

Department of Mathematics

The Department of Mathematics at MIT seeks to improve its top ranking in research and teaching by aggressively hiring the very best faculty, with special attention to recruiting top women and underrepresented minority candidates, and by continuing to serve the broad and varied educational needs of its graduate students, the mathematics majors, and all undergraduates of the Institute.

New Faculty, Promotions, and Departures

The Department had an exceptional year in outside faculty hires for FY2008. James McKernan, a major figure in higher-dimensional algebraic geometry from the University of California, Santa Barbara, will join the Department's faculty as professor of mathematics. Paul Seidel, a leading young researcher in symplectic geometry from the University of Chicago, also joins the faculty as professor. JuLee Kim is another outside senior faculty appointment, joining the Department as associate professor. JuLee is a representation theorist, concentrating on p -adic groups, from the University of Illinois at Chicago. Jacob Lurie also joins our faculty as tenured associate professor. He is an algebraic topologist and an American Institute of Mathematics fellow from Harvard University. The Department will appoint two new assistant professors: Jonathan Kelner, a graduate of MIT, who works on a variety of problems in theoretical computer science, and Abhinav Kumar, a number theorist with a doctorate from Harvard University. Abhinav was MIT's top undergraduate in mathematics in 2002.

Associate professors Martin Bazant and Alexander Postnikov received tenure. Martin Bazant is a physical applied mathematician, and Alexander Postnikov is an algebraic combinatorialist in the applied mathematics group. Assistant professor Kiran Kedlaya, a number theorist in the pure mathematics group, was promoted to associate professor.

Three junior faculty resigned from MIT this year. Associate professor Santosh Vempala accepted an appointment as professor of computer science and systems and director of the Algorithms and Randomness Center at Georgia Tech. Associate professor Jeff Viaclovsky, a geometric analyst, received an appointment as professor of mathematics at the University of Wisconsin, Madison. Assistant professor Jason Starr will join faculty at the State University of New York, Stony Brook; he works in algebraic geometry.

In Memoriam

Professor emeritus George B. Thomas, who served on the mathematics faculty from 1944 to 1978, died on October 31, 2006, at the age of 92. Professor Thomas was an applied mathematician and outstanding teacher. In the early 1950s he authored the widely used textbook, *Thomas' Calculus* (as it is known today), now in its 11th edition by Addison-Wesley. Within the department, Professor Thomas was executive officer for 10 years, and graduate registration officer for five years. On the national scene, he served on the Board of Governors of the Mathematical Association of America (elected vice president 1958–1959), on the Commission of Mathematics of the College Entrance Examination Board (1955–1958), and on the Executive Committee, Mathematics Division, of the American Society for Engineering Education (1956–1959).

Administration

Michael Sipser will continue as department head.

David Jerison and Gigliola Staffilani will follow Pavel Etingof as cochairs of the Graduate Student Committee.

The other faculty committee chairs will remain as follows:

Michel Goemans—Chair of the Committee of Advisors
 Haynes Miller—Chair of the Undergraduate Committee
 Tomasz Mrowka—Chair of the Pure Mathematics Committee
 Alar Toomre—Chair of the Applied Mathematics Committee

Faculty Honors and Awards

Department Chairs

Through the generous support of the Leighton Family Fund established for FY2008, Michel Goemans was selected as the first holder of the Leighton Family Professorship. A world leader in approximation algorithms and combinatorial optimization, Michel also received a John Simon Guggenheim Foundation Fellowship.

Tomasz Mrowka was selected for the Simons Professorship of Mathematics in recognition of his leadership role in research and education. Tom is a major figure in gauge theory and low-dimensional topology. Last January, he received the American Mathematics Society (AMS) Oswald Veblen Prize in Geometry along with Peter Kronheimer from Harvard, “for their joint contributions to both three and four-dimensional topology through the development of deep analytical techniques and applications.” Tom was also elected a member of the American Academy of Arts and Sciences.

Gigliola Staffilani was selected as the next holder of the Abby Rockefeller Mauzé Professorship at MIT for outstanding contributions in education and research. Gigliola is a leading expert in the field of nonlinear partial differential equations. An inspiring mentor and role model for our women graduate students, she and Katrin Wehrheim are organizing an MIT conference for spring 2008 to celebrate MIT women in mathematics.

Katrin Wehrheim was also selected as the next holder of the Rockwell International Career Development Professorship at MIT. In addition, she received an Alfred P. Sloan Research Fellowship and was chosen by the School of Engineering for support by the Charles E. Reed Faculty Initiative Fund.

Additional Faculty Awards

Mark Behrens received an Alfred P. Sloan Research Fellowship.

Victor Kaç was elected a member of the American Academy of Arts and Sciences.

Eric Lauga won the 2007 Andreas Acrivos Dissertation Award in Fluid Dynamics from the American Physical Society.

George Lusztig received the Diploma of Academic Merit by the Romanian Academy.

Kiran Kedlaya and Alexander Postnikov received National Science Foundation Career Awards.

Peter Shor was named one of Caltech's Distinguished Alumni, one of the highest awards Caltech bestows on its graduates.

Richard Stanley was a plenary speaker at the International Congress of Mathematicians in Madrid in August 2006. He received an honorary doctorate of mathematics from the University of Waterloo and was appointed a 2006–2007 Aisenstadt Chair at the Centre of Mathematical Research, University of Montreal.

Gilbert Strang received the Deborah and Franklin Tepper Haimo Award for Distinguished Teaching of Mathematics by the Mathematical Association of America (MAA). He was also selected by the Northeastern Section of the MAA as the 2006 Distinguished University Teacher of Mathematics. In addition, Professor Strang was chosen to be the first recipient of the Su Buchin Prize, awarded by the International Council for Industrial and Applied Mathematics, in support of mathematics in the developing world.

David Vogan was selected by department faculty to be the next Robert E. Collins Distinguished Scholar, in support of his research activities in representation theory and Lie algebra.

Three junior faculty (two incoming) were selected by the School of Science for the following support:

Benjamin Brubaker—James H. Ferry Fund Grant for Innovation in Research Education

Jonathan Kelner—NEC Corporation Fund for Research in Computers and Communications

Abhinav Kumar—Solomon Buchsbaum AT&T Research Fund

Resource Development

The Department of Mathematics' \$15 million campaign for faculty recruitment and retention and for graduate student support, launched in spring 2006, has reached its goal within the two-year time frame. The campaign got under way thanks to the generous leadership gift of \$6 million offered as matching funds by John S. Reed, chair of the Department's visiting committee. Visiting committee member James H. Simons offered to give the last \$3 million if we could raise \$12 million. Within that period, the Department also secured a \$1 million gift from the Liberty Mutual Corporation with the help of visiting committee member Edmund F. Kelly. The Leighton family,

including Professors Tom Leighton and Bonnie Berger Leighton, and David T. and Helen M. Leighton, established the Leighton Family Professorship with a \$3 million gift. The Leighton Professorship will support research in algorithms, theoretical computer science, discrete mathematics, or networking, with special interest in support of a female faculty member. Other gifts included an \$800,000 gift from an alumna, a \$1 million gift from a 1971 graduate, and a \$250,000 pledge from a graduate alumnus.

Education

Graduate Students

There were a total of 119 graduate students in mathematics, all in the PhD program. Last year, 13 students received a doctoral degree, and three a master's degree. There will be 18 new graduate students (five women) in 2007–2008. Next year, all but one of the first-year students (who will receive support in the fall) will have fellowship support for the entire first year. This marks a long-term goal of the department that has been part of our fundraising campaign. We are pleased that two of our new women students will receive the Ida M. Green Fellowship, an Institute-wide fellowship given to eight new graduate women students each year.

Student Awards

Jason M. Burns, and runners-up Ilya Elson and Teena M. Gerhardt, received the Housman Graduate Student Teaching Award for their exceptional skill and dedication to undergraduate teaching.

Silvia Montarani and Luis A. Rademacher were awarded the Charles W. and Jennifer C. Johnson Prize for an outstanding research paper accepted in a major journal by a graduate student in mathematics.

Pavlo M. Pylyavskyy was selected for a 2007 Liftoff Fellowship by the Clay Mathematics Institute.

Undergraduate Education

Majors

During AY2007, there were 284 undergraduates majoring in mathematics—253 in Course 18 Mathematics, and 31 in Course 18-C Mathematics/Computer Science. Bachelor of Science degrees, including double majors, were awarded to 112 students—102 in Course 18 and 10 in Course 18-C.

We continue to be blessed with the strongest group of mathematics majors in the country. To illustrate, the MIT team has dominated the major collegiate mathematics competition—the William Lowell Putnam Intercollegiate Mathematics Competition—since 2003. This success is in no small measure due to the coaching by Professors Hartley Rogers and Richard Stanley and assistant professor Kiran Kedlaya.

The MIT Mathematics team, composed of senior Daniel Kane and juniors Oleg Golberg and Kuat Yessenov, finished third in the 2006 Putnam Mathematical Competition.

Participants included more than 3,600 undergraduates from 500 institutions across the United States and Canada. For the third consecutive year, three MIT undergraduates were among the five or six highest ranking individuals and were designated Putnam fellows. The MIT Putnam fellows were senior Daniel Kane, sophomore Hansheng Diao, and freshman Yufei Zhao. MIT had 10 other students who ranked in the top 26, and 13 more were given honorable mention for finishing in the top 78. (Also of note, three of the five women in that group were MIT students, and two were freshmen at the time of the exam.) This total of 26 undergraduates at honorable mention or higher appears to be an all-time record for a single institution in the Putnam Competition. A total of 126 MIT students took the exam, probably also a record for a single institution.

The mathematics majors have been equally successful in the Mathematical Contest in Modeling Competition, administered by the Consortium for Mathematics and its Applications (COMAP). This is a more international competition than the Putnam exam, with almost a thousand teams—only 30 percent from the United States. The MIT team, coached by associate professor Martin Bazant, has taken top honors every year since 2004. Last year's MIT team, consisting of seniors Daniel Gulotta, Daniel Kane, and Andrew Spann, was selected for the highest category of outstanding winners in the 2007 COMAP modeling competition, capping a four-year streak of success. In addition, the team's paper received a special prize for best paper from the Society for Industrial and Applied Mathematics.

MIT mathematics majors also won the prestigious Frank and Brennie Morgan Prize for the past three years: Daniel Kane '07, Jacob Fox '06, and Reid Barton '05. This award is given for outstanding research in mathematics by an undergraduate student, sponsored by the AMS, the MAA, and the Society for Industrial and Applied Mathematics.

Daniel M. Kane was awarded the Jon A. Bucsela Prize in Mathematics in recognition of distinguished scholastic achievement. This is the Department's highest recognition of a graduating senior.

Senior Yaim R. Cooper was selected by the Association of MIT Alumnae for the Senior Academic Award, presented to an outstanding senior woman who demonstrated the highest level of academic excellence through coursework and related professional activities at MIT. She was also runner-up for the 2007 Alice T. Schafer Prize for excellence in mathematics by an undergraduate woman. This prize is given annually by the Association for Women in Mathematics.

Among seniors awarded degrees in mathematics, 19 were elected to Phi Beta Kappa.

Curriculum

Our commitment to providing excellent instruction in general institute requirement subjects is illustrated by the number of young faculty attracted to this work. Last year Professor Gigliola Staffilani and associate professors Denis Auroux, John Bush, Lars Hesselholt, and Alexander Postnikov lectured on core subjects.

The administrative organization of the educational component of the Mathematics Department was overhauled last spring. These changes should improve communication between the graduate and undergraduate offices and result in other efficiencies. We are also in the process of renovating the Undergraduate Mathematics Office.

Professors Victor Guillemin and Richard Melrose have created a new undergraduate analysis sequence.

We continue to expand our Communications-Intensive for Mathematics offerings. As of next year, there will be 10 undergraduate seminars (in addition to header subjects in pure and applied mathematics), plus the mathematics project laboratory (also fulfilling the institute laboratory requirement), and a subject specifically in mathematical exposition.

Professor Michel Goemans has designed and overseen the implementation of an online checklist to help advisors monitor students' progress through the major. We have initiated a process of systematizing records of subject materials. This will help to improve stability of content and level from year to year and increase the coherence of the Department's subject offerings.

Teacher Training

The Department continues to do a careful job training its new recitation teachers, both graduate teaching assistants and incoming instructors. This training has several components, including a six-hour microteaching workshop (organized by Michel Goemans and Denis Auroux) and written comments (by Professor Arthur Mattuck) on video-recorded recitations. We have also begun to offer a workshop for leaders of our undergraduate seminars to help them develop ideas and skills connected with this form of education and the communication training and grading it entails.

Undergraduate and High School Summer Research Programs

One of the reasons for the increase in the number of highly talented undergraduates is the very active participation by the department in the high school Research Science Institute program (RSI), for many years under the leadership of Hartley Rogers. Professor Rogers also developed and directed a unique Summer Program in Undergraduate Research (SPUR). Direction of these programs passed into the hands of Professor David Jerison last year. Both of these programs are supported mainly by departmental funds.

In summer 2006, nine MIT undergraduates, with five mathematics graduate-student mentors, participated in the department's 10th SPUR, which offers a six-week program of full-time research experience culminating in written papers and lectures to faculty. A jury of senior faculty members awards a prize to the best undergraduate along with his/her mentor. Two such joint SPUR prizes were given: the undergraduate winners were juniors Galyna Dobrovolska and Anand Deopurkar, mentored by Pavlo Pylyavskyy and Xiaoguang Ma, respectively. Ms. Dobrovolska published her work in a joint paper with Mr. Pylyavskyy.

Summer 2006 was also the 14th year of the mathematics department's participation in the RSI summer program for gifted high school students. Seven mathematics graduate students served as mentors for 13 high school seniors for a five-week period. One student from this group, Dmitry Vaintrob, won the \$100,000 first prize in the Siemens competition with his RSI project. He also received the \$50,000 third prize in the Intel competition with closely related work. The problems he solved were suggested by Professor Pavel Etingof.

Research

Here are a few snippets from the great range of research under way in the department.

John Bush, with colleague assistant professor Roman Stocker (Civil and Environmental Engineering), uncovered the dynamics behind the often-observed “beating-heart” phenomenon: that of a drop of oil mixed with detergent expanding and contracting on water like a heartbeat, but stopping when deprived of a fresh air supply. In the July 25 issue of the *Journal of Fluid Mechanics*, Bush and Stocker explained that the movement is due to evaporation-induced variations in surface tension. When a cover is placed obstructing fresh air, evaporation of the surfactant is prevented and the movement stops. The work was done sporadically over the last three years (without funding), with lab assistance by undergraduates Margaret Avenier and Wesley Koo.

Sigurdur Helgason is writing a book on integral geometry and radon transforms, covering some new results, and expanding on his earlier 1999 book, *The Radon Transform*.

Steven Johnson continues research on problems in nanophotonics and electromagnetism in media, structured on the scale of the wavelength. Recently, his work has begun to explore the quantum-electromagnetism regime—from numerical methods for Casimir forces from vacuum fluctuations to designing devices that allow for a single photon to interact with another photon.

Steven Kleiman continued his collaboration with Professor Renato Vidal Martins of the Universidade Federal de Minas Gerais, Brazil, on the canonical model of an arbitrary singular algebraic curve. In addition, starting in December 2006, Steve has renewed his research into the Whitney equisingularity theory of a family of complex analytic germs, in collaboration with two colleagues at Purdue University, Professors Bernd Ulrich and Javid Validashti (along with junior Anand Deopurkar). Steve has been making progress on the next open case, arbitrary isolated singularities. Finally, he and his coauthor, Professor Allen Altman of Bard College at Simon's Rock, have recently begun work on a second edition of their Springer text, *Introduction to Grothendieck Duality Theory*.

Hartley Rogers continues work in recursion theory and on the P versus NP problem.

Richard Stanley continues research on alternative permutations, including connections with symmetric functions and representation theory.

David Vogan has been working on the Jeff Adams project “Atlas of Lie groups and representations” since 2002. This project has involved 15 to 20 mathematicians, including

University of Massachusetts associate professor Alfred Noël and CLE Moore instructor Dan Ciubotaru. Together they have concentrated on a network of closely related problems in representation theory. On January 9, 2006, a computer at the University of Washington finished writing 60 gigabytes of files that mapped out the E_8 Lie group, one of the largest and most complicated mathematical structures ever studied. In March, David lectured on their research, and news of the mathematical feat drew international headlines. The results could lead to new discoveries in a variety of fields and highlight the role of innovative large-scale computing in solving long-standing problems in mathematics.

Katrin Wehrheim was an organizer of the symplectic geometry group (additionally consisting of Denis Auroux, Victor Guillemin, Tomasz Mrowka, and Paul Seidel). With support from the Clay Mathematics Institute, she and her colleagues coordinated a special semester on symplectic geometry in spring 2007. The program brought in junior and senior visitors and stimulated intense interaction through a cluster of activities, including two advanced graduate courses, two weekly focused research seminars, and an additional informal working group meeting at the postdoctoral level.

Lecture Series, Seminars, and Conferences

The Mathematics Department, with its wide representation of fields, continues to be a major hub of mathematical research and seminar activity in the northeast. Our seminar and conference website lists some 25 weekly seminars, including five organized by graduate students, plus the Brandeis-Harvard-MIT-Northeastern Joint Mathematics Colloquium Series.

Simons Lecture Series

Six years ago, the Mathematics Department launched the Simons Lecture Series, named after its benefactor, former colleague, and friend James H. Simons. Each speaker gives three lectures on various mathematical topics, and the two series run for a two-week period in the spring term. The series has brought in such distinguished speakers as Laurent Lafforgue, Peter Shor, Robert MacPherson, Wendelin Werner, Grigori Perelman, Nigel Hitchin, Noga Alon, Akshay Venkatesh, and Yves Couder. Last year we heard lectures by Terence Tao from the University of California, Los Angeles, and David Donoho from Stanford University. Tao's lectures focused on "the dichotomy between structure and randomness," and David Donoho spoke on problems surrounding sparse solutions to underdetermined systems.

Upcoming Events

In fall 2008, the Department will resume the Norbert Wiener Lectures, with Assaf Naor as speaker. Assaf Naor is a leading analyst and geometer at New York University's Courant Institute of Mathematical Sciences.

Gigliola Staffilani and Katrin Wehrheim are organizers of the upcoming spring 2008 conference, "MIT Women in Mathematics: A Celebration." The conference is designed to recognize the large number of and the mathematical and professional accomplishments

of women who graduated from MIT in mathematics. The celebration will also showcase women in mathematics worldwide.

Hartley Rogers is preparing for the Special Year in Logic at MIT, 2007–2008, which will culminate with the spring 2008 visit of Professor Richard Shore of Cornell University. Activities will include seminars and courses addressed primarily to graduate students.

Michael Sipser
Department Head
Professor of Applied Mathematics

More information about the Mathematics Department can be found at <http://www-math.mit.edu/>.