaces maintain a fixed volume while they flex. There is no perfect mathematical bellows. This is also related to a polynomial that relates the volume of the surface to the lengths of its edges. This is at the intersection of discrete geometry, algebraic geometry and topology.

Selected Publications

Mathematics and tensegrity (with A. Back), American Scientist March-April (1998), 142–151.

Tensegrity structures: Why are they stable?; in Rigidity Theory and Applications (M. F. Thorpe and P. M. Duxbury, eds.), Kluwer Academic/Plenum, 1999, pp. 47–54.

The Kneser-Poulsen conjecture (with K. Bezdek), Crelle's Journal, J. reine angew. Math. **553** (2002), 221–236.

The Kneser-Poulsen conjecture for spherical polytopes (with K. Bezdek), submitted.

Straightening polygonal arcs and convexifying polygonal cycles (with E. Demaine and G. Rote), in preparation.

Sarah Day

VIGRE Assistant Professor of Mathematics

I have been working mainly in the area of rigorous numerical techniques for dynamical systems. In particular, I am interested in methods based on an algebraic topological tool called the Conley index. These methods have been used with a number of systems to prove the existence of dynamical objects from fixed points to chaotic attractors. Currently, I am investigating extensions to a wider class of problems in dynamical systems, including bifurcation analysis as well as applications to the study of biological models.

Selected Publications

Towards a rigorous numerical study of the Kot-Schaffer model, Dynamic Systems and Applications **12** no. 1–2 (2003), 87–98.

A rigorous numerical method for the global analysis of infinite dimensional discrete dynamical systems (with O. Junge and K. Mischaikow), SIAM Journal on Applied Dynamical Systems **3** no. 2 (2004), 117–160.

Towards automated chaos verification (with O. Junge and K. Mischaikow), Proc. Equadiff 2003, World Scientific, Singapore, 2005, pp. 157–162.

Rigorous Numerics for Global Dynamics: a study of the Swift-Hohenberg equation (with Y. Hiraoka, K. Mischaikow, and T. Ogawa), SIAM Journal on Applied Dynamical Systems **4** no. 1 (2005), 1–31.

R. Keith Dennis

Professor of Mathematics

Most of my research has been in the field of algebraic *K*-theory. This field is, in some sense, a fancy generalization of linear algebra to arbitrary rings. As such, it has applications in many other areas of mathematics such as topology, algebraic geometry, and even the theory of Markov processes. I have been most interested in the computational aspects of the subject, in particular, the computation of quotients of rings of algebraic integers and in the computation of the Whitehead group for finite abelian groups.

Parts of this work have involved the use of computers to understand a number of examples before formulating and proving the general results. This work has led to the study of questions about group rings, number theory, and theory of finite groups. My current interest lies in studying a number of problems relating to commutators, structure, and invariants of finite groups which can be investigated by computer computations.

While I was executive editor of *Mathematical Reviews*, I became interested in problems dealing with mathematical communication, databases and mathematical bibliography, and how to convert the older mathematical literature into searchable electronic form. I have mainly been involved with these issues during the last several years.

Selected Publications

Recent developments in digital library technologies (with G. O. Michler, M. Suzuki and G. Schneider); in DIAR-03: Workshop on Document Image Analysis and Retrieval (to appear).

Computation of the Scharlau invariant (with Paul Young), in preparation.

Homogeneous functions and algebraic K-theory (with R. Laubenbacher), in preparation.

The number of groups of order n, in preparation.

Generic product decompositions of finite groups, in preparation.

Richard Durrett

Professor of Mathematics

My initiation to work at the interface between mathematics and biology came from a collaboration with Simon Levin that was begun in the late 80's and produced 10 pages on the use of stochastic spatial models in ecology.

In 1997 I began a collaboration with Chip Aquadro in Molecular Biology and Genetics at Cornell. Our first paper on the evolutionary dynamics of DNA repeat sequences (e.g., CA repeated 15 times in a row) was published in the Proceedings of the National Academy of Science. Subsequent work with two graduate students has shown that the dependence of mutation rates on length of repeat is not simple and selection acts to reduce the length of long repeats.

With Rasmus Nielsen in Biological Statistics and Computational Biology, I have developed stochastic methods for studying the evolution of genomes due to large-scale processes: inversions within chromosomes, translocations between chromosomes, chromosomal fissions and fusions, and gene duplication. This work has led to a surprising new result on the behavior of the distance from the origin for random walk on the transposition group.

Joint work with Ted Cox and Iljana Zahle has studied the influence of spatial structure on genealogies. With Jason Schweinsberg, we developed a simple approximation for the effect of fixation of advantageous mutations on the variability of nearby nucleotides. Gene duplication is another topic that I have considered in three papers that are joint work with REU student Rachel Ward, with Deena Schmidt, and with Jason Schweinsberg.

Recently I have become interested in random graphs. Notes from a course I taught in fall 2004 will end up as a short book or long paper on the subject. In addition, I have done research on this topic with REU student Jonah Balisak and with Paul Jung.

Selected Publications

Microsatellite models: Insights from a comparison of humans and chimpanzees (with R. Sainudiin, C. F. Aquadro, and R. Nielsen), Genetics **168** (2004), 383–395.

Bayesian estimation of genomic distance (with R. Nielsen and T. L. York), Genetics **166** (2004), 621–629.

Subfunctionalization: How often does it occur? How long does it take? (with R. Ward), Theor. Pop. Biol. **66** (2004), 93–100.

Adaptive evolution drives the diversification of zinc-finger binding domains (with D. Schmidt), Mol. Biol. Evol. **21** (2004), 2326–2339.

Approximating selective sweeps (with J. Schweinsberg), Theor. Pop. Biol. **66** (2004), 93–100; Ann. Appl. Probab. (to appear).

The stepping stone model, II. Genealogies and the infinite sites model (with I. Zahle and J. T. Cox), Ann. Appl. Probab. **15** (2005), 671–699.

A phase transition in the random transposition random walk (with N. Berestycki), Prob. Theory Rel. Fields (to appear).

Power laws for family sizes in a gene duplication model (with J. Schweinsberg), Ann. Prob. (to appear).

Random Oxford graphs (with J. Blasiak), Stochastic Process and their Applications (to appear).

Two phase transitions for the contact process on small worlds (with P. Jung), Ann. Appl. Probab. (to appear).

Eugene B. Dynkin

Professor of Mathematics and A. R. Bullis Chair

Lie groups were the main subject of my earlier research. Dynkin's Diagrams are widely used by mathematicians and physicists. After 1954, probability theory became the central field of my interests. Principal efforts were devoted to Markov processes and their connections with potential theory and partial differential equations. Other work includes research in mathematical statistics (sufficient statistics, exponential families), optimal control (optimal stopping, control with incomplete data) and mathematical economics (economic growth and economic equilibrium under uncertainty).

In the 80s I worked on the relationship between Markov processes and random fields that arise in statistical physics and quantum field theory. One of the results — an isomorphism theorem connecting Gaussian fields with local times for Markov processes — has a considerable impact on the work of a number of investigators. For the last decade, my main efforts are devoted to the theory of measure-valued branching processes. (The name *superprocesses* suggested by me for these processes is now standard in mathematical literature.) Connections between superdiffusions and a class of nonlinear partial differential equations were established that makes it possible to apply powerful analytic tools for investigating the path behavior of superdiffusions, and that provides a new probabilistic approach to problems of nonlinear PDEs. New directions — the description of all positive solutions of a certain class of nonlinear equations and the study of removable boundary singularities of such solutions — have been started in a series of joint papers of Dynkin and Kuznetsov. A theory developed by them and by a number of other investigators is presented in a systematic way in a monograph of Dynkin published in 2002.

The complete classification of positive solutions of nonlinear equations $\Delta u = u^{\alpha}$ with $1 < \alpha \leq 2$ in a bounded smooth domain resulted from a series of papers by Dynkin and by Dynkin and Kuznetsov written in 2003. A systematic presentation of these results is contained in a book of Dynkin published in 2004.

Selected Publications

An Introduction to Branching Measure-Valued Processes, CRM Monograph Series **6**, American Mathematical Society, Providence, RI, 1994.

Fine topology and fine trace on the boundary associated with a class of semilinear differential equations (with S. E. Kuznetsov), Comm. Pure and Appl. Math. **51** (1998), 897–936.

Selected Papers of E. B. Dynkin with Commentary, Amer. Math. Soc. and International Press, 2000.

Diffusions, Superdiffusions and Partial Differential Equations, AMS Colloquium Publications, Vol. 50, Providence, Rhode Island, 2002.

Superdiffusions and positive solutions of nonlinear partial differential equations, American Mathematical Society, University Lecture Series, Volume 34, 2004.

An application of probability to nonlinear analysis, Proceedings of the Second Abel Symposium, Oslo 2005 (to appear).

Clifford J. Earle

Professor Emeritus of Mathematics

Most of my research concerns invariants belonging to Riemann surfaces. I am especially interested in learning how these invariants change when the complex structure of the Riemann surface is modified. A useful technique is to consider a family of Riemann surfaces depending holomorphically on some parameters and to study how the invariants of the surface change as we move about in the parameter space. Quasiconformal maps and Kleinian groups have proved to be fundamental tools for the construction of good parameter spaces, so I have studied and used them extensively.

Selected Publications

A fibre bundle description of Teichmüller theory (with J. Eells, Jr.), J. Diff. Geom. **3** (1969), 19–43.

Families of Riemann surfaces and Jacobi varieties, Ann. Math. **107** (1978), 255–286.

Conformally natural extension of homeomorphisms of the circle (with A. Douady), Acta Math. **157** (1986), 23–48.

Holomorphic motions and Teichmüller spaces (with I. Kra and S. L. Krushkal), Trans. Amer. Math. Soc. **343** (1994), 927–948.

Geometric isomorphisms between infinite dimensional Teichmüller spaces (with F. P. Gardiner), Trans. Amer. Math. Soc. **348** (1996), 1163–1190.

Roger H. Farrell

Professor Emeritus of Mathematics

Retired as of July 1, 1999, I am still semi-active in the department and try to come in most days to audit classes and work some in the Math Support Center. I am not active in research.

My research concerned the application of decision theory methods to statistical problems to try and characterize completely good and bad methods of estimation and testing. Useful decision theory methods can involve development of inequalities, compactification of spaces, and study of the way sequences of measures converge.

Selected Publications

Proof of a necessary and sufficient condition for admissibility in discrete multivariate problems (with L. D. Brown), J. Mult. Annal. **24** (1988), 46–52.

All admissible linear estimators of the vector of gamma state parameters with application to random effects models (with W. Klonecki and S. Zontek), Ann. Statist. **17** (1989), 268–281.

A lower bound for the risk in estimating the value of a probability density (with L. D. Brown), JASA **85** (1990), 1147–1153.

Estimations of accuracy in testing (with J. T. G. Hwang, G. Casella, C. Robert and M. T. Wells), Ann. Statist. **20** (1992), 490–509.

Spitzer and Bohnenblust, revisited (1997), preprint.

Leonard Gross

Professor of Mathematics

My research could, for the most part, be described as analysis over infinite dimensional spaces. This has sometimes been motivated by problems of mathematical physics, specifically statistical mechanics and the problem of existence of quantum fields. There is usually a naturally arising probability measure on the infinite dimensional space of interest to me that links functional analytic questions to probability theory. In the early 1990s I studied properties of the Dirichlet form associated to pinned Brownian motion on loop groups. A long-range goal was proof of a Hodge-deRham theorem for these manifolds of maps. More recently, I have studied Dirichlet forms in holomorphic function spaces over a complex manifold and their link to a strong kind of hypercontractivity.

Selected Publications

Existence and uniqueness of physical ground states, J. Func. Anal. **10** (1972), 52–109.

Logarithmic Sobolev inequalities, American J. Math. **97** (1975), 1061–1083.

Uniqueness of ground states for Schrödinger operators over loop groups, J. Func. Anal. **112** (1993), 373–441.

Hypercontractivity over complex manifolds, Acta Math. **182** (1999), 159–206.

Holomorphic Dirichlet forms on complex manifolds (with Z. Qian), Math. Z. **246** (2004), 521–561.

John M. Guckenheimer

Professor of Mathematics and Associate Dean of Computing & Information Science

Dynamical systems theory studies long time behavior of systems governed by deterministic rules. Even the simplest nonlinear dynamical systems can generate phenomena of bewildering complexity. Formulas that describe the behavior of a system seldom exist. Computer simulation is the way to see how initial conditions evolve for particular systems. In carrying out simulations with many, many different systems, common patterns are observed repeatedly. One of the main goals of dynamical systems theory is to discover these patterns and characterize their properties. The theory can then be used as a basis for description and interpretation of the dynamics of specific systems. It can also be used as the foundation for numerical algorithms that seek to analyze system behavior in ways that go beyond simulation. Throughout the theory, dependence of dynamical behavior upon system parameters has been an important topic. Bifurcation theory is the part of dynamical systems theory that systematically studies how systems change with varying parameters.

My research is a blend of theoretical investigation, development of computer methods and studies of nonlinear systems that arise in diverse fields of science and engineering. Much of the emphasis is upon studying bifurcations. The computer package DsTool is a product of the research of former students and myself with additional contributions from postdoctoral associates. It provides an efficient interface for the simulation of dynamical models and incorporates several additional algorithms for the analysis of dynamical systems. The program is freely available, subject to copyright restrictions. My current work focuses upon the dynamics of systems with multiple time scales, algorithm development for problems involving periodic orbits and upon applications to the neurosciences, animal locomotion and control of nonlinear systems.

Selected Publications

Nonlinear Oscillations, Dynamical Systems and Bifurcation of Vector Fields (with P. Holmes), Springer-Verlag, 1983, 453 pp.

Phase portraits of planar vector fields: computer proofs, J. Experimental Mathematics **4** (1995), 153–164.

An improved parameter estimation method for Hodgkin-Huxley model (with A. R. Willms, D. J. Baro and R. M. Harris-Warrick), J. Comp. Neuroscience **6** (1999), 145–168.

Computing periodic orbits and their bifurcations with automatic differentiation (with B. Meloon), SIAM J. Sci. Stat. Comp. **22** (2000), 951–985.

The forced van der Pol equation I: the slow flow and its bifurcations (with K. Hoffman and W. Weckesser), SIAM J. App. Dyn. Sys. **2** (2002), 1–35.

Allen Hatcher

Professor of Mathematics and Director of Undergraduate Studies

A common thread through much of my research is the idea of studying the space of all topological objects of a certain kind, for example, the space of all finite polyhedra, the space of all diffeomorphisms of a manifold, or the space of all knots. Recently I have also been writing a couple of graduate-level textbooks in topology.

Selected Publications

Higher simple homotopy theory, Annals of Math. **102** (1975), 101–137.

A proof of the Smale conjecture, Annals of Math. **117** (1983), 553–607.

Algebraic Topology, Cambridge University Press, 2002. (Available online at www.math.cornell.edu/~hatcher.)

Timothy J. Healey

Professor and Chair of Theoretical and Applied Mechanics

I work at the interface between nonlinear analysis of pde's — mostly elliptic systems — and the mechanics of elastic structures and solid continua. Nonlinear (finite) elasticity is the central model of continuum solid mechanics. It has a vast range of applications, including flexible engineering structures, biological structures — both macroscopic and molecular, and materials like elastomers and shape-memory alloys — everything from fighter jets to lingerie! Although the beginnings of the subject date back to Cauchy, the current state of existence theory is quite poor; properly formulated problems of the subject are often out of the range of present day mathematics. In other words there are many open problems.

My work ranges from the abstract — e.g., developing a generalized nonlinear Fredholm degree to obtain solutions "in the large" in 3-D nonlinear elasticity — to the more concrete — e.g., modeling the helical microstructure of DNA in elastic rod models. Most recently I have become quite interested in the analysis of elastic surfaces in models inspired by "biological membranes."

Selected Publications

Global continuation in nonlinear elasticity (with H. Simpson), Arch. Rat. Mech. Anal. **143** (1998), 1–28.

Global continuation in displacement problems of nonlinear elastostatics via the Leray-Schauder degree, Arch. Rat. Mech. Anal. **152** (2000), 273–282.

Global continuation via higher-gradient regularization and singular limits in forced one-dimensional phase transitions (with H. Kielhöfer), SIAM J. Math. Anal. **31** (2000), 1307.

Material symmetry and chirality in nonlinearly elastic rods, Math. Mech. Solids 7 (2002), 405–420.

Global bifurcation in nonlinear elasticity with an application to barrelling states of cylindrical columns (with E. Montes), J. Elasticity **71** (2003), 33–58.

David W. Henderson

Professor of Mathematics

There is a huge crisis in the teaching and learning of mathematics in the world — this crisis is affecting the future of mathematics. My work on mathematics is having an impact on this crisis by stressing that teachers (and thence their students) learn and experience ways of thinking that are as close as possible to the ways that mathematicians think, but yet simultaneously paying attention to the cognitive development of students and teachers and the underlying meanings and intuitions of the mathematics. Only a mathematician with mathematical research experiences can do this work. My main thesis is that we should enliven our conception of what "proof" is and that proofs should be a central part of mathematics teaching at all levels, where my definition of "proof" is: *A convincing communication that answers — Why*. This part of my work on mathematics (as it relates to teaching and learning) I am now calling *Educational Mathematics*.

In addition, I am currently involved in extensive mathematics curriculum innovation projects. My first book, *Experiencing Geometry on Plane and Sphere* (1996), has recently appeared in an expanded and revised third edition: *Experiencing Geometry: Euclidean and Non-Euclidean With History* (with Daina Taimina; Pearson Prentice-Hall, 2005). My second book, *Differential Geometry: A Geometric Introduction* (1998) has just appeared in a Revised Second Edition (2005) and a new Self Study Edition (2006). In 2005 I accepted an invitation to join the high school curriculum development team for Robert Moses' *Algebra Project*.

Selected Publications

Extended hyperbolic surfaces in R^3; in the Ludmilla Keldysh Memorial Volume, Proceedings of the Steklov Institute of Mathematics **247**, 2004, pp.1–13.

Numerous mathematical descriptions and educational modules (some jointly with Daina Taimina) for KMODDL: Kinematic Models for Design — Digital Library; part of the National Science Digital Library, 2004-2005. http://kmoddl.library.cornell.edu/

Experiencing Geometry: Euclidean and Non-Euclidean With History (with Daina Taimina), 3rd Edition, Pearson Prentice-Hall, 2005. (pp: xxx + 402)

How to use history to clarify common confusions in geometry (with Daina Taimina); Chapter 6 in From Calculus to Computers: Using Recent History in the Teaching of Mathematics (A. Shell and D. Jardine, eds.), MAA Notes **68**, 2005, pp. 57–73.

Non-Euclidean geometry (with Daina Taimina) and *Differential geometry,* signed articles in Encyclopedia Britannica, 2005.

Differential Geometry: A Geometric Introduction, Cornell Custom Publishing, Revised Second Edition, 2005; and Self Study Edition, 2006.

Experiencing Meanings in Geometry (with Daina Taimina); Chapter 3 in Aesthetics and Mathematics (David Pimm and N. Sinclair, eds.), Springer-Verlag, 2005, pp. 58–83.

Alive mathematical reasoning; a chapter in Educational Transformations: Changing our lives through mathematics; A tribute to Stephen Ira Brown (L. Copes and F. Rosamond, eds.), Bloomington, Indiana: AuthorHouse, 2006, pp. 247–270.

Tara Holm

Assistant Professor of Mathematics

The focus of my research is symplectic geometry and its relationships with combinatorics, algebraic topology, and algebraic geometry. Recent projects include: (1) studying real loci of symplectic manifolds and the corresponding varieties in real algebraic geometry; and (2) investigating the topology of symplectic quotients that are orbifolds.

Selected Publications

The equivariant cohomology of Hamiltonian G-spaces from residual S^1 actions (with Rebecca Goldin) Math. Res. Letters **8** (2001), 67–78.

Distinguishing chambers of the moment polytope (with Rebecca Goldin and Lisa Jeffrey), J. Symp. Geom. **2** no. 1 (2003), 109–131.

The mod 2 equivariant cohomology of real loci (with Daniel Biss and Victor Guillemin), Adv. in Math. **185** (2004), 370–399.

Conjugation spaces (with Jean-Claude Hausmann and Volker Puppe), Algebr. Geom. Topol. **5** (2005), 923–964.

Computation of generalized equivariant cohomologies of Kac-Moody flag varieties (with Megumi Harada and Andre Henriques), Adv. in Math. (to appear).

Orbifold cohomology of torus quotients (with Rebecca Goldin and Allen Knutson), preprint.

John H. Hubbard

Professor of Mathematics

Differential equations are the main way in which mathematical models of real systems are constructed, and understanding their behavior is the main contribution a mathematician can make to applications. I am interested in understanding the behavior of differential equations and their close relatives: iterative systems. In particular, I try to see how such systems behave in the complex domain, largely because complex analysis brings new and powerful techniques to bear on the problems.

The availability of powerful computers and computer graphics has changed the way this sort of research is done. In the course of investigations of even such simple iterative systems as quadratic polynomials, amazing pictures show up, rather as artifacts to be investigated than as man-made objects. I anticipate that this sort of experimental mathematics will become a major trend.

Most of my research over the last five years has been devoted to dynamics in several complex variables. I have co-authored four foundational papers in the field. I am also writing three books on a very advanced level, one giving a treatment of Teichmüller space and its applications in theorems of Bill Thurston, the second on dynamics of one complex variable, and the third on differential geometry.

Selected Publications

Differential Equations, A Dynamical Systems Approach Part I (with B. West), Texts in Applied Mathematics **5**, Springer-Verlag, NY, 1991.

Differential Equations, A Dynamical Systems Approach: Higher Dimensional Systems (with B. West), Texts in Applied Mathematics **18**, Springer-Verlag, NY, 1995.

Vector Calculus, Linear Algebra and Differential Forms, A Unified Approach (with Barbara Burke Hubbard), 2nd edition, Prentice Hall, 2002.

Student Solution Manual to Accompany Vector Calculus, Linear Algebra and Differential Forms, A Unified Approach; Matrix Editions (with Barbara Burke Hubbard), 2002.

J. T. Gene Hwang

Professor of Mathematics

Recently, I started to focus mainly on the theory of statistical intervals. Statistical intervals, such as confidence intervals, prediction intervals and tolerance intervals are one of the major areas in statistics. By providing intervals, statisticians demonstrate the possible range of the interested parameters or future observations.

Much of my research is stimulated by scientific and engineering applications. Although my primary interest is in theory, the solutions often can be used directly in application. My recent joint work with the National Institute of Standards and Technology is one example.

Selected Publications

Optimal confidence sets, bioequivalence and the limacon of Pascal (with L. D. Brown and G. Casella), JASA **90** (1995), 880–890.

Maximum likelihood estimation under order restricted parameters by the prior feedback method (with C. Robert), JASA **91** (1996), 167–172.

An unbiased test for the bioequivalence problem (with L. D. Brown and Axel Munk), Ann. Stat. **25** (1997), 2345–2367.

Prediction intervals in artificial neural network (with A. Adam Ding), JASA **92** (1997), 748–757.

Prediction intervals, factor analysis models and high-dimensional empirical linear prediction (HELP) (with A. Adam Ding), JASA, to appear.

Yulij Ilyashenko

Professor of Mathematics

Dynamical systems describe evolutionary processes in the world around us. The theory of these systems stimulated the development of different branches of mathematics like topology, Lie groups theory, theory of automorphic functions and so on. The modern theory of dynamical systems contains two parts: higher and lower dimensional systems. The first part is much larger than the second one. Its major goal, amidst others, is to understand the chaotic behavior of deterministic systems, and, in particular, to explain the hydrodynamical turbulence. One of the major problems in the lower dimensional theory, namely, in the theory of planar differential equations, is the Hilbert's 16th problem: *what may be said about number and location of limit cycles of a planar polynomial vector field with components of degree n?* This problem still stays unsolved, but motivated a lot of progress in the theory.

In multidimensional theory, together with my students, I try to find new properties of dynamical systems that persist under small perturbations. The study is based on the heuristic principle: *any effect that occurs in random dynamical systems may be found as well in deterministic ones.* This principle was discovered during the study of nonlocal bifurcations [5] and developed in [13], [7], [6].

New definitions of attractors were suggested in [4]; I study them now together with my students.

The main paradigm of my study of the Hilbert 16th problem is to apply methods of multidimensional complex analysis and theory of Riemann surfaces to the study of real polynomial differential equations. The survey of this approach is contained in [9]. A larger survey of the whole theory is presented in [14]. New methods in the study of complex dynamical systems were developed, in particular, in [12], [8], [3]. Complex dynamical systems gave rise to a new branch of complex analysis, namely, to the theory of *functional cochains and nonlinear Stokes Phenomena* [2]. These cochains were applied to the proof of a partial answer to Hilbert's question: *Any polynomial vector field has but a finite number of limit cycles* [1].

A list of problems that forms my present field of interests is presented in [11]. It was a subject of a minicourse taught in a summer school organized by Christiane Rousseau and myself in Montreal, 2002 [10]. Three lecturers of this school — A. Glutsyuk, V. Kaloshin, and S. Yakovenko — are my former students.

Selected Publications

1. *Finiteness Theorems for Limit Cycles*, AMS, Transl. **94**, 1991, 288 pp.
2. Editor of *Nonlinear Stokes Phenomena*, Advances in Soviet Mathematics **14**, AMS, 1993, 287 pp.
3. Editor (with Yakovenko) of *Concerning Hilbert's 16th Problem*, AMS, 1995, 219 pp.
4. *Minimal and strange attractors* (with Gorodetski), Int'l J. Bifurcation and Chaos **6** no. 6 (1996), 1177–1183.
5. *Nonlocal Bifurcations* (with Li Weigu), Mathematical Surveys and Monographs **66**, AMS, 1999.
6. *Some new robust properties of invariant sets and attractors of dynamical systems* (with Gorodetski), Funct. Anal. Appl. **33** no. 2 (1999), 16–32.
7. *Some properties of skew products over a horseshoe and solenoid* (with A. Gorodetski), Proceedings of the Steklov Institute **231** (2000), 96–118.
8. *Some upper estimates of the number of limit cycles of planar vector fields with applications to Lienard equation* (with A. Panov), Moscow Mathematical Journal **1** no. 4 (2001), 583–599.
9. *Centennial history of Hilbert's 16th problem*, Bull. AMS **39** no. 3 (2002), 301–354.
10. Editor (with C. Rousseau) of *Normal Forms, Bifurcations and Finiteness Problems in Differential Equations*, Proceedings of a NATO seminar, Montreal, 2002, Kluwer, 2004.
11. *Selected topics in differential equations with real and complex time*; in Normal Forms, Bifurcations and Finiteness Problems in Differential Equations, Kluwer, 2004, pp. 317–354.
12. *Kupka-Smale theorem for polynomial automorphisms of C^2 and persistence of heteroclinic intersections* (with G. Buzzard and S. Hruska), Invent. Math. **161** (2005), 45–89.
13. *Non-removable zero Lyapunov exponents* (with A. Gorodetski, V. Kleptsyn, M. Nalski), Functional Analysis and Appl. **39** no. 1 (2005).
14. *Lectures on analytic differential equations* (with S. Yakovenko), book in preparation.

Paul Jung

VIGRE Assistant Professor of Mathematics

My research area is the subdiscipline of stochastic processes called interacting particle systems. In particular I am interested in the ergodic or long-run behavior of these processes. Many of these issues are motivated by problems arising in statistical mechanics. Recently, I am interested in the application of these processes to ecology and biology.

Selected Publications

Extremal reversible measures for the exclusion process, Journal of Statistical Physics (July 2003).

Perturbations of the symmetric exclusion process, Markov Processes and Related Fields **10** no. 4 (2004).

The critical value of the contact process with added and removed edges, J. Theoretical Probability (to appear).

The noisy voter-exclusion process, Stochastic Processes and Applications (to appear).

Two phase transitions for the contact process on small worlds, submitted for publication.

Peter J. Kahn

Professor of Mathematics

For the past few years, I have been working in the area of symplectic topology. My current interests include various existence and classification questions concerning symplectic forms on the total spaces of symplectic fibrations.

Selected Publications

Pseudohomology and homology (Nov. 2001), 35 pp.

Symplectic torus bundles and group extensions (updated Jan. 2005), 20 pp.

Automorphisms of the discrete Heisenberg group (Feb. 2005), 7 pp.

Martin Kassabov

H. C. Wang Assistant Professor of Mathematics

My research interests fall into two main categories: (1) representation theory of discrete groups, mainly Kazhdan property and property tau; (2) combinatorial algebra — applications of different combinatorial methods in abstract algebra.

The main part of my research is related to properties T and tau. These properties arise from the representation theory, and they have many applications in combinatorics.

Another part of my research can be broadly described as combinatorial algebra. My research interests are concentrated in the following topics: automorphism groups, Golod-Shafarevich groups, group rings.

Selected Publications

Kazhdan constants for $SL_n(Z)$, International Journal of Algebra and Computation (to appear).

Symmetric groups and expanders (announcement), Electronic Research Announcements of AMS (to appear).

Diameters of Cayley graphs of $SL_n(Z/kZ)$ (with Tim Riley), preprint January 2005.

Universal lattices and property Tau (with N. Nikolov), preprint February 2005.

Universal lattices and unbounded rank expanders, preprint February 2005.

Symmetric groups and expanders, preprint May 2005.

Todd Kemp

Escobar Assistant Professor of Mathematics

The arena of classical (and most modern) analysis and probability theory consists of function spaces — spaces of measurable functions, L^p functions, holomorphic functions, and so forth. Nevertheless, many theorems (particularly functional inequalities) dealing with classical function spaces can be stated in such a way that the functions themselves are no longer important.

One typical generalization of functional inequalities (motivated by quantum mechanics and quantum field theory) replaces functions with operators on Hilbert space. Some important examples include quantum (i.e., non-commutative) versions of entropy and Sobolev inequalities, as well as semigroup contraction theorems like hypercontractivity. I am primarily interested in non-commutative functional inequalities of these sorts.

In my Ph.D. thesis, I introduced a new family of non-commutative spaces that capture the essence of holomorphic L^p spaces, and I proved a Segal-Bargmann isomorphism theorem and strong hypercontractivity theorem for them. Currently, I am thinking about extending these results, and also about other contraction properties like ultracontractivity. A long-range goal is to prove a hypercontractivity theorem for (non-trivial) C^*-bundles over spin manifolds.

Selected Publications

Hypercontractivity in non-commutative holomorphic spaces, Commun. Math. Phys. **259** (2005), 615–637.

Harry Kesten

Professor Emeritus of Mathematics

I am a probabilist. My main research interests are percolation theory and random walks, and in general I like to dabble in models inspired by statistical mechanics.

One model I have recently worked on can be viewed as a model for the spread of a rumor. There are two kinds of particles, A-particles (corresponding to the people in the know) and B-particles (people who have not heard the rumor). The A-particles perform independent (continuous time) random walks on $\mathbf{Z}^d$ with distribution F_A and similarly the B-particles perform independent random walks with distribution F_B. The only interaction between all the particles is that when a B-particle meets an A-particle it turns into an A-particle and continues forever as an A-particle. We start with independent Poisson numbers of B-particles at the sites of $\mathbf{Z}^d$ and a single A-particle at the origin. How fast does the set of A-particles grow with time? In other words, what is the set of people who heard the rumor by time t, for large t? It is expected that this set grows linearly with t, but so far results are known only if $F_A = F_B$, or if the B-particles do not move at all.

Selected Publications

Products of random matrices (with H. Furstenberg), Ann. Math. Statist. **31** (1960), 457–469.

Hitting Probabilities of Single Points for Processes with Stationary Independent Increments, Memoir **93**, AMS (1969).

Percolation Theory for Mathematicians, Birkhäuser, Boston, 1982.

Aspects of first-passage percolation; in Ecole d'été de Probabilités de Saint-Flour XIV, (P. L. Hennequin, ed.), Lecture Notes in Math 1180, Springer-Verlag, 1986, pp. 125–264.

On the speed of convergence in first-passage percolation, Ann. Appl. Probab. **3** (1993), 296–338.

Dexter Kozen

Joseph Newton Pew, Jr., Professor in Engineering (Computer Science)

My research interests include the theory of computational complexity, especially complexity of decision problems in logic and algebra, and program logic and semantics. In the past I have worked on algorithms for type inference in programming languages; static analysis of programs; functional decomposition of polynomials and rational and algebraic functions; and algorithms for resolution of singularities. My most recent interests include the theory and applications of Kleene algebra and Kleene algebra with tests (Kleene/Boolean algebra) in programming language semantics and verification.

Selected Publications

Kleene algebra and bytecode verification (with Lucja Kot); in Proc. 1st Workshop Bytecode Semantics, Verification, Analysis, and Transformation (Fausto Spoto, ed.), 2005, pp. 201–215.

Coinductive proof principles for stochastic processes; in Proc. 21st Conf. Logic in Computer Science, IEEE, 2006.

Relational semantics for higher-order programs (with Kamal Aboul-Hosn); in Proc. Mathematics of Program Construction, 2006.

Automating proofs in category theory (with Christoph Kreitz and Eva Richter); in Proc. 3rd Int. Joint Conf. Automated Reasoning, 2006.

KAT-ML: an interactive theorem prover for Kleene algebra with tests (with Kamal Aboul-Hosn), Journal of Applied Non-Classical Logics (2006).

Local variable scoping and Kleene algebra with tests (with Kamal Aboul-Hosn); in Proc. 9th Int. Seminar on Relational Methods in Computer Science and 4th Int. Workshop Applications of Kleene Algebra, 2006.

Theory of Computation, Springer, New York, 2006.

Gregory F. Lawler

Professor of Mathematics

Most of my research is on random walk and Brownian motion, especially questions arising from statistical physics. A number of questions are inspired by a desire to understand self-avoiding random walk and other random walks with constraints.

Oded Schramm, Wendelin Werner, and I investigated the limit of lattice models in two dimensions that possess certain conformal invariance properties in the continuum limit. This project produced a number of results, e.g., we have verified a conjecture of Mandelbrot that the Hausdorff dimension of the outer boundary of planar Brownian motion is 4/3.

The big challenge for the future for these problems is understanding three dimensions.

Selected Publications

Intersections of Random Walks, Birkhäuser-Boston, 1991.

Values of Brownian intersection exponents I and II (with O. Schramm and W. Werner), Acta Mathematica **187** (2001), 237–273, 275–308.

Conformal restriction: the chordal case (with O. Schramm and W. Werner), JAMS **16** (2003), 917–955.

Brownian loop soup (with W. Werner), Probab. Theor. Rel. Fields **128** (2004), 565–588.

Conformally Invariant Processes in the Plane, AMS, 2005.

G. Roger Livesay

Professor Emeritus of Mathematics

My major area of research is in topology, 3-dimensional manifolds with finite cyclic fundamental groups.

Alvaro Lozano-Robledo

H. C. Wang Assistant Professor of Mathematics

I study algebraic number theory, in particular p-adic Galois representations and their deformations, and connections with elliptic units and class number divisibility problems. I am also very interested in elliptic surfaces of high rank and constructing elliptic curves of high rank.

Selected Publications

Buscando puntos racionales en curvas elipticas: Metodos explicitos, La Gaceta de la Real Sociedad Matematica Espaola (Journal of the Royal Mathematical Society of Spain) **8** no. 2 (2005), 471–488 (22 pages in spanish).

On the surjectivity of Galois representations attached to elliptic curves over number fields, Acta Arithmetica **117** no. 3 (2005), 283–291.

On elliptic units and p-adic Galois representations attached to elliptic curves, Journal of Number Theory **117** no. 2 (2006), 29 pages.

Constructing one-parameter families of elliptic curves with moderate rank (with Scott Arms and Steven J. Miller), Journal of Number Theory (to appear), 18 pages.

Elliptic curves of maximal rank (with Julian Aguirre and Juan Carlos Peral), preprint.

Carla Martin

Escobar Assistant Professor of Mathematics

My research involves computations with tensors, or multi-dimensional arrays. Specifically, I design fast algorithms to compute SVD-like tensor decompositions. Many of the powerful tools of linear algebra such as the Singular Value Decomposition (SVD) do not, unfortunately, extend easily to tensors of order three and higher. For second-order tensors (i.e., matrices) the SVD is particularly illuminating because it reduces a matrix to diagonal form. In applications (e.g., scientific computing and engineering), this reduction is useful because the SVD compresses the two-dimensional data and allows one to describe more easily interactions and relationships that exist. Extending the SVD to higher-order tensors is nontrivial; even familiar matrix concepts such as diagonalization and rank become ambiguous and complicated.

For my dissertation, I designed an algorithm to compute an orthogonal tensor decomposition such that the resulting decomposition is compressed. The algorithm is based on the Jacobi SVD algorithm for matrices and can be extended to p-dimensional tensors. While computing the tensor rank is still an open problem, both theoretically and computationally, I also developed an algorithm to compute the rank of $n \times n \times 2$ tensors. The algorithm is based on certain eigendecompositions. I was able to prove that the rank of this special subclass of tensors depends on the generalized eigenvalues of the faces of the tensor cube. The results regarding this special subclass provide insight into the general rank problem.

Selected Publications

Shifted Kronecker product systems (with C. F. Van Loan) SIAM J. Matrix Anal. (accepted).

Solving real systems with the complex Schur decomposition (with C. F. Van Loan), SIAM J. Matrix Anal. (accepted).

Decomposing a tensor (with M. E. Kilmer), SIAM News **37** no. 9 (2004).

Product triangular systems with shift (with C. F. Van Loan), SIAM J. Matrix Anal. **24** no. 1 (2001), 292–301.

Mathematician at work, Math Horizons **5** (1997), Mathematical Association of America, p. 9.

A Jacobi-type method for computing orthogonal tensor decompositions (with C.F. Van Loan), SIAM J. Matrix Anal. (submitted).

Michael D. Morley

Professor Emeritus of Mathematics

Professor Morley's primary interest and contribution to the department lies in his devotion to the students. His skill, wisdom, commitment and sensitivity in advising is very well known throughout the Arts College. Comments about Michael Morley speak to his devotion: "[Mike Morley] is exactly the sort of advisor that Cornell needs..."; "...has a creative and total commitment to taking care of students..."; "...has been available to everyone's advisees who wander in unhappy." These comments speak eloquently of Prof. Michael D. Morley.

Professor Morley's primary research interests lie in the areas of advanced mathematical logic and model theory.

Camil Muscalu

Assistant Professor of Mathematics

My research interests include topics from classical analysis and partial differential equations. In recent years I have been studying boundedness properties of certain multilinear singular integrals and their Carleson maximal analogs.

Selected Publications

Multi-linear operators given by singular multipliers (with T. Tao and C. Thiele), JAMS **15** (2002), 469–496.

A discrete model for the bi-Carleson operator (with T. Tao and C. Thiele), GAFA **12** (2002), 1324–1364.

L^p estimates for the biest I. The Walsh case (with T. Tao and C. Thiele), Math. Ann. **329** (2004), 401–426.

L^p estimates for the biest II. The Fourier case (with T. Tao and C. Thiele), Math. Ann. **329** (2004), 427–461.

Bi-parameter paraproducts (with J. Pipher, T. Tao, and C. Thiele), Acta Math. **193** (2004), 269–296.

Anil Nerode

Goldwin Smith Professor of Mathematics

My principal research at present is in theorems and algorithms for extracting controls for hybrid systems using Finsler differential geometry and logic-based controllers. Tools include the relaxed calculus of variations, connections on Finsler manifolds, Lie semigroups, chattering control, and automata theory. I also continue to work on problems in pure and applied logic, including computable model theory of nonstandard logics, automatic structures, foundations of logic programming, and automata models for multiple agent systems.

My professional activities include:

- Chair of the program committee of IEEE-MASS-2005 Security and Survivability Symposium.
- An hour address at IEEE MAS&S2005.
- Keynote speaker at the Tennenbaum Symposium, CUNY, April 2006.
- Chair of the international advisory board of Clearsight Corporation, Bellevue, Washington.
- Member of the international advisory board of Computer Science, NTT, Japan.
- Member of the international advisory board of the Centre for Discrete Mathematics and Theoretical Computer Science, University of Auckland, New Zealand.
- Chair of the steering committee of the Logical Foundations of Computer Science Symposium, scheduled for June 4-7, 2007 at City University, New York City, NY.
- Co-chair of the organizing committee for the IFAC Symposium "Hybrid Systems and Intelligent Control," scheduled for summer 2007 in Irkutsk, Russia.

Selected Publications

Automata Theory and Its Applications (with Bakhadyr Khoussainov), Birkhauser, 2001, 430 pp.

Control in hybrid systems (with W. Kohn, V. Brayman, and P. Cholewinski), Int. J. Hybrid Systems **3** (2003).

Control synthesis in hybrid systems with Finsler dynamics (with Wolf Kohn and Vladimir Brayman), Houston Journal of Mathematics **28** no. 2 (2003), 353–375.

Effective completeness theorems for modal logic (with S. Ganguli), Annals of Pure and Applied Logic **128** no. 1-3 (2004), 141–195.

Tableaux for constructive concurrent dynamic logic (with D. Wijesekera), Annals of Pure and Applied Logic **135** (2005), 1–72.

Finsler Control Theory and its applications (with W. Kohn, V. Brayman), in preparation, 300 pp.

Logic, Categories, Lambda Calculus (with R. Platek, G. Odifreddi), in preparation, 500 pp.

I am also an editor of journals in these fields.

Michael Nussbaum

Professor of Mathematics

My research program focuses on developing a better theoretical understanding of the asymptotic theory of statistical experiments, in connection with statistical smoothing and curve estimation and nonparametric inference for stochastic processes. Current topics include Gaussian and Poisson approximation of nonparametric experiments in the Le Cam sense, constructive realization of equivalence, asymptotic risk bounds for density estimation and nonparametric regression, nonparametric models for point processes, diffusion processes and autoregression, functional limit theorems for empirical processes, statistical treatment of inverse and ill-posed problems.

Selected Publications

Asymptotic equivalence of density estimation and Gaussian white noise, Ann. Stat. **24** (1996), 2399–2430.

Asymptotic equivalence for nonparametric generalized linear models (with I. Grama), Probability Theory and Related Fields **111** (1998), 167–214.

Diffusion limits for nonparametric autoregression (with G. Milstein), Probability Theory and Related Fields **112** (1998), 167–214.

The asymptotic minimax constant for sup-norm loss in nonparametric density estimation (with A. Korostelev), Bernoulli **5** (6) (1999), 1099–1118.

Minimax risk: Pinsker bound; in Encyclopedia of Statistical Sciences, Vol. 3 (S. Kotz, ed.), John Wiley, New York, 1999, pp. 451–460.

Kasso Okoudjou

H. C. Wang Assistant Professor of Mathematics

My research interests lie in harmonic analysis, specifically in time-frequency analysis and wavelet theory. My work to date has focused on studying finer properties of functions, e.g., time-frequency concentration, smoothness and decay using the theory of frames, in particular Gabor and wavelet frames. I am also interested in studying (multilinear) pseudodifferential operators using mainly a time-frequency approach.

Recently I have been working on analysis on pcf self-similar fractals. More precisely, I am interested in extending some "classical" results of analysis on Euclidean spaces to this fractal setting using the analytic tools defined by Jun Kigami on pcf fractals.

Selected Publications

Gabor analysis in weighted amalgam spaces (with K. Grochenig and C. Heil), Sampling Theory in Signal and Image Processing **1** no. 3 (2002), 225–260.

Embeddings of some classical Banach spaces into modulation spaces, PAMS **132** no. 6 (2004), 1639–1647.

Bilinear pseudodifferential operators on modulation spaces (with A. Benyi), Journal of Fourier Analysis and Applications **10** no. 3 (2004), 301–313.

Modulation spaces and a class of bounded multilinear pseudodifferential operators (with A. Benyi, K. Grochenig and C. Heil), J. Operator Theory **54** no. 2 (2005), 389–401.

Weak uncertainty principles on fractals (with R. S. Strichartz), Journal of Fourier Analysis and Applications **11** no 3 (2005), 315–331.

Alessandra Pantano

H. C. Wang Assistant Professor of Mathematics

I am interested in the study of the non-unitarity of a (spherical) principal series of a real group. When the group is split, the signature of a Hermitian form on the isotypic of a "petite" *K*-type can be computed by means of Weyl group calculations. The result is a non-unitarity test for a spherical principal series for split groups, which is especially effective if a lot of "petite" *K*-types are known. My research focuses on the construction of petite *K*-types.

Lawrence E. Payne

Professor Emeritus of Mathematics

My research interests lie in several areas of partial differential equations: isoperimetric inequalities, ill-posed and non-standard problems, growth decay and/or blowup of solutions, and applications to various problems in solid and fluid mechanics.

Selected Publications

Spatial decay bounds for a class of quasilinear parabolic initial-boundary value problems (with G. A. Philippin), International J. Nonlinear Mech. **40** (2005), 295–305.

Some nonstandard problems in generalized heat conduction (with Philip Schaefer and J. C. Song), ZAMP **56** (2005), 931–941.

Improved spatial decay bounds in generalized heat conduction (with J. C. Song), ZAMP **56** (2005), 805–820.

Decay bounds for solutions of second-order parabolic problems and their derivatives IV (with G. A. Philippin and S. Vernier-Piro), Applicable Analysis **85** (2006), 293–302.

Blowup, decay bounds, and continuous dependence inequalities for a class of quasilinear parabolic problems (with G. A. Philippin and S. Vernier-Piro), Math. Meth. Appl. Sci. **29** (2006), 281–295.

Irena Peeva

Associate Professor of Mathematics

My research is broad and at the interface between the fields of commutative algebra, algebraic geometry, and combinatorics. I have worked on problems involving free resolutions, toric varieties, Hilbert schemes, complete intersections, subspace arrangements, monomial resolutions, Gröbner basis, Koszul algebras, shellings, and Castelnuovo-Mumford regularity.

Some of my research interests are focused on the structure of free resolutions and their applications. I study resolutions over polynomial rings and their quotients. In essence constructing a resolution over a ring *R* consists of repeatedly solving systems of *R*-linear equations. From another point of view, resolutions provide a homological method for describing the structure of modules (the idea to associate a resolution to a module was introduced in Hilbert's famous 1890, 1893-papers).

Selected Publications

Complete intersection dimension (with L. Avramov and V. Gasharov), Publications Mathematiques IHES **86** (1997), 67–114.

Generic lattice ideals (with B. Sturmfels), J. American Mathematical Society **11** (1998), 363–373.

Deformations of codimension 2 toric varieties (with V. Gasharov), Compositio Mathematica **123** (2000), 225–241.

Finite regularity and Koszul algebras (with L. Avramov), American J. Math. **123** (2001), 275–281.

Toric Hilbert schemes (with M. Stillman), Duke Math. J. **111** (2002), 419–449.

Philip Protter

Professor of Operations Research and Industrial Engineering

Recent interests include numerical methods for solving stochastic differential equations, filtration expansions and shrinkage, liquidity risk in finance theory, and credit risk in finance theory. All of these topics are related to stochastic calculus and stochastic differential equations, although they bring in techniques from weak convergence, Markov processes, Monte Carlo methods, data analysis, viscosity solutions in stochastic control theory, and the Malliavin calculus.

Selected Publications

Stochastic Integration and Differential Equations, Second Edition, Version 2.1, Springer-Verlag, 2004.

Liquidity risk and arbitrage pricing theory (with R. Jarrow, U. Çetin), Finance & Stochastics **8** (2004), 311–341.

Modeling credit risk with partial information (with U. Çetin, R. Jarrow, and Y. Yildirim), Annals of Applied Probability **14** (2004), 1167–1178.

The approximate Euler method for Levy driven stochastic differential equations (with J. Jacod, T. Kurtz, and S. Meleard), Annales of the Institut Henri Poincaré, special issue dedicated to P. A. Meyer (En Hommage à Paul-André Meyer) **41** (2005), 523–558.

A short history of stochastic integration and mathematical finance: the early years, 1880–1970 (with R. Jarrow); in The Herman Rubin Festschrift, IMS Lecture Notes **45**, 2004, pp. 75–91.

Ravi Ramakrishna

Associate Professor of Mathematics

My research is in Galois theory. This is the branch of mathematics concerned with symmetries of solutions of equations. There is an object that encodes all symmetries of solutions to all equations, the absolute Galois group of the rational numbers. I study this object and its relations with number theory. The study of these symmetries has gained an increasingly important role in number theory in recent years. In particular, Galois theory played an important role in the solution of Fermat's Last Theorem.

Selected Publications

Deforming Galois representations and the conjectures of Serre and Fontaine-Mazur, Ann. Math. (2) **156** no. 1 (2002), 115–154.

Deformations of certain reducible Galois representations, J. Ramanujan Math. Soc. **17** no. 1 (2002), 51–63.

Finitenss of Selmer groups and deformation rings, Invent. Math. **154** (2003), 179–198.

Transcendental ℓ-adic Galois representations (with C. Khare and M. Larsen), Math Research Letters **12** (2005), 685–700.

Constructing semisimple p-adic Galois representations with prescribed properties (with C. Khare and M. Larsen), American Journal of Mathematics **127** (2005), 709–734.

Richard H. Rand

Professor of Theoretical & Applied Mechanics

My research involves using perturbation methods and bifurcation theory to obtain approximate solutions to differential equations arising from nonlinear dynamics problems in engineering and biology.

Current projects involve differential delay equations, quasiperiodic forcing in Mathieu's equation, dynamics of coupled oscillators, and coexistence phenomenon in autoparametric excitation. Applications include NEMS (nano electrical mechanical systems), effects of biorhythms on retinal dynamics, and cardiac arrythmias. These projects are conducted jointly with graduate students and with experts in the respective application area.

Selected Publications

Lecture Notes on Nonlinear Vibrations, version 52, 2005.

Parametric resonance of Hopf bifurcation (with A. Barcilon and T.Morrison), Nonlinear Dynamics **39** (2005), 411–421.

2:1:1 Resonance in the Quasiperiodic Mathieu Equation (with T. Morrison), Nonlinear Dynamics **40** (2005), 195–203.

Coexistence phenomenon in autoparametric excitation of two degree of freedom systems (with G. Recktenwald), International J. Nonlinear Mechanics **40** (2005), 1160–1170.

Self-thinning and community persistence in a simple size-structured dynamical model of plant growth (with F. Dercole and K. Niklas), J. Math. Biology **51** (2005), 333–354.

Third-order intermodulation in a micromechanical thermal mixer (with K. L. Aubin, H. G. Craighead, B. H. Houston, J. M. Parpia, R. B. Reichenbach, and M. Zalalutdinov), J. Microelectromechanical Systems **14** (2005), 1244–1252.

Etienne Rassart

H. C. Wang Assistant Professor of Mathematics

The interplay between combinatorics, the representation theory of complex semisimple Lie algebras, symplectic geometry and convex geometry has been a rich source of mathematical developments in recent years. Most of my recent work has been in using tools from all these areas to explore combinatorial invariants of the irreducible representations of the classical complex semisimple Lie algebras (types A, B, C, D), particularly the weight multiplicities and Clebsch-Gordan coefficients. For type A, these appear in the combinatorial theory of symmetric functions in the form of the Kostka numbers and the Littlewood-Richardson coeffcients respectively. Efficiently computing the weight multiplicities and Clebsch-Gordan coefficients has been a long-standing problem. A variety of formulas and methods exist for them, some of which are efficient for certain ranges of the parameters, but no single approach seems to provide a fast way of computing these combinatorial invariants. The need for efficient algorithms is motivated by the fact that these numbers appear in quantum physical computations. My current research project ties into all these areas of mathematics, using tools from combinatorics, convex geometry and symplectic geometry to study the behavior of the Kostka numbers and Littlewood-Richardson coefficients.

Selected Publications

Enumeration of symmetry classes of convex polyominoes in the square lattice (with P. Leroux and A. Robitaille), Adv. Appl. Math. **21** no. 3 (1998), 343–380.

Path counting and random matrix theory (with Ioana Dumitriu), Electronic J. Comb. **10** no. 1 (2003), R43.

A vector partition function for the multiplicities of $sl_k(C)$ (with S. Billey and V. Guillemin), J. Algebra **278** no. 1 (2004), 251–293.

Signature quantization and representations of compact Lie groups (with Victor Guillemin), Proc. Nat'l Acad. Sci. (USA) **101** (2004), 10884–10889.

A polynomiality property for Littlewood-Richardson coefficients, J. Comb. Theory, Series A **107** no. 2 (2004), 161–179.

James Renegar

Professor of Operations Research and Industrial Engineering

I am currently devoting the majority of my research efforts to devising new algorithms for linear programming, i.e., for solving systems of linear inequalities. Unlike the situation for linear equations, surprisingly basic problems remain unresolved for linear inequalities. For example, it is unknown whether there exists an algorithm that can solve a general system of linear inequalities using a number of arithmetic operations that is bounded polynomially in the number of variables and the number of inequalities in the system. By contrast, elementary Gaussian elimination (i.e., high-school mathematics) solves a system of n linear equations in n unknowns in roughly n^3 operations.

I am also interested in devising algorithms for more general problems involving hyperbolic polynomials. (A hyperbolic polynomial p is a real multivariate polynomial for which there exists a vector v such that all univariate polynomials obtained by restricting p to lines in the direction v have only real roots.) These polynomials have played an especially important role in optimization in recent years.

Timothy Riley

H. C. Wang Assistant Professor of Mathematics

I work on problems pertaining to the geometry, topology and asymptotics of finitely generated groups. My specific research topics include filling functions, isoperimetric problems, the word problem, asymptotic cones, the geometry of Cayley graphs, normal forms, combings, almost convexity, special linear groups, quasi-isometry invariants, nilpotent groups, finiteness conditions, and algorithmic complexity.

Selected Publications

Higher connectedness of asymptotic cones, Topology **42** (2003), 1289–1352.

Isoperimetric inequalities for nilpotent groups (with Steve Gersten and Derek Holt), GAFA **13** (2003), 795–814.

Navigating in the Cayley graphs of $SL_N(Z)$ and $SL_N(F_p)$, Geometriae Dedicata **113** no. 1 (2005), 215–229.

Diameters of Cayley graphs of $SL_n(Z/kZ)$ (with Martin Kassabov), Eur. J. Comb. (to appear).

Extrinsic versus intrinsic diameter for Riemannian filling-discs and van Kampen diagrams (with Martin Bridson).

The absence of efficient dual pairs of spanning trees in planar graphs (with Bill Thurston).

Luke Rogers

H. C. Wang Assistant Professor of Mathematics

My research interests lie broadly in the area of harmonic analysis and geometric function theory, with a particular focus on Sobolev and quasiconformal mappings. In my graduate work I developed a degree-independent extension theorem for Sobolev spaces on locally uniform domains, a result that has its roots in earlier work of Stein and of Jones on this problem. The approach I found may also have application to related function spaces such as the Besov spaces.

At present I am thinking about various problems in the theory of Sobolev spaces on general metric spaces, especially some related to the work of Kigami and of Strichartz in developing an analysis on post-critically finite fractals. I am also interested in several questions about quasiconformal mappings, particularly those related to characterizing quasiconformal and Sobolev removable sets.

Laurent Saloff-Coste

Professor of Mathematics

I am an analyst who enjoys touching on other areas including probability theory and geometric group theory. I study different aspects of heat diffusion on manifolds from the point of view of both partial differential equations and stochastic processes. I am mainly interested in those properties that relate to the large-scale geometry of the underlying space. For instance, I have recently been trying to understand how heat diffusion is affected by the existence of more than one end on a manifold. Potential theory and functional analysis often provide the framework and tools to study these properties.

I also work on random walks on groups. A random walk is a Markov process (g_n) on a group G where g_n is obtained from g_{n-1} by left multiplication by a random element of a fixed finite generating set of G. For instance, card-shuffling methods can be modelized as random walks on the symmetric group S_{52}. In this example, G is finite but G can be infinite. What interests me most in this subject is relating the behavior of random walks to the algebraic structure of the group and to the geometry of its Cayley graphs.

Random walks on finite groups are special examples of finite Markov chains. In the past 10 years, I have worked on quantitative estimates for ergodic finite Markov chains. Some of the most interesting examples of such chains are connected to combinatorial problems that are not tractable by deterministic algorithms but for which a reasonable stochastic algorithm exists. These stochastic algorithms often involve a finite Markov chain as one of the main building blocks. In this context, obtaining quantitative estimates is essential.

Selected Publications

Hitting probabilities for Brownian motion on Riemannian manifolds (with A. Grigor'yan), Journal de Mathématiques Pures et Appliquées **81** (2002), 115–142.

Aspects of Sobolev Type Inequalities, London Mathematical Society Lecture Notes **289**, Cambridge University Press, 2002.

On the sample paths of Brownian motions on compact infinite dimensional groups (with A. Bendikov), Annals of Probability **31** (2003), 1464–1493.

Random walks on finite rank solvable groups (with C. Pittet), Journal of the European Mathematical Society **5** (2003), 313–342.

Random walks on finite groups; in Probability on Discrete Structures, Encyclopaedia Math. Sci. **110** (H. Kesten, ed.), Springer, Berlin, 2004, pp. 263–346.

Alfred H. Schatz

Professor of Mathematics

My field of research is numerical analysis. I have been principally involved in the analysis and construction of finite element methods for the approximate solution of partial differential equations. In particular I have been investigating both the local behavior of such matters and another phenomena associated with them called superconvergence. Many physical problems have solutions that are smooth in some places and are nonsmooth (having singularities) in others. In the numerical solution of these problems, the singular part of the solution is not only difficult to approximate but often lowers the quality of (pollutes) the approximation even where the solution is nice. I have been involved in understanding this phenomena and finding a way to improve the approximations.

Another facet of the research is to find properties of the computed approximate solutions which, when taken into account, can be used to produce better approximations than one has before. These are so called superconvergent approximations and their importance resides in the fact that the original approximations are usually difficult to obtain but usually the new approximates may be orders of magnitude better and easily computed from them.

Selected Publications

Superconvergence in finite element methods and meshes which are locally symmetric with respect to a point (with I. Sloan and L. Wahlbin), SIAM J. Num. Anal. (to appear).

Interior maximum norm estimates for Ritz Galerkin methods, part II (with L. Wahlbin), Mathematics of Computation (to appear).

Some new error estimates for Ritz Galerkin methods with minimal regularity assumptions (with J. Wang), Mathematics of Computation (submitted).

Shankar Sen

Professor of Mathematics

Most of my research concerns invariants associated with representations of Galois groups of p-adic fields and algebraic number fields. These invariants, though of an arithmetic nature, are related to classical invariants arising in complex algebraic geometry; their study should shed light on geometric aspects of equations over number fields or p-adic fields. Recently, I have studied families of Galois representations depending analytically on p-adic parameters, and how the invariants for such families change with the parameters. Techniques from p-adic analytic function theory and functional analysis have proved useful in this connection.

Selected Publications

Lie algebras of Galois groups arising from Hodge-Tate modules, Annals of Math. (1973).

Integral representations associated with p-adic field extensions, Inventiones Math. (1988).

The analytic variation of p-adic Hodge structure, Annals of Math. (1988).

An infinite-dimensional Hodge-Tate theory, Bulletin Math. Soc. France (1992).

Galois cohomology and Galois representations, Inventiones Math. (1993).

Richard A. Shore

Professor of Mathematics

My major research interests have centered around analyzing the structures of relative complexity of computation of functions on the natural numbers. The primary measure of such complexity is given by Turing reducibility: f is easier to compute than g, if there is a (Turing) machine which can compute f if it is given access to the values of g. I have also worked with various other interesting measures of complexity that are defined by restricting the resources available primarily in terms of access to g. The general thrust of my work has been to show that these structures are as complicated as possible both algebraically and logically (in terms of the complexity of the decision problems for their theories). These results also allow one to differentiate among different notions of relative complexity in terms of the orderings they define.

Another major theme in my work has been the relationship between these notions of computational complexity and ones based on the difficulty of defining functions in arithmetic. Restricting the computational resources more directly in terms of time or space leads out of recursion theory and into complexity theory. Relaxing the restrictions by allowing various infinitary procedures leads instead into generalized recursion theory or set theory.

The methods developed in these investigations are also useful in determining the effective content of standard mathematical theorems (when can existence proofs be made effective) and the inherent difficulty of combinatorial theorems in proof theoretic terms. Recently, I have also been working on issues in effective model theory and algebra connected with the problem of how the computational properties of algebraic structures can vary with different (but always computable) presentations of the models.

Selected Publications

The degrees of unsolvability: the ordering of functions by relative computability; in Proceedings of the International Congress of Mathematicians (Warsaw) 1983, PWN-Polish Scientific Publishers, Warsaw 1984, Vol. 1, 337–346.

Definability in the recursively enumerable degrees (with A. Nies and T. Slaman), Bull. Symb. Logic **2** (1996), 392–404.

Logic for Applications (with A. Nerode), Texts and Monographs in Computer Science, Springer-Verlag, New York, 1993; second edition, Graduate Texts in Computer Science, Springer-Verlag, New York, 1997.

Defining the Turing jump (with T. Slaman), Math. Research Letters **6** (1999), 711–722.

Computable structures: presentations matter; In the Scope of Logic, Methodology and the Philosophy of Science, Vol. 1, International Congress of LMPS, Cracow, August 1999 (P. Gardenfors, J. Wolenski and K. Kijania-Placek, eds.), Synthese Library **315**, Kluwer Academic Publishers, Dordrecht, 2002, pp. 81–95.

Reyer Sjamaar

Associate Professor of Mathematics

I study actions of Lie groups on symplectic manifolds. This is an area of differential geometry related to algebraic geometry and mathematical physics. Some of my recent work concerns moment polytopes and leads to improved versions of certain eigenvalue inequalities in matrix analysis.

Selected Publications

Holomorphic slices, symplectic reduction and multiplicities of representations, Ann. Math. (2) **141** (1995), 87–129.

Singular reduction and quantization (with E. Meinrenken), Topology **38** (1998), 699–762.

Moment maps and Riemannian symmetric pairs (with L. O'Shea), Math. Ann. **317** no. 3 (2000), 415–457.

Projections of coadjoint orbits, moment polytopes and the Hilbert-Mumford criterion (with A. Berenstein), J. Amer. Math. Soc. **13** no. 2 (2000), 433–466.

John Smillie

Professor of Mathematics

My area of interest is dynamical systems. I have done work on polygonal billiards and dynamics of flows on Teichmüller space; analysis of algorithms; and diffeomorphisms of surfaces. I am currently working on complex dynamics in two dimensions.

Selected Publications

Ergodicity of billiard flows and quadratic differentials (with S. Kerckhoff and H. Masur), Ann. Math. **124** (1986), 293–311.

Polynomial diffeomorphisms of $\mathbf{C}^2$ VI: connectivity of J (with E. Bedford), Ann. Math., **148** (1998), 695–735.

Polynomial diffeomorphisms of $\mathbf{C}^2$ VII: hyperbolicity and external rays (with E. Bedford), Ann. Scient. Ec. Norm. Sup. **4** (32) (1999), 455–497.

The dynamics of billiard flows in rational polygons; in Encyclopedia of Mathematical Sciences, vol. 100 (edited by Yu. Sinai), Springer-Verlag, 1999.

Billiards on rational-angled triangles (with R. Kenyon), Comment. Math. Helv. **75** (2000), 65–108.

Dynamics in Two Complex Dimensions; in Proceedings of the International Congress of Mathematicians, Beijing 2002, Vol. III: Invited Lectures, Higher Education Press, Beijing 2002, pp. 373–382.

Real polynomial diffeomorphisms with maximal entropy: tangencies (with E. Bedford), Ann. Math. **160** (2004), 1–26.

Birgit E. Speh

Professor of Mathematics

I am interested in the representation theory of reductive Lie groups, the cohomology of arithmetic groups and automorphic forms. In last few years, most of my work was related to geometric and topological properties of locally symmetric spaces. Some of my work also involves the Arthur Selberg Trace Formula.

Selected Publications

Pseudo-Eisenstein forms and cohomology of arithmetic groups (with J. Rohlfs), Manuscripta Mathematica **106** (2001), 505–518.

Absolute convergence of the spectral side of the Arthur trace formula for GL(n) (with W. Mueller), GAFA (to appear).

Pseudo-Eisenstein forms and cohomology of arithemtic groups II (with J. Rohlfs), Proceedings of Conference in honor of Ragunathan (to appear).

Construction of some modular symbols (with T. N. Venkataramana), Math. Zeit. (submitted).

Michael E. Stillman

Professor of Mathematics

My main areas of interest are computational algebra and algebraic geometry, commutative algebra, and algebraic geometry. My original interest in computational methods was their application to problems in algebraic geometry. Since then, my work has proceeded in several related directions. I have studied the complexity of the algorithms (mainly Gröbner bases). I have been developing algorithms for computing in commutative algebra and algebraic geometry (e.g. computing with line bundles, computing Hilbert functions, free resolutions, sheaf cohomology, computing with Hilbert schemes). In the last few years, Peeva and I have been interested in Hilbert schemes: classical ones, toric Hilbert schemes, and parameter spaces over the exterior algebra.

A major part of my research has been the development, with Dan Grayson at University of Illinois at Urbana, of Macaulay 2, a computer algebra system for research in commutative algebra and algebraic geometry. This system has a large following worldwide, a book written about it, and has been in active development for almost ten years.

Recently, I have become interested in the application of computational algebraic geometry to problems in statistics and molecular biology. The joint paper with Garcia and Sturmfels studies ideals and projective varieties that arise naturally when studying Bayesian networks on discrete random variables.

Selected Publications

A criterion for detecting m-regularity (with D. Bayer), Invent. Math. **87** (1987), 1–11.

Computing sheaf cohomology on toric varieties (with D. Eisenbud and M. Mustata), J. Symbolic Computation **29** (2000), 583–600.

Computations in Algebraic Geometry with Macaulay 2 (D. Eisenbud, D. Grayson, M. Stillman, B. Sturmfels, eds.), Springer, 2001.

Toric Hilbert schemes (with I. Peeva), Duke Math. J. **111** (2002), 419–449.

Algebraic geometry of Bayesian networks (with L. Garcia and B. Sturmfels), preprint (2003), available at http://front.math.ucdavis.edu/math.AG/0301255

Robert S. Strichartz

Professor of Mathematics

My research interests cover a wide range of topics in analysis, including harmonic analysis, partial differential equations, analysis on Lie groups and manifolds, integral geometry, wavelets and fractals. My early work using methods of harmonic analysis to obtain fundamental estimates for linear wave equations has played an important role in recent developments in the theory of nonlinear wave equations. My work on fractals began with the study of self-similar measures and their Fourier transforms. More recently I have been concentrating on a theory of differential equations on fractals created by Jun Kigami. Much of this work has been done in collaboration with undergraduate students through a summer Research Experiences for Undergraduates (REU) program at Cornell that I direct. I wrote an expository article — *Analysis on fractals*, Notices of the AMS **46** (1999), 1199–1208 — explaining the basic ideas in this subject area and the connections with other areas of mathematics. An informal textbook I am writing on the subject will be published by Princeton University Press in 2006. In 2004 I discovered two examples of a convergence phenomenon for fractal analogs of Fourier series. (Ordinary Fourier series fail to converge in the expected way.) They are both related to the existence of infinitely many large gaps… something that does not appear to happen in smooth analysis. These are the first examples of theorems in fractal analysis that actually improve on the analogous theorems in smooth analysis. The proofs of the two results are unrelated. One of the results was inspired by experimental evidence gathered during the summer 2002 REU program.

Web sites created by students working with me may be found at www.mathlab.cornell.edu/reu/reu.html

Selected Publications

My web site, www.math.cornell.edu/~str, contains a complete list of my publications.

Steven H. Strogatz

Professor of Theoretical & Applied Mechanics

I have broad interests in applied mathematics. At the beginning of my career I was fascinated by mathematical biology and worked on a variety of problems, including the geometry of supercoiled DNA, the dynamics of the human sleep-wake cycle, the topology of three-dimensional chemical waves, and the collective behavior of biological oscillators, such as swarms of synchronously flashing fireflies.

In the 1990's, my work focused on nonlinear dynamics and chaos applied to physics, engineering, and biology. Several of these projects dealt with coupled oscillators, such as lasers, superconducting Josephson junctions, and crickets that chirp in unison. In each case, the research involved close collaborations with experimentalists.

I also love branching out into new areas, often with students taking the lead. In the past few years, this has led us into such topics as parametric resonance in microelectromechanical systems (MEMS); the nonlinear dynamics of HIV interacting with the immune system; and mathematical explorations of the small-world phenomenon in social networks (popularly known as "six degrees of separation"). Currently, we have been studying a wide variety of complex networks in both the natural and social sciences, using ideas from graph theory, statistical physics, and nonlinear dynamics.

Selected Publications

Sync: The Emerging Science of Spontaneous Order, Hyperion, 2003.

Exploring complex networks, Nature **410** (2001), 268–276.

Collective dynamics of 'small-world' networks (with D. J. Watts), Nature **393** (1998), 440–442.

Synchronization transitions in a disordered Josephson series array (with P. Colet and Wiesenfeld), Physical Review Letters **76** (1996), 404–407.

Nonlinear Dynamics and Chaos: With Applications to Physics, Biology, Chemistry, and Engineering, Perseus Books, 1994.

Crowd synchrony on the Millennium Bridge (with D. M. Abrams, B. Eckhardt, A. McRobie, and E. Ott), Nature **438** (2005), 43–44.

Edward Swartz

Assistant Professor of Mathematics

My research centers on the interplay between combinatorics, geometry/topology and algebra with a special emphasis on matroids and *f*-vectors of simplicial complexes. Matroids are combinatorial abstractions of linear independence. Their enumerative properties have applications in a variety of fields, including graph coloring and flows, linear coding, arrangements of hyperplanes, and problems in reliability theory. My interest in matroids originally started with the discovery of a close connection between matroids and quotients of spheres by elementary abelian *p*-groups. More recently, I have used face rings to establish analogues of the *g*-theorem for simplicial polytopes for a variety of simplicial complexes.

Selected Publications

Matroids and quotients of spheres, Mathematische Zeitschrift **241** (2002), 247–269.

Topological representations of matroids, Journal of the Amer. Math. Soc. **16** (2003), 427–442.

g-elements of matroid complexes, J. Comb. Theory Ser. B **88** no. 2 (2003), 369–375.

Lower bounds for h-vectors of k – CM, independence and broken circuit complexes, SIAM Journal on Discrete Mathematics **18** no. 3 (2005), 647–661.

Moss E. Sweedler

Professor Emeritus of Mathematics

First I worked in the area of Hopf algebras and wrote *Hopf Algebras*, which came to be the standard reference book on the subject. H. Allen and I used Hopf algebras to prove a 25-year-old conjecture of Jacobson. Over the ensuing years until about the mid eighties, I worked and published in the areas of commutative algebra and algebraic geometry, real-algebraic geometry, homological algebra, algebraic groups, purely inseparable field extensions and general positive characteristic phenomena, simple algebras and generalizations of the Brauer group, and differential algebra. Since the mid eighties I have primarily worked in the area of computer algebra, especially computational commutative algebra. This has produced both theoretical and applied results with applications beyond mathematics, such as to error control codes and resulted in my position as Director of the Army Center of Excellence for computer algebra.

Selected Publications

Groups of simple algebras, Institut des Hautes Etudes Scientifiques **44** (1975), 79–189.

A new invariant for the complex numbers over the real numbers (with D. Haile and R. Larson), American Journal of Mathematics **105** (1983), 689–814.

Gröbner bases for linear recursion relations on m-D arrays and applications to decoding (with I. Rubio and C. Heegard), Proc. IEEE Int'l Symp. on Information Theory, June 29–July 4, 1997, Ulm, Germany.

Remarks on automatic algorithm stabilization (with K. Shirayanagi), invited contribution to (fourth) IMACS Conf. on Appl. of Computer Algebra (1998).

Ideal and subalgebra coefficients (with L. Robbiano), Proceedings of the AMS (1998), to appear.

Maria S. Terrell

Senior Lecturer of Mathematics and Director of Teaching Assistant Programs

My recent interests in geometry have included tensegrities and the history of geometrical optics and linear perspective. I am collaborating with a group of faculty and graduate students in an effort to improve undergraduate mathematics instruction through a project we call GoodQuestions. The project is developing materials to help instructors engage students in meaningful discussions about key concepts in calculus. At a recent MER (Mathematicians in Education Reform) workshop I presented a paper about my recent experience in the project. (The GoodQuestions web site is located at www.math.cornell.edu/~goodquestions/.)

Selected Publications

Kaleidoscopes and mechanisms (with R. Connelly and B. Hendrickson), Colloqui Mathematica Societatis Janos Boyai **63** (1991).

Behind the scenes of a random dot stereogram (with R. Terrell), Amer. Math. Monthly **101** no. 8 (1994), 715–724.

Globally rigid symmetric tensegrities (with R. Connelly), Structural Topology **21** (1995).

Asking good questions in the mathematics classroom, Mathematicians and Education Reform Forum Newsletter **15** no. 2 (2003).

Can good questions and peer discussion improve calculus instruction? (with R. Miller and E. Santana-Vega), PRIMUS (to appear).

Robert E. Terrell

Senior Lecturer of Mathematics

Most of my creative work has been in writing educational mathematics software. I have interactive ODE solvers, PDE solvers, IFS makers, a linear algebra program, and various other things available on my web page. These are directed primarily to undergraduates, and the purpose of them is to let the student learn by exploring.

Selected Publications

Behind the scenes of a random dot stereogram (with M. Terrell), Amer. Math. Monthly **101** no. 8 (1994), 715–724.

William Thurston

Professor of Mathematics

Bill Thurston is a topologist, though his work impinges on many other areas of mathematics. He has discovered unexpected links between topology, hyperbolic geometry, and complex analysis.

Highlights of his career include his classification of foliations of codimension greater than one, his classification of surface automorphisms, his hyperbolization theorem in three-dimensional topology, and the theories of automatic groups and confoliations. Thurston has also made fundamental contributions to the theory of symplectic and contact manifolds, dynamics of surface diffeomorphisms, and the combinatorics of rational maps.

His current research includes random 3-manifolds and relations of knot theory to computational complexity. His main interest remains his geometrization conjecture, a far-reaching proposed generalization of his hyperpolization theorem.

Selected Publications

Three-dimensional manifolds, Kleinian groups and hyperbolic geometry, Bull. AMS **6** (1982), 357–381.

Hyperbolic structures on 3-manifolds, I. Deformation of acylindrical manifolds, Ann. Math. **124** (1986), 203–246.

Word Processing in Groups (with D. B. A. Epstein, J. W. Cannon, D. F. Holt, S. V. F. Levy, and M. S. Paterson), Jones and Bartlet Publ., Boston, MA, 1992.

Three-Dimensional Geometry and Topology, Princeton Mathematical Series **35**, Princeton University Press, Princeton, NJ, 1997.

Confoliations (with Y. Eliashberg), AMS, Providence, RI, 1998.

Alexander Vladimirsky

Assistant Professor of Mathematics

My research is mostly focused on building fast methods for problems in which the direction of information flow can be used to speed up the computations.

For example, numerical schemes for non-linear static PDEs often require solving coupled systems of non-linear discretized equations. For the first-order PDEs, partial knowledge of characteristic directions can be used to decouple those systems: solving the discretized equations one at a time is much more efficient. My thesis was devoted to construction of Ordered Upwind Methods (OUMs) for the PDEs arising in the anisotropic exit-time optimal trajectory problems. These methods were later extended to a wider class of problems in anisotropic (and hybrid) control and in front propagation.

My current work (joint with John Guckenheimer) concerns fast methods for approximating invariant manifolds of vector fields. This problem is numerically challenging not only because of the complicated manifold-geometry but also because of the anisotropic behavior of the vector field on that manifold. In our approach, a (co-dimension one) invariant manifold is locally modeled as a graph of some function satisfying a particular quasi-linear PDE, which can be quickly solved using yet another version of OUMs. A more recent extension allows treating manifolds of higher co-dimension by (locally) solving a system of quasi-linear PDEs.

My other projects include games & stochastic control problems on graphs, fast methods for constructing multi-valued solutions of PDEs, and dimension reduction in the context of chemical kinetics.

Selected Publications

Fast methods for the Eikonal and related Hamilton-Jacobi equations on unstructured meshes (with J. A. Sethian), Proc. Natl. Acad. Sci. USA **97** no. 11 (2000), 5699–5703.

Ordered upwind methods for static Hamilton-Jacobi equations (with J. A. Sethian), Proc. Natl. Acad. Sci. USA **98** no. 20 (2001), 11069–11074.

Ordered upwind methods for static Hamilton-Jacobi equations: theory & applications (with J. A. Sethian), SIAM J. Num. Anal. **41** no. 1 (2003), 325–363.

A fast method for approximating invariant manifolds (with J. Guckenheimer), SIAM J. on Applied Dynamical Systems **3** no. 3 (2004) 232–260.

A survey of methods for computing (un)stable manifolds of vector fields (with M. Dellnitz, E. J. Doedel, J. Guckenheimer, M. E. Henderson, O. Junge, B. Krauskopf, and H. M. Osinga), Int. J. Bifurcation and Chaos **15** no. 3 (2005).

Static PDEs for time-dependent control problems, Interfaces and Free Boundaries (to appear).

Karen Vogtmann

Professor of Mathematics

A fundamental technique for studying a group G is to view G as a group of automorphisms of a geometric object X. Geometric and topological properties of X can then be used to study algebraic properties of G. Beautiful classical examples of this are the theory of arithmetic and S-arithmetic groups acting on homogeneous spaces and buildings, including work of Borel and Serre on cohomological properties of these classes of groups, and the theory of groups of surface homeomorphisms acting on the Teichmüller space of the surface. I am interested in developing geometric theories for other classes of groups. In particular, I have worked with orthogonal and symplectic groups, SL(2) of rings of imaginary quadratic integers, groups of automorphisms of free groups, and mapping class groups of surfaces. My main focus in recent years has been on the group of outer automorphisms of a free group, where the appropriate geometric object is called Outer space. This space turns out to have surprising connections with certain infinite-dimensional Lie algebras (discovered by Kontsevich) and also with the study of phylogenetic trees in biology.

Selected Publications

Moduli of graphs and automorphisms of free groups (with M. Culler), Inventionnes **84** (1986), 91–119.

Cerf theory for graphs (with A. Hatcher), J. London Math. Soc. **58** part 3 (1998), 633–655.

The symmetries of Outer space (with M. Bridson), Duke Math Journal **106** no. 2 (2001), 391–409.

Geometry of the space of phylogenetic trees (with L. J. Billera and S. Holmes), Advances in Applied Math **27** (2001), 733–767.

Infinitesimal operations on complexes of graphs (with J. Conant), Math. Ann. **327** (2003), 545–573.

Lars B. Wahlbin

Professor of Mathematics

At present one can compute "solutions" to very tough nonlinear, singular problems on, say, a supercomputer. Most often, numerical analysis does not furnish theorems that cover a practical situation, but it provides insight into the behavior of the relevant numerical method on carefully chosen model problems with, at best, some of the most pertinent difficulties of the real problem present.

My work in numerical analysis is aimed at gaining a fundamental understanding of numerical methods. Such insight is also necessary for constructing better algorithms. My particular interest is in methods for partial differential equations, and lately I have been studying the precise and detailed behavior of the finite-element methods in a variety of problems; the most interesting ones contain singularities of various degrees of nastiness.

Selected Publications

Local behavior in finite element methods; in Handbook of Numerical Analysis (P. G. Ciarlet and J. L. Lions, eds.), vol. II (part 1), North Holland, 1991, pp. 353–522.

Superconvergence in Galerkin Finite Element Methods, Springer Lecture Notes in Mathematics **1605**, Springer-Verlag New York, 1995.

James E. West

Professor of Mathematics

My research has focused on the topology and symmetries of manifolds of finite and infinite dimensions, and on the related topics of polyhedra, absolute neighborhood retracts, function spaces and spaces of sets.

An example of the interplay between these theories is that manifolds modeled on the Hilbert cube appear naturally in several ways as limits of stabilization processes for finite-dimensional objects, and, unlike standard function space stabilization, retain more of their important properties, e.g. simple homotopy type. Study of the Hilbert cube manifolds has produced several of the initial breakthroughs in introducing control into the homeomorphism theory of finite-dimensional manifolds. This in turn, has been useful in analyzing the failure of the classical matrix algebra to describe equivariant homeomorphisms and homotopy types of manifolds with locally linearizable transformation groups, which in turn has led to new results on the topological classification of linear representations of finite groups. I have been involved in these studies.

Selected Publications

Mapping Hilbert cube manifolds to ANR's, Ann. Math. **106** (1977), 1–18.

Equivariant h-cobordisms and finiteness obstructions (with M. Steinberger), Bull. AMS **12** (1985), 217–220.

Nonlinear similarity begins in dimension 6 (with S. Cappell, J. Shaneson, and M. Steinberger), Amer. J. Math. **111** (1989), 717–752.

Fibrations and Bundles with Hilbert Cube Manifold Fibers (with H. Torunczyk), Memoirs of the AMS **406**, 1989, iv + 75 pp.

Compact group actions that raise dimension to infinity (with A. N. Dranishnikov), Topology and its Applications **80** (1997), 101–114.