New and Noteworthy from Springer

Quadratic Diophantine Equations
T. Andreescu, University of Texas at Dallas, Richardson, TX, USA; D. Andrica, University Cluj-Napoca, Romania
This text treats the classical theory of quadratic diophantine equations and guides readers through the last two decades of computational techniques and progress in the area. The presentation features two basic methods to investigate and motivate the study of quadratic diophantine equations: the theories of continued fractions and quadratic fields. It also discusses Pell’s equation.


Introduction to Siegel Modular Forms and Dirichlet Series
A. Andrianov, Russian Academy of the Sciences, Petersburg Department of the Steklov Institute of Mathematics, St. Petersburg, Russia
This is intended for a graduate course on Siegel modular forms, Hecke operators, and related zeta functions. The author’s aim is to present a concise and self-contained introduction to a developing area of number theory that will serve to attract young researchers to this field.


Multiscale Finite Element Methods Theory and Applications
Y. Efendiev, Texas A & M University, College Station, Texas, USA; T. Y. Hou, California Institute of Technology, Pasadena, CA, USA
This text on the main concepts and recent advances in multiscale finite element methods is written for a broad audience. Each chapter contains a simple introduction, a description of proposed methods, and numerical examples of those methods.


Principles of Harmonic Analysis
A. Olevskii, University of Tübingen, Germany; S. Eugenio, University of Münster, Germany
This gently-paced book includes a full proof of Pontryagin Duality and the Plancherel Theorem. The authors emphasize Banach algebras as the cleanest way to put many fundamental results in harmonic analysis.


Solving the Pell Equation
M. J. Jacobson, Jr., H. C. Williams, University of Calgary, AB, Canada
The authors provide a friendly introduction to algebraic number theory via Pell’s Equation. The only prerequisites are knowledge of elementary number theory and abstract algebra.


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New and Forthcoming

Algebra, Arithmetic, and Geometry
In Honor of Y.I. Manin
Yuri Tschinkel, New York University, New York, NY, USA; Yuri G. Zarhin, Pennsylvania State University, University Park, PA, USA (Eds.)


ISBN 978-3-7643-8993-2 $79.95

Observation and Control for Operator Semigroups
Marius Tucsnak, Université Nancy, France; George Weiss, Tel Aviv University, Israel

This book studies observation and control operators for linear systems, in which the state evolution of the state can be described by an operator semigroup on a Hilbert space. Emphasized in the text are well-posedness, observability and controllability properties. The abstract results are supported by a large number of detailed examples coming mostly from partial differential equations.

2009. APPROX. 475 P. HARDCOVER
ISBN 978-3-7643-8993-2 $79.95

Arithmetic and Geometry around Quantization
Ozgur Ceyhan; Yuri I. Manin; Matilde Marcolli, Max-Planck Institut, Bonn, Germany (Eds.)

Quantization has been a potent source of interesting ideas and problems in various branches of mathematics. This volume comprises both research and survey articles originating from the conference on Arithmetic and Geometry around Quantization held in Istanbul in 2006. A wide range of topics related to quantization are covered, thus aiming to give a glimpse of a broad subject from very different perspectives.


2009. APPROX. 400 P. HARDCOVER ISBN 978-0-8176-4830-5 CA. $129.00
PROGRESS IN MATHEMATICS

Developments and Trends in Infinite-Dimensional Lie Theory
Karl-Hermann Neeb, Darmstadt University of Technology, Germany; Arturo Pianzola, University of Alberta, Canada (Eds.)

This collection of invited expository papers focuses on recent developments and trends in infinite-dimensional Lie theory, which has become one of the core areas of modern mathematics. The book is divided into three parts: infinite-dimensional Lie (super)-algebras, geometry of infinite-dimensional Lie (transformation) groups, and representation theory of infinite-dimensional Lie groups.


2009. APPROX. 430 P. HARDCOVER
ISBN 978-0-8176-4740-7 CA. $79.00
PROGRESS IN MATHEMATICS

Symmetry and Spaces
In Honor of Gerry Schwarz
H.E.A. Campbell, Memorial University of Newfoundland, St. John’s, NF, Canada; Loek Helminck, North Carolina State University, Raleigh, NC, USA; Hans-Peter Kraft, Universität Basel, Switzerland; David Wehlau, Queen’s University, Kingston, ON, Canada (Eds.)

This volume covers the wide range of mathematics to which Gerry Schwarz has either made fundamental contributions or stimulated others to pursue. Three papers examine various aspects of modular invariant theory (Broer, Elmer and Fleischmann, Shank and Wehlau), and seven papers concentrate on characteristic 0 (Brion, Daigle and Freudenberg, Greb and Heinzer, Helminck, Kostant, Kraft and Wallach, Travas).

2009. APPROX. 220 P. HARDCOVER
ISBN 978-0-8176-4874-9 CA. $90.00
PROGRESS IN MATHEMATICS

Frobenius Categories versus Brauer Blocks
The Grothendieck Group of the Frobenius Category of a Brauer Block
Lluis Puig, Université Paris VII Denis Diderot, Paris, France

This book examines important questions in modern representation theory of finite groups. On the one hand, it introduces and develops the abstract setting of Frobenius categories (also called Saturated fusion systems), created by the author fifteen years ago for a better understanding of what was loosely called the local theory of finite groups or blocks, and for the purpose of an eventual classification. On the other hand, it presents the application of the abstract setting to the blocks. In particular, it develops a framework for a deeper understanding of one of the central open problems in representation theory, known as Alperin’s Weight Conjecture (AWC).

2009. APPROX. 510 P. HARDCOVER
ISBN 978-3-7643-9997-9 $109.00
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Mathematical Moments

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Ken Golden, University of Utah, on the mathematics of sea ice

Kevin Short, University of New Hampshire, on digitizing a wire recording of Woody Guthrie (and his resulting Grammy® Award)

Tim Chartier, Davidson College, on the connections between mathematics and soccer

and more...

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A Mathematician Runs for Political Office

As I sit down to write this essay, just over a week has elapsed since my narrow defeat in the 2008 election. I was the Democratic nominee for State Representative in the (north suburban Chicago) 17th District of Illinois. Not many mathematicians run for office, but as interest in energy, environmental, and technology policy increases, more people with scientific backgrounds are considering this professional transition. In Illinois, I’m happy to say that this is a bipartisan phenomenon, thanks to Democratic Congressman Bill Foster and Republican State Representative Mike Fortner, both particle physicists. Given my vantage point, I thought it might be useful to offer some insights and suggestions for mathematicians considering politics.

1. You have an important advantage. You’ve probably been struck by how often candidates use the phrase “solving problems”. This is partially because “solving problems” is a kind of antonym of “partisan bickering”, making it a particularly salient concept in 2008’s Obama-driven political culture. There’s another reason, though: when done correctly, policymaking involves solving technical problems by analyzing data and predicting consequences of various actions. This data-driven approach to policymaking is sorely missed today. (And while the Bush administration elevated out the data to a grotesque art form, this practice did not begin in 2001 and is unfortunately not limited to the executive branch of government.) If you’re reading this magazine, chances are you actually solve problems for a living; in other words, you’re more justified than almost anyone in calling yourself a problem-solver. Voters get this, and they like it.

2. You have another important advantage. If you’re reading this magazine, you’re also probably a teacher. That means you speak in public several days a week. Moreover, you do so in circumstances far less favorable than those confronting politicians most days (they talk for ten minutes, not an hour, about subject matter that—and it pains me to say this—most people find less boring than mathematics). By Election Day, I’d become a pretty good political speaker, based only on my experience in the classroom, my passion about the issues, and a lot of hard work. You can too.

3. You have yet another important advantage. Your schedule is flexible. The number of hours you’re in class is quite a bit lower than most people’s time commitment. Your summer vacation is auspiciously scheduled shortly before the first Tuesday after the first Monday in November—squeeze everything you can out of it. Naturally, you have other duties, like research and class preparation, and you need to fulfill those duties responsibly. Just make sure you don’t spend time on them while voters and donors are awake.

4. And you have one more important advantage. Running for office is really hard and involves tons of work and learning about a billion new things. If you’re reading this magazine, you’ve probably always been good at homework. Your campaign (as well as the preparation time you spend figuring out how your campaign will work) is a great time to dust off that skill.

5. But don’t be a big jerk. When I announced my candidacy, one of my mathematical colleagues expressed concern that it would be hard to move out of mathematics, where everyone was “really smart”. Aside from being an obnoxious sentiment, it’s totally wrong. There are reasons I’ve missed being a mathematician, but access to bright people and interesting conversation sure isn’t among them.

6. In fact, if you do this correctly, you’ll learn more than in any other phase of your life. A political campaign is an extremely complicated machine, made up of dozens of moving parts and thousands of people. You’ll encounter more different ideas and tasks than you can possibly imagine. It’s scary and difficult, but truly inspiring.

7. One thing you’ll learn how to do is cut corners. A campaign inevitably involves a lot of corner-cutting. Over 70,000 voters reside in our district, and 52,418 of them cast a ballot in my race. The ideal campaign would involve talking individually with each one for at least half an hour. Obviously, I didn’t have 25,000 hours. The main purpose of a campaign is to short-circuit that process but still deliver substantive communication.

8. You’ll also get a visceral education about long tails. If you’re running in a district smaller than a Congressional district and you want to win, then you’ll knock on doors. Lots of them. (I knocked on over 20,000.) This will be one of the most valuable experiences of your life—you’ll learn so much about your community and human nature. But because of the law of large numbers, you’ll also have a fair number of extraordinary experiences. Besides the naked man in the wheelchair (really) and the horrifying racist, you’ll also encounter your fair share of human stories of struggle. You’ll find yourself hugging, laughing, and crying with a lot more strangers than you can imagine. It’s truly uplifting.

9. But never forget this is still politics. When I began running, some friends worried that I was entering this slimy world of character assassination. I replied “Sure, that’s how politics looks on TV, but I’m not running for president. A local campaign will be much more civil.” Just days before the election, a letter was sent to voters leveling completely fabricated accusations, urging recipients to vote for my opponent, and describing such an action as “a vote against the very worst in politics”. The letter concluded by asking people to call me to express their outrage, and listed my cell phone number.

10. Speaking of my cell phone number, it’s 773-383-6774. I hope you’ll consider running for office, and if you do, please call me. I’d love to help! (Unless you’re a Republican, in which case Fortner would probably be a better bet.)

—Daniel Biss
Evanston, Illinois
daniel@danielbiss.com
Grants to support collaborations between Chinese and U.S./Canadian researchers are made possible through the generosity of Ky and Yu-Fen Fan.

The Fan China Exchange Program is intended to send eminent mathematicians from the U.S. and Canada to make a positive impact on the mathematical research community in China and to bring Chinese scientists in the early stages of their research to the U.S. and Canada to help further their careers. The program encourages host institutions to provide some type of additional support for the travel or living expenses of the visitor and to ensure a suitable length of stay.

Applications received before March 15 will be considered for the following academic year.

For more information on the Fan China Exchange Program and application process see [www.ams.org/employment/chinaexchange.html](http://www.ams.org/employment/chinaexchange.html) or contact the AMS Membership and Programs Department by telephone at 800-321-4267, ext. 4170 (U.S. and Canada), or 401-455-4170 (worldwide), or by email at chinaexchange@ams.org.
Letters to the Editor

Imperfect Mathematics

A thought on Melvyn B. Nathanson’s August 2008 Opinion piece “Desperately seeking truth”:

Just like our lines are not infinitely straight and our points are not infinitely thin, so too our journals and our refereing process are only rough approximations of the idealized notions they are supposed to represent. This is, after all, mathematics done by humans.

—Gabriel Nivasch
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(Received November 2, 2008)

Citation Statistics Report

Citation

I am sorry to report to you that the footnote on page 1221 in the November 2008 Notices is misleading, and quite unfair.

The Citation Statistics report is not an IMU [International Mathematical Union] report. It is a joint IMU-ICIAM-IMS report and should be quoted as such. [ICIAM = International Council for Industrial and Applied Mathematics, IMS = Institute of Mathematical Statistics]. This is all the more distressing as the AMS is an associate member of ICIAM, whereas it is not a member of the IMU. Also, the presence of the IMS as a co-sponsor lends even more weight and credence to such a report on statistics.

Thank you for making the proper corrections, including on the AMS website.

To spread the guilt a little, note that there are many websites which make the same mistake, including SIAM’s, even when SIAM is a founding member of ICIAM!

—Alain Damlamian
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(Paris-12 Val de Marne)
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(Received November 6, 2008)

Editor’s Note: The author is past secretary of ICIAM (1999–2007), and a foreign member of the AMS (since the late 1970s).

Salary Trends

The Annual Survey compares the starting salaries of new Ph.D.’s over the years by giving their (median, quartiles, etc.) annual salaries in past years both in then-current dollars and in 2007 dollars. This adjustment is made via the Cost-of-Living (COL) index and shows what has happened to the real purchasing power of starting salaries over time.

There is another way to adjust salaries to the changing environment that gives additional information. That is to adjust them by the Average Wage Index. For example the AWI for 2007 was US$40,405 while that for 1990 was US$21,028. Their ratio is 1.92. Thus a salary of US$32,000 in 1990 would rank roughly like one of US$61,500 in 2007. (By “rank” I mean its position in the scale of salaries. It would be better to give the actual percentile, but I don’t have those figures.)

The rank of one’s salary in the general salary population is significant. It largely determines in which neighborhoods one can afford to live, and the figures for the whole Ph.D. group may perhaps indicate the changes in the value society places on our profession. The following table shows the median starting salaries for new Ph.D.’s taking 9–10-month academic teaching/teaching-and-research positions. The second and third columns are from p. 822 in the August 2008 Notices; they give the salaries in current and in 2007 dollars respectively. The fourth column gives the salaries adjusted to the AWI (all in hundreds of dollars).

<table>
<thead>
<tr>
<th>Year</th>
<th>Median Salary</th>
<th>75th Percentile</th>
<th>90th Percentile</th>
<th>Median Salary Adjusted to AWI</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>465</td>
<td>493</td>
<td>507</td>
<td>500</td>
</tr>
<tr>
<td>2006</td>
<td>490</td>
<td>503</td>
<td>514</td>
<td>500</td>
</tr>
<tr>
<td>2007</td>
<td>500</td>
<td>500</td>
<td>500</td>
<td>500</td>
</tr>
</tbody>
</table>

The wage-adjusted figures show a downward trend (after 1990) that is not apparent in the COL-adjusted numbers.

—Seymour Haber
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(Received November 8, 2008)

Mathematics Education for Girls

The article “Cross-cultural analysis of students with exceptional talent in mathematical problem solving” [November 2008 Notices] reminded me of how, back in the USSR, everyone claimed that the Soviets had the best math schools in the world. The widely-accepted explanation was that every person who was gifted in technical fields had no choice but to become a scientist. Indeed, neither private business nor the stock market existed in the USSR. Lawyers didn’t need any gifts, other than the ability to obey. The only way to get a hefty salary was to become a big manager, and for this you had to sell your soul by joining the Communist Party.

On the other hand, if you had a Ph.D., you would get a sizable bonus. Hence, every gifted person tried to enter the prestigious world of science and mathematics. No wonder the Soviet math tradition and math education was so good. Can you imagine what would happen to math education in the U.S. if energetic and ambitious people like Google founders Larry Page and Sergey Brin decided to become math educators?

I do think that math education here in the U.S. is a disaster. But it would be a bigger disaster to try to improve it by following the communism path. Let’s find another way.

In examining the data in this article, it appears that girls in Communist countries are doing better in math competitions than American girls. We are supposed to be the democratic leaders around gender
equality issues, but why then are our young women mathematicians behind? I was gratified to see the AMS addressing this concern. I also started exploring issues around women and math on my blog at http://blog.tanyakhovanova.com/?cat=17

—Tanya Khovanova
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(Received November 22, 2008)

Editor's Note: The author was a member of the USSR IMO team (1975 silver medal; 1976 gold medal).

Loewner Archive Established

We are writing to convey to the mathematical community that professional and personal documents from the legacy of Charles Loewner, which were donated to Stanford University by his daughter Marian Tracy, have been organized and catalogued and are part of the Stanford University Archives located in the Stanford University Libraries. The online guide can be accessed at http://content.cdlib.org/view?docId=kt7c6037b

Those wishing to view the material should contact publication staff in the Department of Special Collections and University Archives, at speccolref@stanford.edu.

Many of the current readers will have arrived too recently on the mathematical scene to be directly impacted as we have been by Loewner’s profound insights and originality, by his selfless human qualities, and by the depth and universality of his scientific contributions. Beyond those comments, his life experiences as a Jewish refugee who barely escaped the Nazi Holocaust, and who lost close family members in those horrid events, reflect poignantly the sweeping social changes and the terrible human suffering of the time. The correspondence preserved in these documents also puts into vivid relief the often resentful attitude of the United States university establishment of that time toward refugees of highest creative achievement who were sometimes driven to accept survival salaries under demeaning conditions.

Despite the often difficult circumstances of his life, Loewner produced an impressive body of original work that left permanent imprints on mathematical thinking, in a wide range of directions. He published little, but each work that appeared was on a level to change the direction of mathematics. Much of his contribution was offered in informal conversation with students and colleagues; he shared everything, and fruits of his talent appear in many publications by others. His central interest was geometric function theory, to which he applied variational methods. Using strikingly original reasoning, he proved the initial case for the Bieberbach Conjecture, and the ideas of that proof were central to the later complete proof by de Branges. He was interested also in fluid flow problems, in which his geometric thinking had great influence. His thinking led him to the general study of semi-groups of transformations, for which again there were remarkable consequences in several directions, with unexpected physical applications.

Loewner was also famous for his interaction with students at all levels. His lectures were polished and perfect, presented without notes; they attracted students and also professors. His problem seminar at Stanford was celebrated, and became a birthplace of inspiration leading to Ph.D. dissertations, for many students.

For the convenience of readers, we are enclosing below a brief summary of the material.

Physical Description: 4.5 linear ft. Summary: The first seven boxes of this collection consist largely of Loewner’s lectures notes, 1923-1956, with some exams and class projects; manuscripts and typescripts of articles, 1919-62, including his 1933 thesis; and research notes and writings. Subjects of his writings and research include differential equations, matrices, and semigroups. Other items include several articles by other mathematicians on Loewner’s work, note cards, and a small amount of correspondence. Accession 2007-257 consists of Loewner’s personal papers, which contain correspondence pertaining to his emigration to the United States during World War II, his wartime employment search, and attempts to determine the whereabouts of his family remaining in Europe. This accession also contains academic records and correspondence to and from colleagues at the many academic institutions where Loewner taught including the University of Louisville, Brown University, Syracuse University, and Stanford University. Other items include photographs, publishing contracts, memorial tributes to Loewner and his wife Elizabeth, and news clippings about the Loewner family. Notes: Charles Loewner was born on May 29, 1893, in Lany, Bohemia (now in the Czech Republic), and received his Promotion (Ph.D.) in Mathematics at the (German) Charles University in Prague. From 1922–1928 he taught at Friedrich Wilhelm University in Berlin. Following a brief lectureship at Cologne, he returned to the (German) Charles University as Ausserordentlicher Professor (associate professor) and was later promoted to Ordinarius (full professor). The occupation of Czechoslovakia in 1939 prompted his emigration to the United States. He taught at Louisville, Brown, and Syracuse University prior to his appointment in 1951 as professor of mathematics at Stanford University, where he remained until his death on January 8, 1968. Indexes: Unpublished guide available (folder level inventory). Notes: Gift of Marian Tracy, 2007/1972. Subject (LC): Loewner, Charles, 1893-1968.

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Some mathematicians are birds, others are frogs. Birds fly high in the air and survey broad vistas of mathematics out to the far horizon. They delight in concepts that unify our thinking and bring together diverse problems from different parts of the landscape. Frogs live in the mud below and see only the flowers that grow nearby. They delight in the details of particular objects, and they solve problems one at a time. I happen to be a frog, but many of my best friends are birds. The main theme of my talk tonight is this. Mathematics needs both birds and frogs. Mathematics is rich and beautiful because birds give it broad visions and frogs give it intricate details. Mathematics is both great art and important science, because it combines generality of concepts with depth of structures. It is stupid to claim that birds are better than frogs because they see farther, or that frogs are better than birds because they see deeper. The world of mathematics is both broad and deep, and we need birds and frogs working together to explore it.

This talk is called the Einstein lecture, and I am grateful to the American Mathematical Society for inviting me to do honor to Albert Einstein. Einstein was not a mathematician, but a physicist who had mixed feelings about mathematics. On the one hand, he had enormous respect for the power of mathematics to describe the workings of nature, and he had an instinct for mathematical beauty which led him onto the right track to find nature’s laws. On the other hand, he had no interest in pure mathematics, and he had no technical skill as a mathematician. In his later years he hired younger colleagues with the title of assistants to do mathematical calculations for him. His way of thinking was physical rather than mathematical. He was supreme among physicists as a bird who saw further than others. I will not talk about Einstein since I have nothing new to say.

Francis Bacon and René Descartes
At the beginning of the seventeenth century, two great philosophers, Francis Bacon in England and René Descartes in France, proclaimed the birth of modern science. Descartes was a bird, and Bacon was a frog. Each of them described his vision of the future. Their visions were very different. Bacon said, “All depends on keeping the eye steadily fixed on the facts of nature.” Descartes said, “I think, therefore I am.” According to Bacon, scientists should travel over the earth collecting facts, until the accumulated facts reveal how Nature works. The scientists will then induce from the facts the laws that Nature obeys. According to Descartes, scientists should stay at home and deduce the laws of Nature by pure thought. In order to deduce the laws correctly, the scientists will need only the rules of logic and knowledge of the existence of God. For four hundred years since Bacon and Descartes led the way, science has raced ahead by following both paths simultaneously. Neither Baconian empiricism nor Cartesian dogmatism has the power to elucidate Nature’s secrets by itself, but both together have been amazingly successful. For four hundred years English scientists have tended to be Baconian and French scientists Cartesian. Faraday and Darwin and Rutherford were Baconians; Pascal and Laplace and Poincaré were Cartesians. Science was greatly enriched by the cross-fertilization of the two contrasting cultures. Both cultures were always at work in both countries. Newton was at heart a Cartesian, using
pure thought as Descartes intended, and using it to demolish the Cartesian dogma of vortices. Marie Curie was at heart a Baconian, boiling tons of crude uranium ore to demolish the dogma of the indestructibility of atoms.

In the history of twentieth century mathematics, there were two decisive events, one belonging to the Baconian tradition and the other to the Cartesian tradition. The first was the International Congress of Mathematicians in Paris in 1900, at which Hilbert gave the keynote address, charting the course of mathematics for the coming century by propounding his famous list of twenty-three outstanding unsolved problems. Hilbert himself was a bird, flying high over the whole territory of mathematics, but he addressed his problems to the frogs who would solve them one at a time. The second decisive event was the formation of the Bourbaki group of mathematical birds in France in the 1930s, dedicated to publishing a series of textbooks that would establish a unifying framework for all of mathematics. The Hilbert problems were enormously successful in guiding mathematical research into fruitful directions. Some of them were solved and some remain unsolved, but almost all of them stimulated the growth of new ideas and new fields of mathematics. The Bourbaki project was equally influential. It changed the style of mathematics for the next fifty years, imposing a logical coherence that did not exist before, and moving the emphasis from concrete examples to abstract generalities. In the Bourbaki scheme of things, mathematics is the abstract structure included in the Bourbaki textbooks. What is not in the textbooks is not mathematics. Concrete examples, since they do not appear in the textbooks, are not mathematics. The Bourbaki program was the extreme expression of the Cartesian style. It narrowed the scope of mathematics by excluding the beautiful flowers that Baconian travelers might collect by the wayside.

Jokes of Nature
For me, as a Baconian, the main thing missing in the Bourbaki program is the element of surprise. The Bourbaki program tried to make mathematics logical. When I look at the history of mathematics, I see a succession of illogical jumps, improbable coincidences, jokes of nature. One of the most profound jokes of nature is the square root of minus one that the physicist Erwin Schrödinger put into his wave equation when he invented wave mechanics in 1926. Schrödinger was a bird who started from the idea of unifying mechanics with optics. A hundred years earlier, Hamilton had unified classical mechanics with ray optics, using the same mathematics to describe optical rays and classical particle trajectories. Schrödinger’s idea was to extend this unification to wave optics and wave mechanics. Wave optics already existed, but wave mechanics did not. Schrödinger had to invent wave mechanics to complete the unification. Starting from wave optics as a model, he wrote down a differential equation for a mechanical particle, but the equation made no sense. The equation looked like the equation of conduction of heat in a continuous medium. Heat conduction has no visible relevance to particle mechanics. Schrödinger’s idea seemed to be going nowhere. But then came the surprise. Schrödinger put the square root of minus one into the equation, and suddenly it made sense. Suddenly it became a wave equation instead of a heat conduction equation. And Schrödinger found to his delight that the equation has solutions corresponding to the quantized orbits in the Bohr model of the atom.

It turns out that the Schrödinger equation describes correctly everything we know about the behavior of atoms. It is the basis of all of chemistry and most of physics. And that square root of minus one means that nature works with complex numbers and not with real numbers. This discovery came as a complete surprise, to Schrödinger as well as to everybody else. According to Schrödinger, his fourteen-year-old girl friend Itha Junger said to him at the time, “Hey, you never even thought when you began that so much sensible stuff would come out of it.” All through the nineteenth century, mathematicians from Abel to Riemann and Weierstrass had been creating a magnificent theory of functions of complex variables. They had discovered that the theory of functions became far deeper and more powerful when it was extended from real to complex numbers. But they always thought of complex numbers as an artificial construction, invented by human mathematicians as a useful and elegant abstraction from real life. It never entered their heads that this artificial number system that they had invented was in fact the ground on which atoms move. They never imagined that nature had got there first.

Another joke of nature is the precise linearity of quantum mechanics, the fact that the possible states of any physical object form a linear space.
Before quantum mechanics was invented, classical physics was always nonlinear, and linear models were only approximately valid. After quantum mechanics, nature itself suddenly became linear. This had profound consequences for mathematics. During the nineteenth century Sophus Lie developed his elaborate theory of continuous groups, intended to clarify the behavior of classical dynamical systems. Lie groups were then of little interest either to mathematicians or to physicists. The nonlinear theory of Lie groups was too complicated for the mathematicians and too obscure for the physicists. Lie died a disappointed man. And then, fifty years later, it turned out that nature was precisely linear, and the theory of linear representations of Lie algebras was the natural language of particle physics. Lie groups and Lie algebras were reborn as one of the central themes of twentieth century mathematics.

A third joke of nature is the existence of quasi-crystals. In the nineteenth century the study of crystals led to a complete enumeration of possible discrete symmetry groups in Euclidean space. Theorems were proved, establishing the fact that in three-dimensional space discrete symmetry groups could contain only rotations of order three, four, or six. Then in 1984 quasi-crystals were discovered, real solid objects growing out of liquid metal alloys, showing the symmetry of the icosahedral group, which includes five-fold rotations. Meanwhile, the mathematician Roger Penrose discovered the Penrose tilings of the plane. These are arrangements of parallelograms that cover a plane with pentagonal long-range order. The alloy quasi-crystals are three-dimensional analogs of the two-dimensional Penrose tilings. After these discoveries, mathematicians had to enlarge the theory of crystallographic groups to include quasi-crystals. That is a major program of research which is still in progress.

A fourth joke of nature is a similarity in behavior between quasi-crystals and the zeros of the Riemann Zeta function. The zeros of the zeta-function are exciting to mathematicians because they are found to lie on a straight line and nobody understands why. The statement that with trivial exceptions they all lie on a straight line is the famous Riemann Hypothesis. To prove the Riemann Hypothesis has been the dream of young mathematicians for more than a hundred years. I am now making the outrageous suggestion that we might use quasi-crystals to prove the Riemann Hypothesis. Those of you who are mathematicians may consider the suggestion frivolous. Those who are not mathematicians may consider it uninteresting. Nevertheless I am putting it forward for your serious consideration. When the physicist Leo Szilard was young, he became dissatisfied with the ten commandments of Moses and wrote a new set of ten commandments to replace them. Szilard’s second commandment says: “Let your acts be directed towards a worthy goal, but do not ask if they can reach it: they are to be models and examples, not means to an end.” Szilard practiced what he preached. He was the first physicist to imagine nuclear weapons and the first to campaign actively against their use. His second commandment certainly applies here. The proof of the Riemann Hypothesis is a worthy goal, and it is not for us to ask whether we can reach it. I will give you some hints describing how it might be achieved. Here I will be giving voice to the mathematician that I was fifty years ago before I became a physicist. I will talk first about the Riemann Hypothesis and then about quasi-crystals.

There were until recently two supreme unsolved problems in the world of pure mathematics, the proof of Fermat’s Last Theorem and the proof of the Riemann Hypothesis. Twelve years ago, my Princeton colleague Andrew Wiles polished off Fermat’s Last Theorem, and only the Riemann Hypothesis remains. Wiles’ proof of the Fermat Theorem was not just a technical stunt. It required the discovery and exploration of a new field of mathematical ideas, far wider and more consequential than the Fermat Theorem itself. It is likely that any proof of the Riemann Hypothesis will likewise lead to a deeper understanding of many diverse areas of mathematics and perhaps of physics too. Riemann’s zeta-function, and other zeta-functions similar to it, appear ubiquitously in number theory, in the theory of dynamical systems, in geometry, in function theory, and in physics. The zeta-function stands at a junction where paths lead in many directions. A proof of the hypothesis will illuminate all the connections. Like every serious student of pure mathematics, when I was young I had dreams of proving the Riemann Hypothesis. I had some vague ideas that I thought might lead to a proof. In recent years, after the discovery of quasi-crystals, my ideas became a little less vague. I offer them here for the consideration of any young mathematician who has ambitions to win a Fields Medal.

Quasi-crystals can exist in spaces of one, two, or three dimensions. From the point of view of physics, the three-dimensional quasi-crystals are the most interesting, since they inhabit our three-dimensional world and can be studied experimentally. From the point of view of a mathematician, one-dimensional quasi-crystals are much more interesting than two-dimensional or three-dimensional quasi-crystals because they exist in far greater variety. The mathematical definition of a quasi-crystal is as follows. A quasi-crystal is a distribution of discrete point masses whose Fourier transform is a distribution of discrete point frequencies. Or to say it more briefly, a quasi-crystal is a pure point distribution that has a pure point spectrum. This definition includes
as a special case the ordinary crystals, which are periodic distributions with periodic spectra.

Excluding the ordinary crystals, quasi-crystals in three dimensions come in very limited variety, all of them associated with the icosahedral group. The two-dimensional quasi-crystals are more numerous, roughly one distinct type associated with each regular polygon in a plane. The two-dimensional quasi-crystal with pentagonal symmetry is the famous Penrose tiling of the plane. Finally, the one-dimensional quasi-crystals have a far richer structure since they are not tied to any rotational symmetries. So far as I know, no complete enumeration of one-dimensional quasi-crystals exists. It is known that a unique quasi-crystal exists corresponding to every Pisot-Vijayaraghavan number or PV number. A PV number is a real algebraic integer, a root of a polynomial equation with integer coefficients, such that all the other roots have absolute value less than one, [1]. The set of all PV numbers is infinite and has a remarkable topological structure. The set of all one-dimensional quasi-crystals has a structure at least as rich as the set of all PV numbers and probably much richer. We do not know for sure, but it is likely that a huge universe of one-dimensional quasi-crystals not associated with PV numbers is waiting to be discovered.

Here comes the connection of the one-dimensional quasi-crystals with the Riemann hypothesis. If the Riemann hypothesis is true, then the zeros of the zeta-function form a one-dimensional quasi-crystal according to the definition. They constitute a distribution of point masses on a straight line, and their Fourier transform is likewise a distribution of point masses, one at each of the logarithms of ordinary prime numbers and prime-power numbers. My friend Andrew Odlyzko has published a beautiful computer calculation of the Fourier transform of the zeta-function zeros, [6]. The calculation shows precisely the expected structure of the Fourier transform, with a sharp discontinuity at every logarithm of a prime or prime-power number and nowhere else.

My suggestion is the following. Let us pretend that we do not know that the Riemann Hypothesis is true. Let us tackle the problem from the other end. Let us try to obtain a complete enumeration and classification of one-dimensional quasi-crystals. That is to say, we enumerate and classify all point distributions that have a discrete point spectrum. Collecting and classifying new species of objects is a quintessentially Baconian activity. It is an appropriate activity for mathematical frogs. We shall then find the well-known quasi-crystals associated with PV numbers, and also a whole universe of other quasi-crystals, known and unknown. Among the multitude of other quasi-crystals we search for one corresponding to the Riemann zeta-function and one corresponding to each of the other zeta-functions that resemble the Riemann zeta-function. Suppose that we find one of the quasi-crystals in our enumeration with properties that identify it with the zeros of the Riemann zeta-function. Then we have proved the Riemann Hypothesis and we can wait for the telephone call announcing the award of the Fields Medal.

These are of course idle dreams. The problem of classifying one-dimensional quasi-crystals is horrendously difficult, probably at least as difficult as the problems that Andrew Wiles took seven years to explore. But if we take a Baconian point of view, the history of mathematics is a history of horrendously difficult problems being solved by young people too ignorant to know that they were impossible. The classification of quasi-crystals is a worthy goal, and might even turn out to be achievable. Problems of that degree of difficulty will not be solved by old men like me. I leave this problem as an exercise for the young frogs in the audience.

Abram Besicovitch and Hermann Weyl

Let me now introduce you to some notable frogs and birds that I knew personally. I came to Cambridge University as a student in 1941 and had the tremendous luck to be given the Russian mathematician Abram Samoilovich Besicovitch as my supervisor. Since this was in the middle of World War Two, there were very few students in Cambridge, and almost no graduate students. Although I was only seventeen years old and Besicovitch was already a famous professor, he gave me a great deal of his time and attention, and we became life-long friends. He set the style in which I began to work and think about mathematics. He gave wonderful lectures on measure-theory and integration, smiling amiably when we laughed at his glorious abuse of the English language. I remember only one occasion when he was annoyed by our laughter. He remained silent for a while and then said, “Gentlemen. Fifty million English speak English you speak. Hundred and fifty million Russians speak English I speak.”
Besicovitch was a frog, and he became famous when he was young by solving a problem in elementary plane geometry known as the Kakeya problem. The Kakeya problem was the following. A line segment of length one is allowed to move freely in a plane while rotating through an angle of 360 degrees. What is the smallest area of the plane that it can cover during its rotation? The problem was posed by the Japanese mathematician Kakeya in 1917 and remained a famous unsolved problem for ten years. George Birkhoff, the leading American mathematician at that time, publicly proclaimed that the Kakeya problem and the four-color problem were the outstanding unsolved problems of the day. It was widely believed that the minimum area was $\pi/8$, which is the area of a three-cusped hypocycloid. The three-cusped hypocycloid is a beautiful three-pointed curve. It is the curve traced out by a point on the circumference of a circle with radius one-quarter, when the circle rolls around the inside of a fixed circle with radius three-quarters. The line segment of length one can turn while always remaining tangent to the hypocycloid with its two ends also on the hypocycloid. This picture of the line turning while touching the inside of the hypocycloid at three points was so elegant that most people believed it must give the minimum area. Then Besicovitch surprised everyone by proving that the area covered by the line as it turns can be less than $\epsilon$ for any positive $\epsilon$.

Besicovitch had actually solved the problem in 1920 before it became famous, not even knowing that Kakeya had proposed it. In 1920 he published the solution in Russian in the Journal of the Perm Physics and Mathematics Society, a journal that was not widely read. The university of Perm, a city 1,100 kilometers east of Moscow, was briefly a refuge for many distinguished mathematicians after the Russian revolution. They published two volumes of their journal before it died amid the chaos of revolution and civil war. Outside Russia the journal was not only unknown but unobtainable. Besicovitch left Russia in 1925 and arrived at Copenhagen, where he learned about the famous Kakeya problem that he had solved five years earlier. He published the solution again, this time in English in the Mathematische Zeitschrift. The Kakeya problem as Kakeya proposed it was a typical frog problem, a concrete problem without much connection with the rest of mathematics. Besicovitch gave it an elegant and deep solution, which revealed a connection with general theorems about the structure of sets of points in a plane.

The Besicovitch style is seen at its finest in his three classic papers with the title, "On the fundamental geometric properties of linearly measurable plane sets of points", published in Mathematische Annalen in the years 1928, 1938, and 1939. In these papers he proved that every linearly measurable set in the plane is divisible into a regular and an irregular component, that the regular component has a tangent almost everywhere, and the irregular component has a projection of measure zero onto almost all directions. Roughly speaking, the regular component looks like a collection of continuous curves, while the irregular component looks nothing like a continuous curve. The existence and the properties of the irregular component are connected with the Besicovitch solution of the Kakeya problem. One of the problems that he gave me to work on was the division of measurable sets into regular and irregular components in spaces of higher dimensions. I got nowhere with the problem, but became permanently imprinted with the Besicovitch style. The Besicovitch style is architectural. He builds out of simple elements a delicate and complicated architectural structure, usually with a hierarchical plan, and then, when the building is finished, the completed structure leads by simple arguments to an unexpected conclusion. Every Besicovitch proof is a work of art, as carefully constructed as a Bach fugue.

A few years after my apprenticeship with Besicovitch, I came to Princeton and got to know Hermann Weyl. Weyl was a prototypical bird, just as Besicovitch was a prototypical frog. I was lucky to overlap with Weyl for one year at the Princeton Institute for Advanced Study before he retired from the Institute and moved back to his old home in Zürich. He liked me because during that year I published papers in the Annals of Mathematics about number theory and in the Physical Review about the quantum theory of radiation. He was one of the few people alive who was at home in both subjects. He welcomed me to the Institute, in the hope that I would be a bird like himself. He was disappointed. I remained obstinately a frog. Although I poked around in a variety of mud-holes, I always looked at them one at a time and did not look for connections between them. For me, number theory and quantum theory were separate worlds with separate beauties. I did not look at them as Weyl did, hoping to find clues to a grand design.

Weyl's great contribution to the quantum theory of radiation was his invention of gauge fields. The idea of gauge fields had a curious history. Weyl invented them in 1918 as classical fields in his unified theory of general relativity and electromagnetism, [7]. He called them "gauge fields" because they were concerned with the non-integrability of measurements of length. His unified theory was promptly and publicly rejected by Einstein. After this thunderbolt from on high, Weyl did not abandon his theory but moved on to other things. The theory had no experimental consequences that could be tested. Then in 1929, after quantum mechanics had been invented by others, Weyl realized that his gauge fields fitted far better into the quantum world than they did into the
classical world, [8]. All that he needed to do, to change a classical gauge into a quantum gauge, was to change real numbers into complex numbers. In quantum mechanics, every quantity of electric charge carries with it a complex wave function with a phase, and the gauge field is concerned with the non-integrability of measurements of phase. The gauge field could then be precisely identified with the electromagnetic potential, and the law of conservation of charge became a consequence of the local phase invariance of the theory.

Weyl died four years after he returned from Princeton to Zürich, and I wrote his obituary for the journal Nature, [3]. “Among all the mathematicians who began their working lives in the twentieth century,” I wrote, “Hermann Weyl was the one who made major contributions in the greatest number of different fields. He alone could stand comparison with the last great universal mathematicians of the nineteenth century, Hilbert and Poincaré. So long as he was alive, he embodied a living contact between the main lines of advance in pure mathematics and in theoretical physics. Now he is dead, the contact is broken, and our hopes of comprehending the physical universe by a direct use of creative mathematical imagination are for the time being ended.” I mourned his passing, but I had no desire to pursue his dream. I was happy to see pure mathematics and physics marching ahead in opposite directions.

The obituary ended with a sketch of Weyl as a human being: “Characteristic of Weyl was an aesthetic sense which dominated his thinking on all subjects. He once said to me, half joking, ‘My work always tried to unite the true with the beautiful; but when I had to choose one or the other, I usually chose the beautiful’. This remark sums up his personality perfectly. It shows his profound faith in an ultimate harmony of Nature, in which the laws should inevitably express themselves in a mathematically beautiful form. It shows also his recognition of human frailty, and his humor, which always stopped him short of being pompous. His friends in Princeton will remember him as he was when I last saw him, at the Spring Dance of the Institute for Advanced Study last April: a big jovial man, enjoying himself splendidly, his cheerful frame and his light step giving no hint of his sixty-nine years.”

The fifty years after Weyl’s death were a golden age for Baconian travelers picking up facts, for frogs exploring small patches of the swamp in which we live. During these fifty years, the frogs accumulated a detailed knowledge of a large variety of cosmic structures and a large variety of particles and interactions. As the exploration of new territories continued, the universe became more complicated. Instead of a grand design displaying the simplicity and beauty of Weyl’s mathematics, the explorers found weird objects such as quarks and gamma-ray bursts, weird concepts such as supersymmetry and multiple universes. Meanwhile, mathematics was also becoming more complicated, as exploration continued into the phenomena of chaos and many other new areas opened by electronic computers. The mathematicians discovered the central mystery of computability, the conjecture represented by the statement P is not equal to NP. The conjecture asserts that there exist mathematical problems which can be quickly solved in individual cases but cannot be solved by a quick algorithm applicable to all cases. The most famous example of such a problem is the traveling salesman problem, which is to find the shortest route for a salesman visiting a set of cities, knowing the distance between each pair. All the experts believe that the conjecture is true, and that the traveling salesman problem is an example of a problem that is P but not NP. But nobody has even a glimmer of an idea how to prove it. This is a mystery that could not even have been formulated within the nineteenth-century mathematical universe of Hermann Weyl.

Frank Yang and Yuri Manin

The last fifty years have been a hard time for birds. Even in hard times, there is work for birds to do, and birds have appeared with the courage to tackle it. Soon after Weyl left Princeton, Frank Yang arrived from Chicago and moved into Weyl’s old house. Yang took Weyl’s place as the leading bird among my generation of physicists. While Weyl was still alive, Yang and his student Robert Mills discovered the Yang-Mills theory of non-Abelian gauge fields, a marvelously elegant extension of Weyl’s idea of a gauge field, [11]. Weyl’s gauge field was a classical quantity, satisfying the commutative law of multiplication. The Yang-Mills theory had a triplet of gauge fields which did not commute. They satisfied the commutation rules of the three components of a quantum mechanical spin,
which are generators of the simplest non-Abelian Lie algebra $A_2$. The theory was later generalized so that the gauge fields could be generators of any finite-dimensional Lie algebra. With this generalization, the Yang-Mills gauge field theory provided the framework for a model of all the known particles and interactions, a model that is now known as the Standard Model of particle physics. Yang put the finishing touch to it by showing that Einstein’s theory of gravitation fits into the same framework, with the Christoffel three-index symbol taking the role of gauge field, [10].

In an appendix to his 1918 paper, added in 1955 for the volume of selected papers published to celebrate his seventieth birthday, Weyl expressed his final thoughts about gauge field theories (my translation), [12]: “The strongest argument for my theory seemed to be this, that gauge invariance was related to conservation of electric charge in the same way as coordinate invariance was related to conservation of energy and momentum.” Thirty years later Yang was in Zürich for the celebration of Weyl’s hundredth birthday. In his speech, [12], Yang quoted this remark as evidence of Weyl’s devotion to the idea of gauge invariance as a unifying principle for physics. Yang then went on, “Symmetry, Lie groups, and gauge invariance are now recognized, through theoretical and experimental developments, to play essential roles in determining the basic forces of the physical universe. I have called this the principle that symmetry dictates interaction.” This idea, that symmetry dictates interaction, is Yang’s generalization of Weyl’s remark. Weyl observed that gauge invariance is intimately connected with physical conservation laws. Weyl could not go further than this, because he knew only the gauge invariance of commuting Abelian fields. Yang made the connection much stronger by introducing non-Abelian gauge fields. With non-Abelian gauge fields generating nontrivial Lie algebras, the possible forms of interaction between fields become unique, so that symmetry dictates interaction. This idea is Yang’s greatest contribution to physics. It is the contribution of a bird, flying high over the rain forest of little problems in which most of us spend our lives.

Another bird for whom I have a deep respect is the Russian mathematician Yuri Manin, who recently published a delightful book of essays with the title Mathematics as Metaphor [5]. The book was published in Moscow in Russian, and by the American Mathematical Society in English. I wrote a preface for the English version, and I give you here a short quote from my preface. “Mathematics as Metaphor is a good slogan for birds. It means that the deepest concepts in mathematics are those which link one world of ideas with another. In the seventeenth century Descartes linked the disparate worlds of algebra and geometry with his concept of coordinates, and Newton linked the worlds of geometry and dynamics with his concept of fluxions, nowadays called calculus. In the nineteenth century Boole linked the worlds of logic and algebra with his concept of symbolic logic, and Riemann linked the worlds of geometry and analysis with his concept of Riemann surfaces. Coordinates, fluxions, symbolic logic, and Riemann surfaces are all metaphors, extending the meanings of words from familiar to unfamiliar contexts. Manin sees the future of mathematics as an exploration of metaphors that are already visible but not yet understood. The deepest such metaphor is the similarity in structure between number theory and physics. In both fields he sees tantalizing glimpses of parallel concepts, symmetries linking the continuous with the discrete. He looks forward to a unification which he calls the quantization of mathematics.

“Manin disagrees with the Baconian story, that Hilbert set the agenda for the mathematics of the twentieth century when he presented his famous list of twenty-three unsolved problems to the International Congress of Mathematicians in Paris in 1900. According to Manin, Hilbert’s problems were a distraction from the central themes of mathematics. Manin sees the important advances in mathematics coming from programs, not from problems. Problems are usually solved by applying old ideas in new ways. Programs of research are the nurseries where new ideas are born. He sees the Bourbaki program, rewriting the whole of mathematics in a more abstract language, as the source of many of the new ideas of the twentieth century. He sees the Langlands program, unifying number theory with geometry, as a promising source of new ideas for the twenty-first. People who solve famous unsolved problems may win big prizes, but people who start new programs are the real pioneers.”

The Russian version of Mathematics as Metaphor contains ten chapters that were omitted from the English version. The American Mathematical Society decided that these chapters would not be of interest to English language readers. The omissions are doubly unfortunate. First, readers of the English version see only a truncated view of Manin, who is perhaps unique among mathematicians in his broad range of interests extending far beyond mathematics. Second, we see a truncated view of Russian culture, which is less compartmentalized than English language culture, and brings mathematicians into closer contact with historians and artists and poets.

John von Neumann

Another important figure in twentieth century mathematics was John von Neumann. von Neumann was a frog, applying his prodigious technical skill to solve problems in many branches of mathematics and physics. He began with the
foundations of mathematics. He found the first satisfactory set of axioms for set-theory, avoiding the logical paradoxes that Cantor had encountered in his attempts to deal with infinite sets and infinite numbers. Von Neumann’s axioms were used by his bird friend Kurt Gödel a few years later to prove the existence of undecidable propositions in mathematics. Gödel’s theorems gave birds a new vision of mathematics. After Gödel, mathematics was no longer a single structure tied together with a unique concept of truth, but an archipelago of structures with diverse sets of axioms and diverse notions of truth. Gödel showed that mathematics is inexhaustible. No matter which set of axioms is chosen as the foundation, birds can always find questions that those axioms cannot answer.

Von Neumann went on from the foundations of mathematics to the foundations of quantum mechanics. To give quantum mechanics a firm mathematical foundation, he created a magnificent theory of rings of operators. Every observable quantity is represented by a linear operator, and the peculiarities of quantum behavior are faithfully represented by the algebra of operators. Just as Newton invented calculus to describe classical dynamics, von Neumann invented rings of operators to describe quantum dynamics.

Von Neumann made fundamental contributions to several other fields, especially to game theory and to the design of digital computers. For the last ten years of his life, he was deeply involved with computers. He was so strongly interested in computers that he decided not only to study their design but to build one with real hardware and software and use it for doing science. I have vivid memories of the early days of von Neumann’s computer project at the Institute for Advanced Study in Princeton. At that time he had two main scientific interests, hydrogen bombs and meteorology. He used his computer during the night for doing hydrogen bomb calculations and during the day for meteorology. Most of the people hanging around the computer building in daytime were meteorologists. Their leader was Jule Charney. Charney was a real meteorologist, properly humble in dealing with the inscrutable mysteries of the weather, and skeptical of the ability of the computer to solve the mysteries. John von Neumann was less humble and less skeptical. I heard von Neumann give a lecture about the aims of his project. He spoke, as he always did, with great confidence. He said, “The computer will enable us to divide the atmosphere at any moment into stable regions and unstable regions. Stable regions we can predict. Unstable regions we can control.” Von Neumann believed that any unstable region could be pushed by a judiciously applied small perturbation so that it would move in any desired direction. The small perturbation would be applied by a fleet of airplanes carrying smoke generators, to absorb sunlight and raise or lower temperatures at places where the perturbation would be most effective. In particular, we could stop an incipient hurricane by identifying the position of an instability early enough, and then cooling that patch of air before it started to rise and form a vortex. Von Neumann, speaking in 1950, said it would take only ten years to build computers powerful enough to diagnose accurately the stable and unstable regions of the atmosphere. Then, once we had accurate diagnosis, it would take only a short time for us to have control. He expected that practical control of the weather would be a routine operation within the decade of the 1960s.

Von Neumann, of course, was wrong. He was wrong because he did not know about chaos. We now know that when the motion of the atmosphere is locally unstable, it is very often chaotic. The word “chaotic” means that motions that start close together diverge exponentially from each other as time goes on. When the motion is chaotic, it is unpredictable, and a small perturbation does not move it into a stable motion that can be predicted. A small perturbation will usually move it into another chaotic motion that is equally unpredictable. So von Neumann’s strategy for controlling the weather fails. He was, after all, a great mathematician but a mediocre meteorologist.

Edward Lorenz discovered in 1963 that the solutions of the equations of meteorology are often chaotic. That was six years after von Neumann died. Lorenz was a meteorologist and is generally regarded as the discoverer of chaos. He discovered the phenomena of chaos in the meteorological context and gave them their modern names. But in fact I had heard the mathematician Mary Cartwright, who died in 1998 at the age of 97, describe the same phenomena in a lecture in Cambridge in 1943, twenty years before Lorenz discovered them. She called the phenomena by different names, but they were the same phenomena. She discovered them in the solutions of the van der Pol equation which describe the oscillations of a nonlinear amplifier, [2]. The van der Pol equation was important in World
thing about mathematics, he pulled an old lecture that he had to travel to Amsterdam and say something. Then, at the last moment, when he remembered things, he had neglected to prepare the lecture. Von Neumann forgotten about it. Being busy with many other things, all expecting to hear a brilliant lecture worthy of such a historic occasion. The mathematicians, thought about it deeply, and he would have had something important to say about it in 1954.

Von Neumann got into trouble at the end of his life because he was really a frog but everyone expected him to fly like a bird. In 1954 there was an International Congress of Mathematicians in Amsterdam. These congresses happen only once in four years and it is a great honor to be invited to speak at the opening session. The organizers of the Amsterdam congress invited von Neumann to give the keynote speech, expecting him to repeat the act that Hilbert had performed in Paris in 1900. Just as Hilbert had provided a list of unsolved problems to guide the development of mathematics for the first half of the twentieth century, von Neumann was invited to do the same for the second half of the century. The title of von Neumann’s talk was announced in the program of the congress. It was “Unsolved Problems in Mathematics: Address by Invitation of the Organizing Committee”. After the congress was over, the complete proceedings were published, with the texts of all the lectures except this one. In the proceedings there is a blank page with von Neumann’s name and the title of his talk. Underneath, it says, “No manuscript of this lecture was available.”

What happened? I know what happened, because I was there in the audience, at 3:00 p.m. on Thursday, September 2, 1954, in the Concertgebouw concert hall. The hall was packed with mathematicians, all expecting to hear a brilliant lecture worthy of such a historic occasion. The lecture was a huge disappointment. Von Neumann had probably agreed several years earlier to give a lecture about unsolved problems and had then forgotten about it. Being busy with many other things, he had neglected to prepare the lecture. Then, at the last moment, when he remembered that he had to travel to Amsterdam and say something about mathematics, he pulled an old lecture from the 1930s out of a drawer and dusted it off. The lecture was about rings of operators, a subject that was new and fashionable in the 1930s. Nothing about unsolved problems. Nothing about the future. Nothing about computers, the subject that we knew was dearest to von Neumann’s heart. He might at least have had something new and exciting to say about computers. The audience in the concert hall became restless. Somebody said in a voice loud enough to be heard all over the hall, “Aufgewärmte Suppe”, which is German for “warmed-up soup”. In 1954 the great majority of mathematicians knew enough German to understand the joke. Von Neumann, deeply embarrassed, brought his lecture to a quick end and left the hall without waiting for questions.

**Weak Chaos**

If von Neumann had known about chaos when he spoke in Amsterdam, one of the unsolved problems that he might have talked about was weak chaos. The problem of weak chaos is still unsolved fifty years later. The problem is to understand why chaotic motions often remain bounded and do not cause any violent instability. A good example of weak chaos is the orbital motions of the planets and satellites in the solar system. It was discovered only recently that these motions are chaotic. This was a surprising discovery, upsetting the traditional picture of the solar system as the prime example of orderly stable motion. The mathematician Laplace two hundred years ago thought he had proved that the solar system is stable. It now turns out that Laplace was wrong. Accurate numerical integrations of the orbits show clearly that neighboring orbits diverge exponentially. It seems that chaos is almost universal in the world of classical dynamics.

Chaotic behavior was never suspected in the solar system before accurate long-term integrations were done, because the chaos is weak. Weak chaos means that neighboring trajectories diverge exponentially but never diverge far. The divergence begins with exponential growth but afterwards remains bounded. Because the chaos of the planetary motions is weak, the solar system can survive for four billion years. Although the motions are chaotic, the planets never wander far from their customary places, and the system as a whole does not fly apart. In spite of the prevalence of chaos, the Laplacian view of the solar system as a perfect piece of clockwork is not far from the truth.

We see the same phenomena of weak chaos in the domain of meteorology. Although the weather in New Jersey is painfully chaotic, the chaos has firm limits. Summers and winters are unpredictably mild or severe, but we can reliably predict that the temperature will never rise to 45 degrees Celsius or fall to minus 30, extremes that are often exceeded in India or in Minnesota. There
is no conservation law of physics that forbids temperatures from rising as high in New Jersey as in India, or from falling as low in New Jersey as in Minnesota. The weakness of chaos has been essential to the long-term survival of life on this planet. Weak chaos gives us a challenging variety of weather while protecting us from fluctuations so severe as to endanger our existence. Chaos remains mercifully weak for reasons that we do not understand. That is another unsolved problem for young frogs in the audience to take home. I challenge you to understand the reasons why the chaos observed in a great diversity of dynamical systems is generally weak.

The subject of chaos is characterized by an abundance of quantitative data, an unending supply of beautiful pictures, and a shortage of rigorous theorems. Rigorous theorems are the best way to give a subject intellectual depth and precision. Until you can prove rigorous theorems, you do not fully understand the meaning of your concepts. In the field of chaos I know only one rigorous theorem, proved by Tien-Yien Li and Jim Yorke in 1975 and published in a short paper with the title, “Period Three Implies Chaos”, [4]. The Li-Yorke paper is one of the immortal gems in the literature of mathematics. Their theorem concerns nonlinear maps of an interval onto itself. The successive positions of a point when the mapping is repeated can be considered as the orbit of a classical particle. An orbit has period $N$ if the point returns to its original position after $N$ mappings. An orbit is defined to be chaotic, in this context, if it diverges from all periodic orbits. The theorem says that if a single orbit with period three exists, then chaotic orbits also exist. The proof is simple and short. To my mind, this theorem and its proof throw more light than a thousand beautiful pictures on the basic nature of chaos. The theorem explains why chaos is prevalent in the world. It does not explain why chaos is so often weak. That remains a task for the future. I believe that weak chaos will not be understood in a fundamental way until we can prove rigorous theorems about it.

String Theorists

I would like to say a few words about string theory. Few words, because I know very little about string theory. I never took the trouble to learn the subject or to work on it myself. But when I am at home at the Institute for Advanced Study in Princeton, I am surrounded by string theorists, and I sometimes listen to their conversations. Occasionally I understand a little of what they are saying. Three things are clear. First, what they are doing is first-rate mathematics. The leading pure mathematicians, people like Michael Atiyah and Isadore Singer, love it. It has opened up a whole new branch of mathematics, with new ideas and new problems. Most remarkably, it gave the mathematicians new methods to solve old problems that were previously unsolvable. Second, the string theorists think of themselves as physicists rather than mathematicians. They believe that their theory describes something real in the physical world. And third, there is not yet any proof that the theory is relevant to physics. The theory is not yet testable by experiment. The theory remains in a world of its own, detached from the rest of physics. String theorists make strenuous efforts to deduce consequences of the theory that might be testable in the real world, so far without success.

My colleagues Ed Witten and Juan Maldacena and others who created string theory are birds, flying high and seeing grand visions of distant ranges of mountains. The thousands of humbler practitioners of string theory in universities around the world are frogs, exploring fine details of the mathematical structures that birds first saw on the horizon. My anxieties about string theory are sociological rather than scientific. It is a glorious thing to be one of the first thousand string theorists, discovering new connections and pioneering new methods. It is not so glorious to be one of the second thousand or one of the tenth thousand. There are now about ten thousand string theorists scattered around the world. This is a dangerous situation for the tenth thousand and perhaps also for the second thousand. It may happen unpredictably that the fashion changes and string theory becomes unfashionable. Then it could happen that nine thousand string theorists lose their jobs. They have been trained in a narrow specialty, and they may be unemployable in other fields of science.

Why are so many young people attracted to string theory? The attraction is partly intellectual. String theory is daring and mathematically elegant. But the attraction is also sociological. String theory is attractive because it offers jobs. And why are so many jobs offered in string theory? Because string theory is cheap. If you are the chairperson of a physics department in a remote place without much money, you cannot afford to build a modern laboratory to do experimental physics, but you can afford to hire a couple of string theorists. So you offer a couple of jobs in string theory, and you have a modern physics department. The temptations are strong for the chairperson to offer such jobs and for the young people to accept them. This is a hazardous situation for the young people and also for the future of science. I am not saying that we should discourage young people from working in string theory if they find it exciting. I am saying that we should offer them alternatives, so that they are not pushed into string theory by economic necessity.

Finally, I give you my own guess for the future of string theory. My guess is probably wrong. I have no illusion that I can predict the future. I tell
you my guess, just to give you something to think about. I consider it unlikely that string theory will turn out to be either totally successful or totally useless. By totally successful I mean that it is a complete theory of physics, explaining all the details of particles and their interactions. By totally useless I mean that it remains a beautiful piece of pure mathematics. My guess is that string theory will end somewhere between complete success and failure. I guess that it will be like the theory of Lie groups, which Sophus Lie created in the nineteenth century as a mathematical framework for classical physics. So long as physics remained classical, Lie groups remained a failure. They were a solution looking for a problem. But then, fifty years later, the quantum revolution transformed physics, and Lie algebras found their proper place. They became the key to understanding the central role of symmetries in the quantum world. I expect that fifty or a hundred years from now another revolution in physics will happen, introducing new concepts of which we now have no inkling, and the new concepts will give string theory a new meaning. After that, string theory will suddenly find its proper place in the universe, making testable statements about the real world. I warn you that this guess about the future is probably wrong. It has the virtue of being falsifiable, which according to Karl Popper is the hallmark of a scientific statement. It may be demolished tomorrow by some discovery coming out of the Large Hadron Collider in Geneva.

**Manin Again**

To end this talk, I come back to Yuri Manin and his book *Mathematics as Metaphor*. The book is mainly about mathematics. It may come as a surprise to Western readers that he writes with equal eloquence about other subjects such as the collective unconscious, the origin of human language, the psychology of autism, and the role of the trickster in the mythology of many cultures. To his compatriots in Russia, such many-sided interests and expertise would come as no surprise. Russian intellectuals maintain the proud tradition of the old Russian intelligentsia, with scientists and poets and artists and musicians belonging to a single community. They are still today, as we see them in the plays of Chekhov, a group of idealists bound together by their alienation from a superstitious society and a capricious government. In Russia, mathematicians and composers and film producers talk to one another, walk together in the snow on winter nights, sit together over a bottle of wine, and share each others’ thoughts.

Manin is a bird whose vision extends far beyond the territory of mathematics into the wider landscape of human culture. One of his hobbies is the theory of archetypes invented by the Swiss psychologist Carl Jung. An archetype, according to Jung, is a mental image rooted in a collective unconscious that we all share. The intense emotions that archetypes carry with them are relics of lost memories of collective joy and suffering. Manin is saying that we do not need to accept Jung’s theory as true in order to find it illuminating.

More than thirty years ago, the singer Monique Morelli made a recording of songs with words by Pierre MacOrlan. One of the songs is *La Ville Morte*, the dead city, with a haunting melody tuned to Morelli’s deep contralto, with an accordion singing counterpoint to the voice, and with verbal images of extraordinary intensity. Printed on the page, the words are nothing special:

“En pénétrant dans la ville morte,
Je tenait Margot par le main…
Nous marchions de la nécropole,
Les pieds brisés et sans parole,
Devant ces portes sans cadole,
Devant ces trous indéfinis,
Devant ces portes sans parole
Et ces poubelles pleines de cris”.

“As we entered the dead city, I held Margot by the hand…We walked from the graveyard on our bruised feet, without a word, passing by these doors without locks, these vaguely glimpsed holes, these doors without a word, these garbage cans full of screams.”

I can never listen to that song without a disproportionate intensity of feeling. I often ask myself why the simple words of the song seem to resonate with some deep level of unconscious memory, as if the souls of the departed are speaking through Morelli’s music. And now unexpectedly in Manin’s book I find an answer to my question. In his chapter, “The Empty City Archetype”, Manin describes how the archetype of the dead city appears again and again in the creations of architecture, literature, art and film, from ancient to modern times, ever since human beings began to congregate in cities, ever since other human beings began to congregate in armies to ravage and destroy them. The character who speaks to us in MacOrlan’s song is an old soldier who has long ago been part of an army of occupation. After he has walked with his wife through the dust and ashes of the dead city, he hears once more:

“Chansons de charme d’un clairon
Qui fleurissait une heure lointaine
Dans un rêve de garnison”.

“The magic calls of a bugle that came to life for an hour in an old soldier’s dream”.

The words of MacOrlan and the voice of Morelli seem to be bringing to life a dream from our collective unconscious, a dream of an old soldier wandering through a dead city. The concept of the collective unconscious may be as mythical as the concept of the dead city. Manin’s chapter describes the subtle light that these two possibly mythical
concepts throw upon each other. He describes the collective unconscious as an irrational force that powerfully pulls us toward death and destruction. The archetype of the dead city is a distillation of the agony of hundreds of real cities that have been destroyed since cities and marauding armies were invented. Our only way of escape from the insanity of the collective unconscious is a collective consciousness of sanity, based upon hope and reason. The great task that faces our contemporary civilization is to create such a collective consciousness.

References
Mathematics Research Communities Program Kicks Off

Allyn Jackson

“Talking to so many other young mathematicians with my same interests was very inspiring.”

“I felt that this conference is unique in how it allowed me to make connections with others in my field that could easily blossom into working relationships.”

“The conference was wonderful…Many collaborations will come out of it. This is invaluable for young mathematicians like me. Also, it was a lot of fun in a beautiful place.”

These are typical comments from participants in Mathematics Research Communities (MRC), an innovative program started by the AMS to help young mathematicians create networks of peers who are interested in similar areas of research. With support from the National Science Foundation, MRC got off the ground in summer 2008 with three 1-week conferences held in Snowbird, Utah. The program also provides means to keep the participants connected during the 2008–2009 academic year. A new set of conferences will be held in summer 2009.

The MRC conferences have a unique structure: They are organized by a small number of senior mathematicians, but all of the participants are graduate students or postdocs. While the organizers are there to keep everything running smoothly and to give some lectures, most of the activities are in the hands of the participants, who lecture to each other about their work and hold informal sessions for exchanging ideas. Included are professional development sessions covering such topics as how to write a research grant and job search tips. Participants also take responsibility for organizing special sessions at the Joint Mathematics Meetings, they stay in touch during the academic year through electronic discussion networks by research topic, and they are provided with ongoing mentoring by the conference organizers. The AMS is also carrying out a longitudinal study of the careers of the MRC participants. (The quotations in this article are taken from participant responses to questions in an online survey.)

The largest of the three 2008 conferences focused on low-dimensional topology and Teichmüller theory and had about forty participants. The mornings were devoted to expository talks and the afternoons to short presentations by the participants, each of whom gave a talk on their research interests. While the nature and quality of the talks was not uniform, they helped participants to find others with similar interests. “I really appreciated that the conference was meant as a stepping-stone for us to collaborate with others,” said one participant. “The short talks...helped us find each other.” Another participant commented that the highlight
of the conference came when others sought him out to ask him about his talk. There were also informal sessions that drew many questions and much discussion about what the major open questions are in the area. “The program gave the participants exposure to a nice mixture of elementary topics and current research,” one participant said. “I wouldn’t change anything.”

The two other conferences were smaller, with about twenty participants apiece. The first, which focused on computational algebra and convexity, had two main themes: studying a 2006 paper that contains new ideas and technical tools that would be useful for the students to master, and exploring the use of computational algebra software for computing primary decomposition. The participants broke up into working groups centered on the two themes, and each group made a presentation at the end of the conference. “I appreciated…the chance to wrap it all up into a ‘final presentation’ of what we had learned,” one participant commented. “That really helped crystallize how much progress we had made in a week.”

The format of the MRC conferences is very flexible, and early on the organizers realized that having some evening “basic notions” talks would be helpful. These talks were held from 9:00 p.m. to 10:00 p.m. after a long day, but this did not dampen participants’ enthusiasm. “We could ask the dumbest questions and get good answers without fear of looking dumb,” one participant commented. “It was a great learning environment!”

The third conference was on scientific computing and advanced computation. “Overall the program was one of the best and richest experiences I have had,” one of the participants commented. The primary topics discussed were new programming languages for scientific computing, parallel computing, and multiscale analysis. There were several talks by senior researchers, after which the participants carried out group work. One novel feature of this conference was an exercise in grant writing. Participants broke up into groups and selected a project about which to write proposals and chose one group member to be the lead principal investigator. Then each member of the group helped write a “letter of intent” and presentation slides. On the last day of the MRC, groups presented their proposals to a panel of senior researchers. The intensive group work spurred rich interactions among the participants. “The highlight for me was definitely the people,” one participant remarked.

“I came not knowing anyone, and left with a whole new community of researchers.”

A new crop of MRC participants will join in four conferences to be held in summer 2009, again in Snowbird. The dates and topics of the conferences are: June 13–19, 2009, Mathematical Challenges of Relativity; June 20–26, 2009, Inverse Problems; June 27–July 3, 2009, Modern Markov Chains and Their Statistical Applications; and June 27–July 3, 2009, Harmonic Analysis. For further information about applying, see “Mathematics Opportunities” in this issue of the Notices or consult the webpage [http://www.ams.org/amsmtgs/mrc-09.html](http://www.ams.org/amsmtgs/mrc-09.html).

The application deadline is March 2, 2009, for participation in the summer 2009 conferences. In addition, organizers are sought for MRC conferences in summer 2010; a call for organizers appeared in the January 2009 issue of the Notices, page 87, and is available on the Web at [http://www.ams.org/amsmtgs/mrc-proposals.html](http://www.ams.org/amsmtgs/mrc-proposals.html).

—Allyn Jackson

Photographs courtesy of David Eisenbud and Ellen Maycock.
The two theories that revolutionized physics in the twentieth century, relativity and quantum mechanics, are full of predictions that defy common sense. Recently, we used three such paradoxical ideas to prove “The Free Will Theorem” (strengthened here), which is the culmination of a series of theorems about quantum mechanics that began in the 1960s. It asserts, roughly, that if indeed we humans have free will, then elementary particles already have their own small share of this valuable commodity. More precisely, if the experimenter can freely choose the directions in which to orient his apparatus in a certain measurement, then the particle’s response (to be pedantic—the universe’s response near the particle) is not determined by the entire previous history of the universe.

Our argument combines the well-known consequence of relativity theory, that the time order of space-like separated events is not absolute, with the EPR paradox discovered by Einstein, Podolsky, and Rosen in 1935, and the Kochen-Specker Paradox of 1967 (See [2]). We follow Bohm in using a spin version of EPR and Peres in using his set of 33 directions, rather than the original configuration used by Kochen and Specker. More contentiously, the argument also involves the notion of free will, but we postpone further discussion of this to the last section of the article.

Note that our proof does not mention “probabilities” or the “states” that determine them, which is fortunate because these theoretical notions have led to much confusion. For instance, it is often said that the probabilities of events at one location can be instantaneously changed by happenings at another space-like separated location, but whether that is true or even meaningful is irrelevant to our proof, which never refers to the notion of probability.

For readers of the original version [1] of our theorem, we note that we have strengthened it by replacing the axiom FIN together with the assumption of the experimenters’ free choice and temporal causality by a single weaker axiom MIN. The earlier axiom FIN of [1], that there is a finite upper bound to the speed with which information can be transmitted, has been objected to by several authors. Bassi and Ghirardi asked in [3]: what precisely is “information”, and do the “hits” and “flashes” of GRW theories (discussed in the Appendix) count as information? Why cannot hits be transmitted instantaneously, but not count as signals? These objections miss the point. The only information to which we applied FIN is the choice made by the experimenter and the response of the particle, as signaled by the orientation of the apparatus and the spot on the screen. The speed of transmission of any other information is irrelevant to our argument. The replacement of FIN by MIN has made this fact explicit. The theorem has been further strengthened by allowing the particles’ responses to depend on past half-spaces rather than just the past light cones of [1].

The Axioms

We now present and discuss the three axioms on which the theorem rests.
Figure 1. The three colored cubes in Figure 1a are obtained by rotating the white cube through 45° about its coordinate axes. The 33 directions are the symmetry axes of the colored cubes and pass through the spots in Figure 1a. Figure 1b shows where these directions meet the white cube.

(i) The SPIN Axiom and the Kochen-Specker Paradox

Richard Feynman once said that “If someone tells you they understand quantum mechanics, then all you’ve learned is that you’ve met a liar.” Our first axiom initially seems easy to understand, but beware—Feynman’s remark applies! The axiom involves the operation called “measuring the squared spin of a spin 1 particle”, which always produces the result 0 or 1.

**SPIN Axiom:** Measurements of the squared (components of) spin of a spin 1 particle in three orthogonal directions always give the answers 1, 0, 1 in some order.

Quantum mechanics predicts this axiom since for a spin 1 particle the squared spin operators $s^2_x, s^2_y, s^2_z$ commute and have sum 2.

This “101 property” is paradoxical because it already implies that the quantity that is supposedly being measured cannot in fact exist before its “measurement”. For otherwise there would be a function defined on the sphere of possible directions taking each orthogonal triple to 1, 0, 1 in some order. It follows from this that it takes the same value on pairs of opposite directions, and never takes two orthogonal directions to 0.

We call a function defined on a set of directions that has all three of these properties a “101 function” for that set. But unfortunately we have:

The Kochen-Specker Paradox: There does not exist a 101 function for the 33 pairs of directions of Figure 1 (the Peres configuration).

**Proof.** We shall call a node even or odd according as the putative 101 function is supposed to take the value 0 or 1 at it, and we progressively assign even or odd numbers to the nodes in Figure 1b as we establish the contradiction.

We shall use some easily justified orthogonalties—for instance the coordinate triple rotates to the triple $(2, 3, -3)$ that starts our proof, which in turn rotates (about $-1$) to the triples $(8, -7, 9)$ and $(-8, 7, -9)$ that finish it.

Without loss of generality nodes 1 and $-1$ are odd and node 2 even, forcing 3 and $-3$ to be odd. Now nodes 4 and $-x$ form a triple with 3, so one of them (without loss of generality 4) is even. In view of the reflection that interchanges $-4$ and $x$ while fixing 4 and $-x$, we can without loss of generality suppose that $-4$ is also even.

There is a 90° rotation about 1 that moves 7, 5, 9 to 4, 6, $x$, showing that 5 is orthogonal to 4, while 1, 5, 6 is a triple, and also that 6 is orthogonal to both 7 and 9. Thus 5 is odd, 6 even, and 7, 9 odd. A similar argument applies to nodes $-5$, $-6$, $-7$, $-9$.

Finally, 8 forms a triple with $-7$ and 9, as does $-8$ with 7 and $-9$. So both these nodes must be even, and since they are orthogonal, this is a contradiction that completes the proof.

Despite the Kochen-Specker paradox, no physicist would question the truth of our SPIN axiom, since it follows from quantum mechanics, which is one of the most strongly substantiated scientific theories of all time. However, it is important to realize that we do not in fact suppose all of
quantum mechanics, but only two of its testable consequences, namely this axiom SPIN and the axiom TWIN of the next section.

It is true that these two axioms deal only with idealized forms of experimentally verifiable predictions, since they refer to exact orthogonal and parallel directions in space. However, as we have shown in [1], the theorem is robust, in that approximate forms of these axioms still lead to a similar conclusion. At the same time, this shows that any more accurate modifications of special relativity (such as general relativity) and of quantum theory will not affect the conclusions of the theorem.

(ii) The TWIN Axiom and the EPR Paradox

One of the most curious facts about quantum mechanics was pointed out by Einstein, Podolsky, and Rosen in 1935. This says that even though the results of certain remotely separated observations cannot be individually predicted ahead of time, they can be correlated.

In particular, it is possible to produce a pair of "twinned" spin 1 particles (by putting them into the "singleton state" of total spin zero) that will give the same answers to the above squared spin measurements in parallel directions. Our "TWIN" axiom is part of this assertion.

The TWIN Axiom: For twinned spin 1 particles, suppose experimenter A performs a triple experiment of measuring the squared spin component of particle a in three orthogonal directions x, y, z, while experimenter B measures the twinned particle b in one direction, w. Then if w happens to be in the same direction as one of x, y, z, experimenter B's measurement will necessarily yield the same answer as the corresponding measurement by A.

In fact we will restrict w to be one of the 33 directions in the Peres configuration of the previous section, and x, y, z to be one of 40 particular orthogonal triples, namely the 16 such triples of that configuration and the 24 further triples obtained by completing its remaining orthogonal pairs.

(iii) The MIN Axiom, Relativity, and Free Will

One of the paradoxes introduced by relativity was the fact that temporal order depends on the choice of inertial frame. If two events are space-like separated, then they will appear in one time order with respect to some inertial frames, but in the reverse order with respect to others. The two events we use will be the above twinned spin measurements.

It is usual tacitly to assume the temporal causality principle that the future cannot alter the past. Its relativistic form is that an event cannot be influenced by what happens later in any given inertial frame. Another customarily tacit assumption is that experimenters are free to choose between possible experiments. To be precise, we mean that the choice an experimenter makes is not a function of the past. We explicitly use only some very special cases of these assumptions in justifying our final axiom.

The MIN Axiom: Assume that the experiments performed by A and B are space-like separated. Then experimenter B can freely choose any one of the 33 particular directions w, and a's response is independent of this choice. Similarly and independently, A can freely choose any one of the 40 triples x, y, z, and b's response is independent of that choice.

It is the experimenters' free will that allows the free and independent choices of x, y, z, and w. But in one inertial frame—call it the "A-first" frame—B's experiment will only happen some time later than A's, and so a's response cannot, by temporal causality, be affected by B's later choice of w. In a B-first frame, the situation is reversed, justifying the final part of MIN. (We shall discuss the meaning of the term "independent" more fully in the Appendix.)

The (Strong) Free Will Theorem

Our theorem is a strengthened form of the original version of [1]. Before stating it, we make our terms more precise. We use the words "properties", "events", and "information" almost interchangeably: whether an event has happened is a property, and whether a property obtains can be coded by an information-bit. The exact general meaning of these terms, which may vary with some theory that may be considered, is not important, since we only use them in the specific context of our three axioms.

To say that A's choice of x, y, z is free means more precisely that it is not determined by (i.e., is not a function of) what has happened at earlier times (in any inertial frame). Our theorem is the surprising consequence that particle a's response must be free in exactly the same sense, that it is not a function of what has happened earlier (with respect to any inertial frame).

The Free Will Theorem. The axioms SPIN, TWIN and MIN imply that the response of a spin 1 particle to a triple experiment is free—that is to say, is not a function of properties of that part of the universe that is earlier than this response with respect to any given inertial frame.

Proof. We suppose to the contrary—this is the "functional hypothesis" of [1]—that particle a's response (i, j, k) to the triple experiment with directions x, y, z is given by a function of properties α, ... that are earlier than this response with respect to some inertial frame F. We write this as

$$\theta^F_\alpha = \text{one of } (0, 1, 1), (1, 0, 1), (1, 1, 0)$$

(in which only a typical one of the properties α is indicated).
Similarly we suppose that $b$’s response 0 or 1 for the direction $w$ is given by a function

$$\theta_w^G(\beta) = \text{ one of 0 or 1}$$

of properties $\beta_1, \ldots$ that are earlier with respect to a possibly different inertial frame $G$.

(i) If either one of these functions, say $\theta_w^G$, is influenced by some information that is free in the above sense (i.e., not a function of $A$’s choice of directions and events F-earlier than that choice), then there must be an an earliest (“infimum”) F-time $t_0$ after which all such information is available to $a$. Since the non-free information is also available at $t_0$, all these information bits, free and non-free, must have a value 0 or 1 to enter as arguments in the function $\theta_w^G$. So we regard $a$’s response as having started at $t_0$.

If indeed, there is any free bit that influences $a$, the universe has by definition taken a free decision near $a$ by time $t_0$, and we remove the pedantry by ascribing this decision to particle $a$. (This is discussed more fully in the section “Free Will Versus Determinism”.)

(ii) From now on we can suppose that no such new information bits influence the particles’ responses, and therefore that $\alpha$ and $\beta$ are functions of the respective experimenters’ choices and of events earlier than those choices.

Now an $\alpha$ can be expected to vary with $x, y, z$ and may or may not vary with $w$. However, whether the function varies with them or not, we can introduce all of $x, y, z, w$ as new arguments and rewrite $\theta_w^G$ as a new function (which for convenience we give the same name)

$$\theta^G_w(x, y, z, w; \alpha')$$

of $x, y, z, w$ and properties $\alpha'$ independent of $x, y, z, w$.

To see this, replace any $\alpha$ that does depend on $x, y, z, w$ by the constant values $\alpha_1, \ldots, \alpha_{1320}$ it takes for the $40 \times 33 = 1320$ particular quadruples $x, y, z, w$ we shall use. Alternatively, if each $\alpha$ is some function $\alpha(x, y, z, w)$ of $x, y, z, w$, we may substitute these functions in $(\star)$ to obtain information bits independent of $x, y, z, w$.

Similarly, we can rewrite $\theta_w^G$ as a function

$$\theta^G_b(x, y, z, w; \beta')$$

of $x, y, z, w$ and properties $\beta'$ independent of $x, y, z, w$.

Now for the particular choice of $w$ that $B$ will make, there is a value $\beta_0$ for $\beta'$ for which

$$\theta^G_b(x, y, z, w; \beta_0)$$

is defined. By the above independence of $\beta'$ from $w$, the function $\theta^G_b(x, y, z, w; \beta_0)$ is defined with the same value $\beta_0$ for all 33 values of $w$. (The fact that MIN allows $B$ to freely vary his choice of $w$ makes this intuitively clear.)

We now define

$$\theta^G_0(w) = \theta^G_b(x, y, z, w; \beta_0),$$

noting that since by MIN the response of $b$ cannot vary with $x, y, z$, $\theta^G_0$ is a function just of $w$.

Similarly there is a value $\alpha_0$ of $\alpha'$ for which the function

$$\theta^G_1(x, y, z) = \theta^G_b(x, y, z, w; \alpha_0)$$

is defined for all 40 triples $x, y, z$, and it is also independent of $w$, which argument we have therefore omitted.

But now by TWIN we have the equation

$$\theta^G_1(x, y, z) = (\theta^G_0(x), \theta^G_b(y), \theta^G_0(z)).$$

However, since by SPIN the value of the left-hand side is one of $(0, 1, 1), (1, 0, 1), (1, 1, 0)$, this shows that $\theta^G_0$ is a 101 function, which the Kochen-Specker paradox shows does not exist. This completes the proof.

Locating the Response

We now provide a fuller discussion of some delicate points.

(i) Since the observed spot on the screen is the result of a cascade of slightly earlier events, it is hard to define just when “the response” really starts. We shall now explain why one can regard $a$’s response (say) as having already started at any time after $A$’s choice when all the free information bits that influence it have become available to $a$.

Let $N(a)$ and $N(b)$ be convex regions of space-time that are just big enough to be “neighborhoods of the respective experiments”, by which we mean that they contain the chosen settings of the apparatus and the appropriate particle’s responses. Our proof has shown that if the backward half-space $t < t_F$ determined by a given F-time $t_F$ is disjoint from $N(a)$, then the available information it contains is not enough to determine $a$’s response. On the other hand, if each of the two such half-spaces contains the respective neighborhood, then of course they already contain the responses. By varying $F$ and $G$, this suffices to locate the free decisions to the two neighborhoods, which justifies our ascribing it to the particles themselves.

(ii) We remark that not all the information in the G-backward half-space (say) need be available to $b$, because MIN prevents particle $b$’s function $\theta^G_b$ from using experimenter $A$’s choice of directions $x, y, z$. The underlying reason is of course, that relativity allows us to view the situation from a $B$-first frame, in which $A$’s choice is made only later than $b$’s response, so that $A$ is still free to choose an arbitrary one of the 40 triples. However, this is our only use of relativistic invariance—the argument actually allows any information that does not reveal $A$’s choice to be transmitted superluminally, or even backwards in time.
(iii) Although we’ve precluded the possibility that $\theta_0^E$ can vary with $A$’s choice of directions, it is conceivable that it might nevertheless vary with $a$’s (future!) response. However, $\theta_0^E$ cannot be affected by $a$’s response to an unknown triple chosen by $A$, since the same information is conveyed by the responses $(0, 1, 1)$, to $(x, y, z)$, $(1, 0, 1)$ to $(z, x, y)$, and $(1, 1, 0)$ to $(y, z, x)$. For a similar reason $\theta_0^G$ cannot use $b$’s response, since $B$’s experiment might be to investigate some orthogonal triple $u, v, w$ and discard the responses corresponding to $u$ and $v$.

(iv) It might be objected that free will itself might in some sense be frame-dependent. However, the only instance used in our proof is the choice of directions, which, since it becomes manifest in the orientation of some macroscopic apparatus, must be the same as seen from arbitrary frames.

(v) Finally, we note that the new proof involves four inertial frames—$A$-first, $B$-first, $F$, and $G$. This number cannot be reduced without weakening our theorem, since we want it to apply to arbitrary frames $F$ and $G$, including for example those in which the two experiments are nearly simultaneous.

**Free Will Versus Determinism**

We conclude with brief comments on some of the more philosophical consequences of the Free Will Theorem (abbreviated to FWT).

Some readers may object to our use of the term “free will” to describe the indeterminism of particle responses. Our provocative ascription of free will to elementary particles is deliberate, since our theorem asserts that if experimenters have a certain freedom, then particles have exactly the same kind of freedom. Indeed, it is natural to suppose that this latter freedom is the ultimate explanation of our own.

The humans who choose $x, y, z$, and $w$ may of course be replaced by a computer program containing a pseudo-random number generator. If we dismiss as ridiculous the idea that the particles might be privy to this program, our proof would remain valid. However, as we remark in [1], free will would still be needed to choose the random number generator, since a determined deterministic could maintain that this choice was fixed from the dawn of time.

We have supposed that the experimenters’ choices of directions from the Peres configuration are totally free and independent. However, the freedom we have deduced for particles is more constrained, since it is restricted by the TWIN axiom. We introduced the term “semi-free” in [1] to indicate that it is really the pair of particles that jointly makes a free decision.

Historically, this kind of correlation was a great surprise, which many authors have tried to explain away by saying that one particle influences the other. However, as we argue in detail in [1], the correlation is relativistically invariant, unlike any such explanation. Our attitude is different: following Newton’s famous dictum “Hypotheses non fingo”, we attempt no explanation, but accept the correlation as a fact of life.

Some believe that the alternative to determinism is randomness, and go on to say that “allowing randomness into the world does not really help in understanding free will.” However, this objection does not apply to the free responses of the particles that we have described. It may well be true that classically stochastic processes such as tossing a (true) coin do not help in explaining free will, but, as we show in the Appendix and in §10.1 of [1], adding randomness also does not explain the quantum mechanical effects described in our theorem. It is precisely the “semi-free” nature of twinned particles, and more generally of entanglement, that shows that something very different from classical stochasticism is at play here.

Although the FWT suggests to us that determinism is not a viable option, it nevertheless enables us to agree with Einstein that “God does not play dice with the Universe.” In the present state of knowledge, it is certainly beyond our capabilities to understand the connection between the free decisions of particles and humans, but the free will of neither of these is accounted for by mere randomness.

The tension between human free will and physical determinism has a long history. Long ago, Lucretius made his otherwise deterministic particles “swerve” unpredictably to allow for free will. It was largely the great success of deterministic classical physics that led to the adoption of determinism by so many philosophers and scientists, particularly those in fields remote from current physics. (This remark also applies to “compatibilism”, a now unnecessary attempt to allow for human free will in a deterministic world.)

Although, as we show in [1], determinism may formally be shown to be consistent, there is no longer any evidence that supports it, in view of the fact that classical physics has been superseded by quantum mechanics, a non-deterministic theory. The import of the free will theorem is that it is not only current quantum theory, but the world itself that is non-deterministic, so that no future theory can return us to a clockwork universe.

**Appendix. Can There Be a Mechanism for Wave Function Collapse?**

Granted our three axioms, the FWT shows that nature itself is non-deterministic. It follows that there can be no correct relativistic deterministic
theory of nature. In particular, no relativistic version of a hidden variable theory such as Bohm's well-known theory [4] can exist.

Moreover, the FWT has the stronger implication that there can be no relativistic theory that provides a mechanism for reduction. There are nonlinear extensions of quantum mechanics, which we shall call collectively GRW theories (after Ghirardi, Rimini, and Weber, see [5]) that attempt to give such a mechanism. The original theories were not relativistic, but some newer versions make that claim. We shall focus here on Tumulka’s theory rGRWf (see [6]), but our argument below applies, mutatis mutandis, to other relativistic GRW theories. We disagree with Tumulka’s claim in [7] that the FWT does not apply to rGRWf, for reasons we now examine.

(i) As it is presented in [6], rGRWf is not a deterministic theory. It includes stochastic “flashes” that determine the particles’ responses. However, in [1] we claim that adding randomness, or a stochastic element, to a deterministic theory does not help:

“To see why, let the stochastic element in a putatively relativistic GRW theory be a sequence of random numbers (not all of which need be used by both particles). Although these might only be generated as needed, it will plainly make no difference to let them be given in advance. But then the behavior of the particles in such a theory would in fact be a function of the information available to them (including this stochastic element).”

Tumulka writes in [7] that this “recipe” does not apply to rGRWf:

“Since the random element in rGRWf is the set of flashes, nature should, according to this recipe, make at the initial time the decision where-when flashes will occur, make this decision ‘available’ to every space-time location, and have the flashes just carry out the pre-determined plan. The problem is that the distribution of the flashes depends on the external fields, and thus on the free decision of the experimenters. In particular, the correlation between the flashes in A and those in B depends on both external fields. Thus, to let the randomness ‘be given in advance’ would make a big difference indeed, as it would require nature to know in advance the decision of both experimenters, and would thus require the theory either to give up freedom or to allow influences to the past.”

Tumulka writes that if that is the case, then rGRWf acquires some nasty properties: In some frame Λ, “[the flash] \( f_{i}^{Λ} \) will entail influences to the past.” Actually, admitting that the functional hypothesis applies to rGRWf has more dire consequences—it leads to a contradiction. For if, as we just showed, the functional hypothesis applies to the flashes, and the first flashes determine the particles’ responses, then it also applies to these responses, which by the FWT leads to a contradiction.

(ii) Another possible objection is that in our statement of the MIN axiom, the assertion that \( a \)'s response is independent of \( B \)'s choice was insufficiently precise. Our view is that the statement must be true whatever precise definition is given to the term “independent”, because in no inertial frame can the past appearance of a macroscopic spot on a screen depend on a future free decision.

It is possible to give a more precise form of MIN by replacing the phrase “particle b's response is independent of A's choice” by “if a's response is determined by B's choice, then its value does not vary with that choice.” However, we actually need precision only in the presence of the functional hypothesis, when it takes the mathematical form that a's putative response function \( d_{\alpha}^{B} \) cannot in fact vary with B's choice. To accept relativity but deny MIN is therefore to suppose that an experimenter can freely make a choice that will alter the past, by changing the location on a screen of a spot that has already been observed.

1 This unfortunately makes rGRWf non-predictive—it can only find the flash distribution that “explains” either particle's behavior when both experimenters' fields are given.
Tumulka claims in [7] that since in the twinning experiment the question of which one of the first flashes at A and B is earlier is frame-dependent, it follows that the determination of which flash influences the other is also frame-dependent. However, MIN does not deal with flashes or other occult events, but only with the particles' responses as indicated by macroscopic spots on a screen, and these are surely not frame-dependent.

In any case, we may avoid any such questions about the term “independent” by modifying MIN to prove a weaker version of the FWT, which nevertheless still yields a contradiction for relativistic GRW theories, as follows.

\(\text{MIN}':\) In an A-first frame, B can freely choose any one of the 33 directions \(w\), and a’s prior response is independent of B’s choice. Similarly, in a B-first frame, A can independently freely choose any one of the 40 triples \(x, y, z\), and b’s prior response is independent of A’s choice.

To justify \(\text{MIN}'\) note that a’s response, signaled by a spot on the screen, has already happened in an A-first frame, and cannot be altered by the later free choice of \(w\) by B; a similar remark applies to B’s response. In [7], Tumulka apparently accepts this justification for \(\text{MIN}'\) in rGRW: “… the first flash \(f_A\) does not depend on the field \(F_B\) in a frame in which the points of B are later than those of A.”

This weakening of MIN allows us to prove a weaker form of the FWT:

\(\text{FWT}':\) The axioms SPIN, TWIN, and \(\text{MIN}'\) imply that there exists an inertial frame such that the response of a spin 1 particle to a triple experiment is not a function of properties of that part of the universe that is earlier than the response with respect to this frame.

This result follows without change from our present proof of the FWT by taking \(F\) to be an A-first frame and \(G\) a B-first frame, and applying \(\text{MIN}'\) in place of MIN to eliminate \(\partial^w_{x,y,z}\)'s dependence on \(w\) and \(\partial^w_{x,y,z}\)'s dependence on \(x, y, z\).

We can now apply \(\text{FWT}'\) to show that rGRW’s first flash function \(f_{R}\) of [4], which determines a’s response, cannot exist, by choosing A to be the frame named in \(\text{FWT}'\).

The Free Will Theorem thus shows that any such theory, even if it involves a stochastic element, must walk the fine line of predicting that for certain interactions the wave function collapses to some eigenfunction of the Hamiltonian, without being able to specify which eigenfunction this is. If such a theory exists, the authors have no idea what form it might take.

References

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Mathematicians rarely make it into the newspaper, much less into fashion spreads. But on September 21, 2008, the fashion section of the New York Times Sunday magazine carried a picture of Annalisa Crannell, a professor of mathematics at Franklin & Marshall College (and a book reviewer in this issue of the Notices). The magazine contacted Crannell saying that it was doing a photo portfolio about academics and had chosen her because she had received the Haimo Award from the Mathematical Association of America. "By phone, I learned that the ‘photo portfolio' was really about fashion, which was pretty funny because part of my Haimo Award speech included the price tags of the clothes I usually wear (US$1 or less),” she said.

A crew of eight spent three hours dressing Crannell and doing her hair and makeup. One of them told Crannell he loves mathematics and asked her some questions about fractals. The picture of Crannell, which can be found on the Web, does not show the US$2,500 Gucci boots, which Crannell called “pretty darned uncomfortable”. “I was wearing my blue AMS ‘I love math' bracelet that I'd picked up at MathFest, and the guy admired it so I gave it to him,” Crannell recalled. “I didn’t get to keep any of the clothes they brought, but he got to keep my bracelet!”

Noticed
Mathematics and the Aesthetic
Reviewed by Annalisa Crannell

Mathematics and the Aesthetic is a heavy book. I mean this in the literal sense: at 288 pages, it weighs 721 grams. The book has the same dimensions as the little 206-page book on Fourier series that my mother studied from in 1959 [1], but into that small space it packs almost half again the number of pages and one-third again the mass. This weight is a tangible sign of the care that the authors, editors, and publisher used in putting the book together. The high-quality paper is matched by a sense of attention to detail throughout. The color pictures are carefully chosen and well presented; the text is easy to read. Which is all as it should be for a book with the word "Aesthetic" in the title.

This is a daunting project to pull together, and there are many possible ways to botch the job. When we try to describe the aesthetics of mathematics—the discipline that gives us cohomology and nonlinear fourth-order partial differential equations—it’s far too easy to become pretentious and wordy. I’ve often caught myself at the other extreme of sophistication, figuratively burbling in my beer: “No, man, it’s beautiful. No, really!” And the middle ground, that space between pretension and exuberance, has been so famously traveled by the likes of Hardy and Poincaré, that it seems like hubris or folly (or both) to trod this ground once again. Who could touch their eloquence? What more could a body say?

Enter Sinclair, Pimm, and Higginson. This trio of editors/authors assembled a group of scholars with diverse academic credentials: philosophers, math educators, and (yes) research mathematicians. The authors’ combined contributions are not (as I might have originally supposed) additional propaganda to convince the masses that math is beautiful. Rather, each author explores the ways in which mathematics is an aesthetic experience. For some authors, “aesthetic” translates into positive notions (like “elegance” or “beauty”); other authors use “aesthetic” in a more technical, neutral meaning of “relating to the senses and sensibility”. If the second sense seems far from logic and from the abstract reasoning of mathematics, we might use instead the definition proposed by Judith Wechsler [3, page 2]:

In its dealings with “things perceptible to the senses”, aesthetics comes to grips with relations: structure, context, schemata, similarity/dissimilarity, consonance/dissonance. (About isolated,
There are ten authors of nine chapters (eleven chapters, if you count the forward and afterward), and often this mix would lend a hodge-podge feel to a volume. It’s true that this work didn’t escape completely from the bane of variable quality. Still, more than in any other collection of essays I’ve read, the editors clearly worked hard with the authors to ensure a sense of the whole; authors from one chapter often compare their own descriptions to those that appear in other chapters, and navigating through the book is easy to do.

Are there general themes that emerge?

One of the things that struck me as I read through these chapters—particularly through the first half of the book—was the recurring theme of describing the doing of mathematics, rather than describing the mathematics itself. We often articulate the usefulness of doing mathematics (for example, telling our students that “mathematics is not a spectator sport”). But these authors move beyond utility to aesthetics, in ways I’ll elaborate below. Their collective perspectives made me wish for a few new good verbs. There is no good verb for “to do beautiful things”, for example: beautify, as a transitive verb, doesn’t quite work, since it requires that something else get beautified, rather than implying the action itself is beautiful. And similarly, there’s no good verb for “to do mathematics”.

This impoverishment of vocabulary strikes me as a shame. The authors in this volume frequently used theorems and proofs (well-known, surprising, or personally dear) to illustrate their points, but they just as often described the experiences of grappling with mathematics, of puzzling through it, and of making sudden sense of previously confusing concepts. Poincaré famously described his own epiphanic experience of completing a perplexing proof, and many mathematicians are familiar with that kind of “aha” gift of insight. To me an even more touching description of the doing of mathematics is Doris Schattschneider’s description (page 56) of pleasure in hammering together some not-so-beautiful mathematics. After describing in some particular detail why the proof she had worked on was neither elegant, nor ingenious, nor generalizable, nor insightful, nor illuminating, she continued on:

Yet, I received a measure of satisfaction in proving this result. I had believed it was true and now it was proven to be true. And, along the way, I saw some connections that I could not have seen without actually going through the process …

And then she delightedly shares some of the connections she discovered.

The aesthetic of “doing” arises in other chapters: Sinclair (Chapter 4) divides her analysis of “The aesthetic sensibilities of mathematicians” into three parts: how we evaluate mathematics, how we generate new mathematics, and how we are motivated to do various kinds of mathematics. Schiralli (Chapter 5) creates parallels between mathematics and art (and the aesthetics of each) by creating a page-long, bulleted list, each bullet beginning with an italicized verb (e.g., “create novel or original symbolic patterns”). Jackiw (Chapter 7) devotes his entire chapter to “dynamic geometry” and to ways in which mathematicians understand a figure by moving its parts. Henderson and Taimina (Chapter 3) address the noun/verb issue explicitly in their essay on “Experiencing meanings in geometry” (page 83):

...In fact, rarely do we find proofs, in and of themselves, to be aesthetic objects. Instead, we locate the aesthetic value of mathematics in the coming-to-understanding, in the integration of experience and meaning.

But this emphasis on verbs is a motif that I myself have imposed on the reading of this book. It would be fairer to the book for me to sketch its outline and give a quick tour of the content of its chapters. Here is an overview, which I’ll follow with a deeper examination of one or two of the more provocative chapters.

The editors divide the main body of the work into three-chapter groupings, which fit into three sections: first, mathematics as an aesthetic subject; second, an explanation of “the aesthetic dimension of mathematics”; and third, a description of how both of these subjects fit into the study of aesthetics in other disciplines. If the first two sections seem similar, I will add that locating the emphasis on mathematics (in the first case) or on aesthetics (in the second) is key: Section A is authored by research mathematicians who look at mathematics through their own perspectives; Section B is authored by mathematics educators and philosophers who look at mathematics, so to speak, through other people’s eyes. Each of the three sections comes with a one-page introduction from the editors.

In addition, the editors include Chapters Alpha and Omega to introduce and close out the book. Chapter Alpha was for me a welcome introduction to the history that precedes this book, telling the story of mathematical paradigms from the time of the Pythagoreans through St. Augustine, Gauss, Hadamard, Russell, and others, and then pointing toward the future. (I’ll pick a fight with Chapter Omega in due time.)

Section A (“The mathematician’s art”) is probably the most familiar and comfortable material to readers of the Notices. Jonathan Borwein leads
off with a chapter that takes a, “Hey! Look at this cool proof!” approach. He doesn’t use those words or even exclamation points, which would be too campy, but his enthusiasm shines through. He shares some of his favorite insights into the number $\pi$, and he demonstrates some elegant geometric proofs of the almost-without-words variety.

Then Doris Schattschneider takes over with a chapter that—in true mathematical style—leads off with illustrative examples that provide the context and motivation for a more general aesthetic framework. She starts with some of the historical, classical theorems that have shaped our own mathematical culture and then lists five attributes of mathematical work that we claim are beautiful (page 43); elegance, ingenuity, insight, connections, and paradigm. (My art colleagues, I think, would appreciate this list.) Throughout, she uses specific pieces of mathematics (like an elegant proof of the arithmetic-geometric mean inequality) to illustrate these ideas in context.

David Henderson and Daina Taimina close out this section by examining our “need” for meaning. They illustrate this need through mathematical examples and paradoxes, comparing various definitions of the concept “line” (e.g., “shortest distance” versus “no wiggles” versus “circle of infinite radius”). Correctness of the results alone, they maintain, feeds the belly but not the soul:

For example, [a 1973 paper by Henderson] has a very concise, simple (half-page) proof. This proof has provoked more questions from other mathematicians than any of his other research papers, and most of the questions were of the sort: “Why is it true?”, “Where did it come from?”, “How did you see it?” They accepted the proof logically, yet were not satisfied. (page 66)

If Section A starts with the math and then describes where aesthetics fits in, then Section B (“A sense for mathematics”) does the reverse. Nathalie Sinclair uses interviews with a half-dozen living mathematicians, co-mingled with the writings of many other prolific mathematicians, to explore aesthetic considerations in mathematics. She is methodical and clear, and I enjoyed her insights, even as I felt a bit like a biological specimen displayed under a microscope. For example, when she describes standard ways that mathematicians approach solving problems, she includes “playing” and “establishing intimacy”, perhaps by naming or claiming the objects involved: my triangle. Maybe next time I'll lower the blinds.

Martin Schiralli builds on Keith Devlin’s book on mathematics and pattern [2] by adding a consideration of the aesthetic connections between these two concepts. He notes that the Pythagoreans’ conception of arithmetic (as understood to represent ordered arrangements of numbers) connected the subject with “the very fabric of the knowable world and their efforts to find the principles unifying that fabric in the mathematical-aesthetic ratio of harmonic intervals” (page 119). He continues in this vein to describe how later philosophers such as Wittgenstein and Kant used “numbers as cognitive scaffolding” for understanding natural phenomena. William Higginson finishes the section with a chapter that flits among stereotypes of mathematicians, popularizations of mathematics, and the anthropological and historical basis for mathematical capacity.

Section C (oddly titled “Mathematical agency”) contains three essays that take interdisciplinary approaches to examining aesthetics. This section is a wild ride. It begins with an essay on the didactics of dynamic geometry by Nicholas Jackiw (the chief technology officer of KCP Technologies and original designer of the Geometer’s Sketchpad). It concludes with an essay by the late Dick Tahta that takes a Freudian approach to “the perennial debate about the nature of mathematical objects” (page 204) and all that this implies about our anxiety regarding our mothers. Sandwiched between those two pieces sits something pure and holy.

David Pimm’s essay (“Drawing on the image in mathematics and art”) caught me by surprise and kept me up late reading it. In it, he describes how one particular aesthetic (the purity of iconoclasm) permeated and became ritual in both the Bourbaki movement and in the reformed English Church. He contends that notions of “purity” (in the religious and also in the “pure math” sense) led to the same sense of iconoclasm: rejection of figures (geometric or human) and an attempt to get at Truth directly, without any mediating interference. There is more; it is worth reading. I am unabashedly unfamiliar with the subject and don’t pretend to have the slightest idea of the correctness of his argument. And yet I very much appreciated this one essay which homed in so narrowly on a single historical mathematical movement and which chose one single particular aesthetic ideal, and tied the two together so neatly. And fittingly, if surprise and insight are aesthetic qualities, then I have all the philosophical justification I’d need to say this essay is an aesthetic work.

Why, then, did Pimm and Sinclair have to muck around in Chapter Omega? Darn it, the review would have been lovely if I could have stopped one paragraph ago—just as this book would have been lovely if it stopped one chapter earlier (or two, depending on how you feel about Freud and maternal separation anxieties). Chapter Omega comes in several unhappy pieces, three of which I lay out here (in a butchered and, I admit, unfair way). The first is that mathematics is dehumanizing (to be more specific, “decontextualized”, “depersonalized”, and “detemporalized”), a fact...
the authors conclude from the way we write our research articles. Second, the mathematical mind is a melancholy one, for which the most striking evidence is the famous etching *Melencolia I* by Albrecht Dürer. Dürer was melancholy. True, he was an artist, but (as the authors take pains to point out) he was an artist who **liked mathematics**. Third, there is some connection between mathematics and autism, particularly in the way we (don’t) relate to other people. The authors wend their way through the argument for this connection by noting that we seem to have similar modes of reasoning, but also (on pages 240–241):

- some famous mathematicians might have had autism (that is, some psychologists have written speculative articles with post hoc diagnoses of a half-dozen mathematicians);
- by implication, most mathematicians are deficient at relating to other people, and
- this might "be part of the explanation" about why women are less likely to be mathematicians.

Well, faugh.

Leaving aside completely questions of scholarship and evidence, this chapter stands at odds with the rest of this book. It certainly is no summary of the previous essays, and indeed, it contrasts most markedly with the writings of Section A (written by the research mathematicians themselves).

For me, this chapter was particularly surreal because I read it while I was at the 2008 MathFest. There, Christine Stevens spoke about the more-than-1000 Project NExT Fellows and about the impact they have had on the mathematical community—and about how they have had this impact precisely by building and strengthening communities. Erik Demaine gave a series of standing-room-only talks about the mathematics of folding, and he wove in touching stories of working with his father and with his many coauthors. “The main point of these talks,” he repeated often, “is that you ought to have fun.” Sixteen hundred people joined together in a celebration of mathematics, in meeting new people, and in reacquainting with old friends.

And if this book has any glaring holes, it is perhaps this. Aside from a brief nod from Sinclair (two paragraphs) that social factors can have a motivating influence on the kinds of mathematics we choose to do, there’s little mention of the collaborative aspects of mathematics. Nobody writes about the aesthetics of co-authoring, the joy of mentoring junior faculty, the sheer hero-worship that impels us to follow others, nor the invigoration that can come from bouncing our ideas off of other people. Nobody writes about talking out loud about mathematics, nor of hearing others talk about it. For a book that arose—as the first sentence of the preface tells us—from a series of talks at a conference, this is an odd and paradoxical omission.

But perhaps I am being too harsh—perhaps I am complaining that I didn’t get an action toy in my box of Cracker Jack, and forgetting to be grateful for the secret decoder ring that did come with my snack. *Mathematics and the Aesthetic* is a thought-full collection of essays, bound together with careful organization, attention to small details, and even a bit of elegance.

Which is all as it should be for a book with the word “Mathematics” in the title.

**References**


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Mathematician Jason Brown of Dalhousie University in Halifax, Canada, was in the news for his work analyzing the opening chord of the Beatles’ song “A Hard Day’s Night”. It was known that most of the chord was played by George Harrison, but the exact nature of the chord remained a mystery for forty years. Brown used a Fourier transform to analyze the frequencies and solve the mystery. He found an F note in the opening sound that could not be played on Harrison’s 12-string guitar and deduced that the note was part of a piano chord played along with the guitar. The *Halifax Chronicle Herald* has more about Brown and his research at [http://thechronicleherald.ca/](http://thechronicleherald.ca/).
While driving across my home state of Michigan not so long ago, I noticed that the format for the state’s license plates had changed. The old format had three letters followed by three digits; sometime recently, a fourth digit was added. Wondering why the change had been made, I figured that the old format had $26^3 \cdot 1000$ possible designations and quickly estimated that this gave around 16 million possibilities. I knew that the population of Michigan is about 10 million so I could see, assuming license plates are not reused, how we could be running low on plates either now or in the near future. Maybe this was a good time to add another digit.

Mathematicians do this kind of thinking frequently. There’s no deep mathematics involved, but our comfort with computation can help explain observations we make as well as make a long drive a little less tedious.

In his wonderful new book, *Group Theory in the Bedroom, and Other Mathematical Diversions*, Brian Hayes shows how pleasurable this kind of thinking can be and the surprising places to which it can lead. The book collects and slightly reworks twelve of Hayes’ essays, which originally appeared over the last decade in the *The Sciences* and *American Scientist*. Each essay also includes an “Afterthoughts” section in which Hayes reflects on the original work, scrupulously owns up to errors, and discusses responses received from readers.

Let’s begin by looking at the essay, “Dividing the continent”, appropriately placed in the middle of the collection. Hayes describes a recent driving trip, and the question that arose in his mind as he drove over the continental divide on the Idaho-Montana border: What is the mathematical nature of the continental divide and how would one determine its location? Written in the first person, the essay consists of his evolving thoughts as his journey continues (“Somewhere in North Dakota or Minnesota ...I finally began to settle on an idea...”).

Eventually, Hayes begins searching for an algorithm to detect the continental divide. Interestingly, his resources are limited; being on the road, he is away from a computer and a library. Thinking is his only tool. Continuing on, Hayes shows us several possible algorithms, which initially seem promising but are seen after further thought to be deficient, before arriving at an especially appealing, elegant solution.

Back at home, Hayes continues the project by acquiring a digital elevation map and implementing his algorithm. Sure enough, the continental divide shows up just where we expect. He also

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searches the literature on this subject, finding early papers by Arthur Cayley and James Clerk Maxwell and comparing their thoughts to his own. Hayes also finds that, in addition to the expected work in geography, this problem is also important in image analysis and artificial vision.

Relating these thoughts as part of a long trip serves Hayes’ larger purpose. As he writes in the “Afterthoughts” section: “In telling the story, I wanted to focus not so much on the solution to the watershed problem as on the process by which people go about finding or inventing solutions. Where do the ideas come from? How do we evaluate alternatives? How do we know when to stop?” This story is about traveling rather than arriving, and we feel involved in it. At several points, I put the book down and developed an outline for my own algorithm.

While the other essays do not originate in a long car trip, many of them read like travel essays, as Hayes takes us on expeditions through landscapes surrounding interesting mathematical questions. Sometimes, such as when the continental divide appears before our eyes, we realize the joy has been in the journey as much as the destination. Other times, these investigations lead to surprising questions that reflect more broadly on who we are, what we value, and the nature of mathematics.

Another essay, “Statistics of deadly quarrels”, presents a study of the number of human-caused casualties in recent history. Hayes begins by introducing us to Lewis Fry Richardson, a British meteorologist who, after serving in the first world war, began to apply the mathematical techniques he had used in meteorology to a study of war. Richardson painstakingly attempted to tally all deaths between 1820 and 1950 attributable to the war, was hoping to explain what he had seen. (It is easy to speculate that Richardson, perhaps haunted by the horrors he witnessed in the war, was hoping to explain what he had seen.)

Of course, this is a daunting task that is necessarily incomplete. However, a statistical analysis of the data is fascinating for what it does not show. Factors that might be thought to influence the outbreak of war—such as countries sharing a common language or engaging in an arms race—are seen to be statistically insignificant. Instead, the most striking observation is that the number of new wars per year closely follows a Poisson distribution, which would follow if the probability of a war breaking out at any given time is constant. This does not, of course, imply that individual wars occur randomly; rather, it appears that war is a perpetual feature of our human existence.

Topics of other essays include:
- a remarkable working clock, constructed with gears in the 1800s, built to be accurate for at least 10,000 years. Hayes deftly relates this to the crisis that was predicted to follow the Y2K phenomenon, a crisis thought to result from software engineers who failed to imagine their code would be running in a few decades;
- an investigation of randomness, whether it really exists, and what it means that mathematics has not found a way to create randomness;
- a survey of early attempts to explain the genetic code, the means by which a string of nucleotides on a DNA molecule represents a sequence of amino acids. Nature’s code is much less elegant than the mathematical ones first proposed, but in the end nature seems to have gotten it right;
- an economic model of the distribution of wealth based on the kinetic theory of gases. Paradoxically, an economy based on theft leads to a more equitable distribution of wealth than one based on fair trading;
- the partitioning problem, and what it means for a problem to be hard;
- name spaces, such as radio station call letters and airport codes (and, yes, license plates), and how they fill up;
- ways in which the base three number system is superior to the more familiar binary and decimal systems;
- how it can be tricky to determine if two things are really the same;
- and night thoughts on how to flip a mattress periodically so that all possible orientations are used equally. This essay lends its title to the book as well.

As may be seen, the essays, for the most part, originate in “real world” issues. Hayes writes the “Computing Science” column in American Scientist, so it’s no surprise that many of the topics have a computational component. Indeed, Hayes is quick to write some code to test an idea, and some readers, like this one, will no doubt be inspired to follow suit. It is not expected, however, that the audience shares this interest in computing. Instead, computation is used as a means to address other issues. In his blog, \[http://bit-player.org/\]
Hayes accurately describes some of his work as “inquisitive programming”, which he defines as “computer programming [used] as a tool for exploring, experimenting, and problem-solving”.

Most of the essays contain interesting bits of what could be called trivia, though they never seem superfluous. There are often interesting biographical sketches of little-known players as well as tidbits such as how random numbers are used in the Ethernet networking protocol; the origin of the equals sign; and why Brocot, a French watchmaker, was led to discover what we now call the
Stern-Brocot tree. The writing is uniformly good, exceptionally clear, and with abundant humor and humanity. Hayes writes with a refreshing openness; as part of his colloquial style, he is quick to admit errors and naive ideas.

Group Theory in the Bedroom should be accessible to a wide audience. Hayes uses almost no mathematical notation and assumes relatively little mathematical knowledge. For instance, when $e$ is used at some point, Hayes writes, "$e$ is the number 2.718 (known as Euler’s number)." A formula for the Poisson distribution is given, but Hayes quickly gives a lucid interpretation of its meaning.

This is not a book that aims to teach grand mathematical theory or to follow in the footsteps of giants. So what is its aim? Asking the question almost feels wrong. Hayes seems to be enjoying himself so much, and the reader is so involved, that no greater goal seems required. These are, after all, "mathematical diversions". What I found, however, is that the essays, taken as a whole, demonstrate convincingly the joy of mathematical thinking and the real power available when it is applied to more general inquiries.

As much as any book I can name, Group Theory in the Bedroom conveys to a general audience the playfulness involved in doing mathematics: how questions arise as a form of play, how our first attempts at answering questions usually seem naive in hindsight but are crucial for finding eventual solutions, and how a good solution just feels right. As Hayes writes, "I’m not a mathematician, but I’ve been hanging out with some of them long enough to know how the game is played." In addition, Hayes’ writing, with its openness, invites the reader to participate actively. I often felt I was having a conversation, and at times an argument, with the author.

We often hear it said that more students need to take more mathematics courses, even if they never subsequently use the content, for mathematics helps build general problem-solving and critical thinking skills. This argument seems dicey to me: why should mathematics, as least as traditionally taught, foster critical thinking any more than philosophy or literature or physics?

Without addressing the issue explicitly, Group Theory in the Bedroom presents a more compelling argument for the importance of mathematics. Whether it develops general skills or not, mathematics is a fundamental tool in an intellectual toolkit and is crucial for making sense of the world around us.

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About the Cover

Long divide

This month’s cover was produced by Brian Hayes, and is derived from images he included in the column “Dividing the Continent” that he wrote for the November 2000 issue of American Scientist (available at [http://www.americanscientist.org/issues/pub/dividing-the-continent/](http://www.americanscientist.org/issues/pub/dividing-the-continent/)). It illustrates how the algorithm he used proceeds to find the continental divide of North America, drawn as the thin red trail of pixels in the final image. Basically, it floods the ocean basins and keeps track of where they meet as the flood rises.

Brian Hayes has been writing the column “Computing Science” for American Scientist for many years, and it is a constant source of interesting mathematical and computational ideas. Some of his columns have been collected in the book Group Theory in the Bedroom, reviewed by David Austin in this issue of the Notices. The elevation data for Hayes’s maps come from [http://www.ngdc.noaa.gov/mgg/global/etopo5.html](http://www.ngdc.noaa.gov/mgg/global/etopo5.html).

He writes: “The basic idea is to raise the level of both oceans in stages until the waters meet. The line along which they meet is the continental divide. This physical process is easy to describe, but that’s because water performs an extraordinary parallel computation when it seeks its own level. Trying to emulate that process in a sequential, digital computer takes considerably more trouble.” He also tells us that an animated version of the process can be found at [http://bit-player.org/bph-publications/AmSci-2000-11-Hayes-Cont-Divide/animate.html](http://bit-player.org/bph-publications/AmSci-2000-11-Hayes-Cont-Divide/animate.html).

—Bill Casselman, Graphics Editor (notices−covers@ams.org)
Consider all formal linear sums of oriented links in a 3-manifold $M$. Coefficients are to be in $\mathbb{Z}[v^{-1}, v, z^{-1}, z]$, the Laurent polynomials in $v$ and $z$. Impose on this all relations of the form 

$$v^{-1}L_+ - vL_- = zL_0,$$

where $L_+$, $L_-$, and $L_0$ are three links identical except near a point where they are as in Figure 1. The result is the oriented linear skein module of $M$.

$$L_+ \begin{array}{c} \uparrow \dashv \downarrow \end{array} L_- \begin{array}{c} \uparrow \dashv \downarrow \end{array} L_0$$

**Figure 1. The only differences in $L_+$, $L_-$, and $L_0$.**

A link is, of course, a finite collection of disjoint simple closed curves (strings) in $M$, two links being the same if one can be moved to become the other without breaking the strings (such a movement is technically an ambient isotopy). A fundamental theorem is that, when $M$ is ordinary 3-space $\mathbb{R}^3$, or the 3-sphere $S^3$, this skein module is free of dimension one with base the unknot $U$. Thus the coordinate, or evaluation, of an oriented link $L$ with respect to $U$ is a polynomial invariant $P_L(v, z)$ of $L$.

Let $T$ be the solid torus $A \times [0, 1]$, where $A$ is an annulus. The union of a link in the solid torus $A \times [0, \frac{1}{2}]$ with a link in $A \times [\frac{1}{2}, 1]$ is a link in $T$. This defines a product, and the skein module of $T$ becomes a commutative algebra. A short argument, using the above relation to "change crossings", shows this is generated as an algebra by \{$L_r : r \in \mathbb{Z}$\}, where $L_r$ is a single string steadily encircling $T$, in as simple a way as possible, $r$ times. Finding an easy description of the skein module of an arbitrary 3-manifold is usually not possible. However, any orientable 3-manifold $M$ can be formed from $S^3$ by surgery, by removing and replacing differently solid tori fattening a link $L$ in $S^3$. Evaluation of a certain carefully chosen element of the skein module of $T$ placed around every component of $L$, can produce "quantum" invariants of $M$. The intricate details of this are in [3]. An evaluation of elements of skein modules, linear sums of links (or later, tangles) in some configuration, will always mean the multilinear sum of all evaluations of unions of summands.

Evaluating a link in terms of a base of a skein module can be seen as a partial calculation of a link invariant. In a relative version of the above, $M$ has non-empty boundary $\partial M$ containing $2N$ specified "fixed" points; $N$ of these have an inwards orientation and $N$ an outwards one. The theory proceeds as before using tangles instead of links. A tangle is a disjoint union of oriented simple closed curves with $N$ oriented arcs joining in pairs the $2N$ specified points. Two tangles are the same if one can be moved to the other keeping $\partial M$ fixed during the movement. In a famous example of J. H. Conway, $M$ is a ball with four specified points. The skein module of $M$ is then 2-dimensional with base the two tangles $t_0$ and $t_\infty$ of Figure 2. Any 2-string tangle in the ball can be expressed as a linear combination of $t_0$ and $t_\infty$. The tangle $t_{2n}$ shown with $2n$ crossings is $v^{2n}t_0 + z(v^{2n} - 1)(v^2 - 1)^{-1}t_\infty$, for example, and wherever a copy of $t_{2n}$ occurs in a calculation this can be substituted. If a sphere $S$ cuts a knot $K$ contained in $S^3$ in four points, it divides $K$ into a tangle in the ball inside $S$ and another in the ball outside. The polynomial...
P_k(v, z) can be found by expressing these tangles in terms of the bases of the two balls and combining the bases together with a simple 2 × 2 matrix. Now note that a π-rotation about one of the three coordinate axes of Figure 2, together with reversal of arrows if needed, leaves the two base elements unchanged. Thus, if K is changed to K’ by removing the tangle inside S, giving at each point of a normal frame, the giving at each point of a normal frame, was the only relevant oriented link invariant (where the ring \( \mathbb{Z}[A^{-1}, A] \), a generator being one untwisted curve, \( \alpha \) say, encircling \( T \) once. Depict the ball \( B \) with \( 2n \) boundary points as a rectangle with \( n \) points on each of the left and right sides. Concatenation of rectangles makes the skein module of \( B \) into an algebra. It is the \( n^{th} \) Temperley-Lieb algebra of dimension \( \frac{1}{n-1} \binom{2n}{n} \) but generated as an algebra by \( n \) elements \( \{1, e_1, e_2, \ldots, e_{n-1}\} \) shown in Figure 5. This algebra has a unique element \( f(n) \), the Jones-Wenzl idempotent, such that \( f(n)e_i = 0 = e_if(n) \) and \( f(n) - 1 \) belongs to the algebra generated by \( \{e_1, e_2, \ldots, e_{n-1}\} \), (so \( f(n)f(n) = f(n) \)). Placing \( f(n) \) in a solid torus \( T \), and connecting the \( n \) points on the left to those on the right directly around \( T \), produces \( S_n(\alpha) \), a Chebyshev polynomial in \( \alpha \). If \( S_n(\alpha) \) contained in \( T \) is placed, without twisting, around the unknot and interpreted in the skein module of \( S^3 \), its coordinate (with \( \emptyset \) as base) is \( \Delta_n = (-1)^n(A^{2(n+1)} - A^{-2(n+1)})(A^2 - A^{-2})^{-1} \). Thus \( \Delta_n = 0 \) if \( A \) is chosen to be a complex \( (4n + 4)^{th} \) root of unity. Then the (normalised) evaluation of \( \sum_{r=0}^{n} \Delta_rS_r(\alpha) \) placed around each component of a surgery link defining a 3-manifold, gives a 3-manifold invariant.

The evaluation of a link with \( S_{n+r}(\alpha) \) placed around its \( r^{th} \) component is the Jones polynomial of the link coloured by the function \( c \). The form of the above 3-manifold invariant gives motivation to the calculation of coloured invariants. As \( S_n(\alpha) \) is just \( f(n) \) with its end points joined around a solid torus, this leads to consideration of configurations of many \( f(n) \)’s joined together in subtle
Mathematical Gates. The main entrance to the Centre for Mathematical Sciences in Cambridge is sealed by iron gates. Medallions in these gates show the only two knots with at most eleven crossings, other than the unknot, that have trivial Alexander polynomial. One gate shows the knot studied by S. Kinoshita and H. Terasaka, whilst the other gate shows the knot discovered by J. H. Conway in his classification of eleven-crossing knots. Related as they are by one of Conway's mutations they cannot be distinguished by any invariant based on skein theory. The medallions were created by John Robinson and donated by Damon de Laszlo and Robert Hefner III.

ways. Such configurations are drawn as labelled planar trivalent graphs, possibly with crossings, where an integer \( a \geq 0 \) labelling an edge indicates the presence of a copy of \( f^{(a)} \) in \( a \) strings parallel to the edge. A vertex, where edges labelled \( a, b, \) and \( c \) meet, denotes the element of the skein module of a ball with \( a + b + c \) specified points shown in Figure 6 (i) where \( x + y = c, y + z = a, \) and \( z + x = b. \) For this to exist, \( \{a, b, c\} \) must be compatible, meaning that \( a + b + c \) is even, \( a \leq b + c, \) \( b \leq c + a, \) and \( c \leq a + b. \) The labelled graph of Figure 6 (ii) evaluates to

\[
\theta(a, b, c) = \frac{\Delta_{x+y+z!}\Delta_{x-1!}\Delta_{y-1!}\Delta_{z-1!}}{\Delta_{y+z-1!}\Delta_{z+x-1!}\Delta_{x+y-1!}},
\]

where \( \Delta_n! \) denotes \( \Delta_n\Delta_{n-1}\Delta_{n-2}...\Delta_1. \)

In the Kauffman Bracket skein module of the ball with four specified boundary sets of \( a, b, c, \) and \( d \) points, consider the submodule of all skeins having \( f^{(a)}, f^{(b)}, f^{(c)}, \) and \( f^{(d)} \) adjacent to these sets (see Figure 7). It is not hard to show that all the elements \( [(a, b)j(c, d)] \), with both triples compatible, form a base of this submodule. So do the elements \( [(b, c)i(d, a)]. \) The terms in the change of base matrix, defined by \( [(a, b)j(c, d)] = \sum_i\{a \ b \ c \ d \ i \} \{b \ c \ i(d, a)] \), are called “6j-symbols”. A cumbersome closed formula is known for them. An arc labelled \( a \) over-crossing one labelled \( b \) has \( j^b \) coordinate \( (-1)^{a+b-1}\Delta_{j}\theta(a, b, j)^{-1}A^{a+b-j+(a^2+b^2-j^2)/2} \) with respect to base \( [(a, b)] \). Using this, an expression for any coloured Jones polynomial can be derived in terms of the \( \Delta_n \), the \( \theta(a, b, c) \), and the 6j symbols.

Finally, the evaluation \( \tau \) of the edges of a tetrahedron labelled with \( \{c, b, j\} \) around a face and \( \{a, d, i\} \) on the edges opposite is

\[
\Delta^{-1}\theta(i, b, c)\theta(i, a, d)\{a \ b \ c \ d \ i \} \{a \ b \ c \ i(d, a)\},
\]

When \( A^4n+1 = 1 \), the Turaev-Viro 3-manifold invariant is

\[
k^v\sum_k\left\{\prod\theta(st)!\right\},
\]

where \( k = (A^2 - A^{-2})^2/(-2n - 2). \) Here \( e, f, \) and \( t \) are the edges, faces, and tetrahedra of a triangulation with \( v \) vertices, and \( s \) runs through edge-labellings compatible around any face, with face sums at most \( 2n - 2. \) A tetrahedron with labelling dual to \( s \) on \( t \) (three labels at a vertex now encircle a face) is denoted \( st. \)

Further Reading

Weill Cornell Medical College in Qatar

**MATHEMATICS**

**Faculty Position**

In a pioneering international initiative, the Weill Cornell Medical College (WCMC) established the Weill Cornell Medical College in Qatar (WCMC-Q) with the sponsorship of the Qatar Foundation for Education, Science and Community Development. WCMC-Q is located in Doha, Qatar, and in its seventh year of operation, its inaugural class having graduated with Cornell MD degrees in May 2008.

WCMC-Q seeks candidates for a full-time senior level faculty position to teach in Doha in the Pre-medical Program, with major responsibility for teaching mathematics to premedical students. The two-year Pre-medical Program is designed to prepare students for admission to the WCMC-Q Medical Program. Intensive and challenging, this two-year program has been specifically prepared for students in the Middle East. It provides them with instruction in subjects that comprise the pre-medical requirements of most medical colleges in the US.

The successful candidate will teach one course per semester at the level of college calculus and introductory statistics. In addition, he/she will participate in student academic advising, committee work, and the academic life of WCMC-Q. Research funding support is available and active participation in relevant research will be encouraged.

Qualifications include a Ph.D. in Mathematics, demonstrable teaching skills, and teaching experience at the college/university level. Candidates are expected to have experience in the American higher education system and must be willing to relocate to Doha, Qatar for the duration of the appointment. Academic rank and salary are commensurate with training and experience and are accompanied by an attractive foreign-service benefits package. Qualified applicants should submit a curriculum vitae and a letter of interest outlining their teaching and research experience to:

[http://job.qatar-med.cornell.edu](http://job.qatar-med.cornell.edu)*

*Please select the appropriate position under the Academic options and indicate job # 08-wcmcq-MT

Cornell University is an equal opportunity, affirmative action educator and employer. Details regarding the WCMC-Q program and facilities can be accessed at [www.qatar-med.cornell.edu](http://www.qatar-med.cornell.edu)

The screening of applications will begin immediately and continue until suitable candidates are identified. Please note that due to the high volume of applications, only short-listed candidates will be contacted. Service is expected to begin in August 2009.

Short-listed candidates will be asked to provide names of three references.
Tribute to André Lichnerowicz (1915–1998)

Yvette Kosmann-Schwarzbach

Thirty years ago: *Annals of Physics, 111*. Deformation quantization was born. This sequence of two articles [BBFLS 1978] had been preceded by several papers written by Daniel Sternheimer, who has just addressed you,1 by Moshé Flato whose memory Daniel has just recalled and whose personality and work in mathematics and physics were so remarkable, and by André Lichnerowicz.

Who was Lichnerowicz? To his students, he was “Lichné”. To his friends, he was “André”. As a mathematician, mathematical physicist, reformer of the French educational system and its mathematical curriculum, and as a philosopher, he was known to the public as “Lichnerowicz”, a man of vast culture, an affable person, a great scientist.

There are many ways to approach André Lichnerowicz. One would be to read all his more than three hundred sixty articles and books that have been reviewed in *Mathematical Reviews* (MathSciNet), another would be to read only his personal choices among them, those that were published by the Éditions Hermann in 1982 as a 633-page book, *Choix d’œuvres mathématiques* [L 1982]. You can read the summaries of his work up to 1986 that were published by Yvonne Choquet-Bruhat, Marcel Berger, and Charles-Michel Marle in the proceedings of a conference held in his honor on the occasion of his seventieth birthday [PQG 1988], or his portrait and an interview that appeared in a handsome, illustrated volume describing the careers of twenty-eight of the most important French scientists of the twentieth century, *Homes de Science* [HdeS 1990]. Finally, and sadly, scientific obituaries appeared in the *Gazette des Mathématiciens* [Gazette 1999], and they were quickly translated for the *Notices of the AMS* [Notices 1999] because Lichnerowicz was as famous outside France as he was within it. Other obituaries appeared in the *Journal of Geometry and Physics*, of which he had been one of the founders, and in many other journals.

Lichnerowicz had an exceptional career. He was a student from 1933 to 1936 at the École Normale Supérieure in Paris where he studied under Élie Cartan, who had a lasting influence on his mathematics. He completed his thesis, written under the direction of Georges Darmois, in 1939, and was named professor of mechanics at the University of Strasbourg in 1941. Because of the war, the faculty of the University of Strasbourg had already moved to Clermont-Ferrand in order to avoid functioning under the German occupation. However in 1943, the Germans occupied Clermont-Ferrand as well, and there was a wave of arrests in which Lichnerowicz was taken, but he was fortunate enough, or daring enough, to escape. In those days, he did what he could to help those who were in mortal danger, in particular Jewish colleagues.2 After the Liberation, the University of Strasbourg returned to Strasbourg. In 1949 he was named professor at the University of Paris, and then in 1952 he was

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1 This tribute was delivered at the conference “Poisson 2008, Poisson Geometry in Mathematics and Physics” at the École Polytechnique Fédérale, Lausanne, in July 2008. It was preceded by tributes to Stanisław Zakrzewski, founder of the series of international conferences on Poisson geometry, who died in April 1998 (by Alan Weinstein), to Paulette Libermann on the first anniversary of her death (by Charles-Michel Marle), and to Moshé Flato, co-author and friend of Lichnerowicz, who died in November 1998 (by Daniel Sternheimer). This tribute was followed by the award of the “André Lichnerowicz Prize in Poisson Geometry” to two prominent young mathematicians. The October 2008 issue of the Gazette des Mathématiciens, in addition to carrying a French version of the present article, has an announcement of the prize; an announcement also appeared in the November 2008 Notices, page 1285.

2 In his autobiography [S 1997, p. 200], Laurent Schwartz wrote that one day Lichnerowicz contrived to be in a police station and, while an officer was inattentive, he managed to borrow a stamp and apply it to a false identity card which he, himself, did not need, but which could save the life of a colleague or a student. To survive the war years in France with some honor was itself a great achievement.
harmonic spinors \([L\ 1963]\), in which he proved that, for any spinor field, \(\psi\),

\[
\Delta \psi = -\nabla^\rho \nabla_\rho \psi + \frac{1}{4} R \psi ,
\]

where \(\Delta = P^2\) is the Laplacian on spinors, the square of the Dirac operator \(P\), \(\nabla\) is the covariant derivative, and \(R\) is the scalar curvature. And he continued working on spinors to his last days.

At the beginning of the 1970s Lichnerowicz’s interest turned to the geometric theory of dynamical systems. Symplectic geometry had been studied for some time.\(^4\) In January 1973 a conference, “Geometria simplicetta e fisica matematica”, was held in Rome that was, I believe, the first international meeting on this topic. As a young researcher I attended the congress, and heard and met many of the founders of symplectic geometry among whom were Jean Leray, Irving Segal, Bertram Kostant, Shlomo Sternberg, Włodzimierz Tulczyjew, Jean-Marie Souriau as well as the young Alan Weinstein and Jerry Marsden. And Lichnerowicz was one of the organizers of the meeting and delivered the opening lecture.

The main reason that we pay tribute to Lichnerowicz’s memory here, today, at this conference on Poisson geometry, is that he founded it. This was a few years before the publication of the deformation quantification paper I recalled at the beginning of this tribute.


\(^3\)A chair in mathematics was established by François I at the founding of the Collège in 1531!
before!" [CMF 2000] Starting in 1974, working with Moshé Flato and Daniel Sternheimer, Lichnerowicz formulated the definition of a Poisson manifold in terms of a bivector, i.e., the contravariant 2-tensor advocated by Lie, Carathéodory, and Tulczyjew, which is the counterpart of the 2-form of symplectic geometry. In his article published in Topics in Differential Geometry [L 1976] he defined the canonical manifolds, and one can already find in that paper a formula for the bracket of 1-forms associated to a Poisson bracket of functions, although still only for exact forms,

\[ [df, dg] = df \wedge g. \]

(Later he showed that the canonical manifolds are those Poisson manifolds whose symplectic foliation is everywhere of co-dimension one.) In his 1977 article in the Journal of Differential Geometry, "Les variétés de Poisson et leurs algèbres de Lie associées" [L 1977], Lichnerowicz introduced the cohomology operator that is now called the "Poisson cohomology operator" but really should be called the "Lichnerowicz-Poisson cohomology operator", a profound discovery. We read there as well as in [BBFLS, 1978] that, in the particular case of a symplectic manifold,

\[ \mu((G, A)) = d\mu(A), \]

where \( A \) is a field of multivectors. (The notations are \( G \) for the Poisson bivector and \( \mu \) for the prolongation to multivectors of the isomorphism from the tangent bundle to the cotangent bundle defined by the symplectic form, the bracket is the Schouten-Nijenhuis bracket, and \( d \) is the de Rham differential.) This formula, which we rewrite in a more familiar notation,

\[ \omega^\sharp([\pi, A]) = d(\omega^\sharp(A)) \quad \text{or} \quad \pi^\sharp(d\omega) = d_n(\pi^\sharp\omega) \]

(here \( G \) is replaced by \( \pi \), and \( \mu \) by \( \omega^\sharp \), with inverse \( \pi^\sharp \), while \( \alpha \) is a differential form and \( d_n \) is the Lichnerowicz-Poisson differential, \( d_n = [\pi, \cdot] \), acting on multivectors) is the precursor of the chain map property of the Poisson map, mapping the de Rham complex to the Lichnerowicz-Poisson complex, and, more generally, this article is the point of departure for the great development of Poisson geometry that we have witnessed and in which we are participating here. Together with his earlier articles written jointly with Flato and Sternheimer [FLS 1974, 1975, 1976] and with the article in the Annals of Physics [BBFLS 1978], solving quantization problems by a deformation of the commutative multiplication of the classical observables when given a Poisson structure, this article established the foundation of what has become a vast field of mathematical research.

It was a privilege for Lichnerowicz's many doctoral students, of whom I was one in the late 1960s, to be received by him in his small office under the roof of the Collège de France, or in the study of his apartment on the Avenue Paul Appell, on the southern edge of Paris. Surrounded by collections of journals and piles of papers, Lichné, with his pipe, would offer encouragement and invaluable hints as to how to make progress on a difficult research problem. I knew then, we all knew, that we were talking to a great mathematician. But I did not even guess that I was talking to the creator of a theory which would develop into a field in its own right, one with ramifications in a very large number of areas of mathematics and physics.

References


• Yvonne Choquet-Bruhat, L’œuvre de André Lichnerowicz en relativité générale, pp. 1–10.

• Marcel Berger, L’œuvre d’André Lichnerowicz en géométrie riemannienne, pp. 11–24.

• Charles-Michel Marle, L’œuvre d’André Lichnerowicz en géométrie symplectique, pp. 25–42.


Notices: As AMS president, you have attended many meetings and talked to many mathematicians. What kinds of issues or challenges did you hear about in these conversations?

Glimm: Of course, the math community is quite diverse, and the challenges are reflected by the diversity of the community. There are concerns about getting bright students into majors, because many of them are placing out of calculus courses, which is a traditional way of recruiting students. They take calculus in high school instead. There is a set of pedagogical issues of that type. In terms of research, I think there is the usual concern about the poor level of funding in mathematics. I actually would turn the question around a little bit and argue that there is a lot of vitality in the math community. I think there are many positive things going on.

Notices: Can you give some examples?

Glimm: Intellectually, the triumph with the Poincaré conjecture is certainly something that we are all delighted about. The continued progress in the connections between geometry and string theory always seems to be very surprising. The continued blossoming of new applications requiring new types of mathematics is always very heartening. Sometimes the math community thinks they’ve missed the boat. People say, “That already happened twenty years ago and now it’s too late.” But there are always new opportunities and new chances.

Notices: One of these new areas of opportunity was the subject of a special session you organized at the 2008 Joint Mathematics Meetings called “Mathematics of Knowledge and Information”, and you will organize another special session on this topic at the January 2009 meetings. Can you describe what this field is about and why it is important?

Glimm: Certainly for several centuries, mathematics, in its applications, has been dominated by following in the footsteps of physics: taking equations from the physical sciences, figuring out what could be said about the solution spaces, finding numerical methods for evaluating solutions, making estimates and approximations, taking asymptotic limits. There are all sorts of ways that a mathematician can extract information related to a set of equations. Going forward, that process is maturing, and some of the more innovative developments are in the past. If you look into the future, there will be a big emphasis on doing the same thing, where the input is not the laws of physics but observed data. Just as there was an explosion of computer knowledge that allowed the solution of equations in physics, there is an explosion of sensor data that allows meaningful analysis of experimental facts independently of any laws of physics. Sometimes there isn’t even the prospect of an intermediate law of physics, for example, if you are doing pattern recognition of photographs in a newspaper or something like that. Sometimes people run conservation laws to sharpen up boundaries in images, but basically the problem is not directly connected to physical equations in any obvious way. The modeling is pretty much independent of the equations.

Notices: So this area offers new ways for mathematicians to contribute?

Glimm: Absolutely. If you think that we have had several centuries squeezing juice out of the equations of physics, we might have some number
of centuries with data. I think it’s a big issue. It’s a century-long issue.

**Notices: Are scientists clamoring for mathematicians’ help with this?**

**Glimm:** Yes, in part, and partly they just do it without us. But that is no reason for us to stand back and not join in. If we do stand back, we will find that other people will step forward, and we will once again find our subject diminished by having lost a very vital component. It was for this reason that I thought this was a strategic choice to emphasize this particular application. It has nothing to do with my own research, so I have no personal interest in it. I just believe that it has a huge role in the future of mathematics.

**Notices:** *Can you give examples of work in this area?*

**Glimm:** The topics in the special session were very diverse. One talk was about trying to understand the traffic patterns in the Internet. Financial mathematics wasn’t included in the session but might well have been, and that is another example. People use this method for analyzing genome data, medical data, and protein expression data. The biomedical world is part of this explosion of data. For instance, even in structural biology, when you are trying to predict a protein, there are two basic approaches. One is based on solving the classical equations of physics for the interaction of atoms that lead to the formation of molecules. But you can just as well do it by pattern recognition, where you look at different bonds between the proteins and how they attach. They attach first of all on a linear chain, and then they have to fold up in certain characteristic patterns. There is a wealth of data about the geometry of proteins whose structure has been solved. It’s like a library of solutions. You look through this library and pick a solution that is very similar to your current problem or little piece of a current problem, and you figure out that a certain bond is likely to fold in a certain way. That’s basically pattern recognition. There are many cases in biomedical research where there are laws of physics that apply, but it is more efficient and effective to solve problems on the level of pattern recognition. The same happens in weather forecasting. Global weather forecasts are achieved by solving differential equations numerically. For local weather forecasting, usually they see what the global forecast says is coming in and then look up the local history and find an event that most closely matches the regional part of the global forecast. They look up weather for those days and get a range of what could happen as the forecast. So it’s basically pattern recognition.

**Notices:** *So this really goes across all areas of science?*

**Glimm:** Absolutely, all of science, but also areas that were not previously considered to be science. For instance, there are ways of recognizing handwriting, or of automatically translating between languages, that are based on computer models that solve Markov processes. There is something called a hidden Markov model that drives the statistics of language recognition and of speech recognition.

One of the themes that I have been pushing, especially for AMS meetings, is what I call the “big tent” philosophy of mathematics. This has several aspects. One is that lively areas that happen to be somewhat at the fringe of whatever people think the center is, should not be competing against things in the center. They both have their own validity. Neither should compete against the other, but each one should compete against some absolute standard of what we want in our meetings. In the big tent philosophy, the way the tent gets big is by emphasizing the edges. It has to be done by enlarging the space, so that includes enlarging the meetings. I have been continually urging the AMS to enlarge its meetings. Now, that can’t be done instantly because there are long-term contracts and meetings are planned out years in advance. It’s a little bit like trying to steer a battleship. But you can always change the direction, achieve incremental progress, and move towards something that will reach these goals over some period of years. In the Washington meeting I think the “big tent” spirit has been reflected in the program.

**Notices:** *You also have been interested in undergraduate education during your time as president. Can you tell me about this?*

**Glimm:** We have a particular project that I think is probably going to be promising, to look into computer grading of homework. Now, the practices for grading of homework are all over the map. Sometimes homework is graded assiduously, sometimes it is not graded at all, sometimes it is graded by an undergraduate who didn’t take much care, sometimes it is graded but returned two weeks later. On the average, there is a lot of room for improvement.

Computer-graded homework captures the students’ attention. Apparently the students get excited about homework and spend more time on it because they get instant feedback. It’s somewhat like a computer game. So they just sit there and do it until they have mastered it, and of course that’s the way to learn. The problems are generated with random input, which discourages copying. The experience is that, with computer-graded homework, we probably have the same number of Ds and Fs that we always had, but some of the Cs have moved up to Bs and some of the Bs have moved up to As. The overall effect is roughly a grade point average in the scoring. That’s what the rumor circuit says, and we are proposing to have a more careful evaluation and to discover the “lessons learned”. We will find out what people have to say when they have used computer grading—whether they kept it, whether they didn’t keep it, and why. Also, we will
find out practical things, like what is needed for infrastructure, for computer resources or human resources, to run it. We will make this information available to the math community. If you are a freshman taking precalculus or calculus, what is the chance you would be in such a course? I would guess it would be in the single digits of percentages. But I think it is ready to jump, to 20 percent, then 40 percent, maybe 60 percent. At that point it would be freestanding, and people would do what they judge worthwhile with it.

**Notices:** What would be the AMS role in this?

**Glimm:** The AMS has a very important role to play in issues relating to education of undergraduates. Obviously, MAA will be in the lead for many aspects of these issues, but the AMS retains an important role. The faculty at research universities are responsible for the education of a very significant number of freshman and sophomores. Many of these faculty look primarily to the AMS for leadership. Generally, the faculty who teach effectively enjoy their teaching greatly, and so the rewards of good teaching are rather obvious. We want to promote ways to help bring this about, and, particularly for faculty at research universities, we want to do this without compromising the quality of their research. The computer grading of homework seems to be the type of low-hanging fruit that is ideally suited to this situation.

We have applied for a grant from the National Science Foundation—to the Division of Undergraduate Education, so the grant would not compete with research grants in the Division of Mathematical Sciences. We proposed that the AMS do the kind of study I just indicated. So that is one role. I have been pushing this through my office as president in any forum where I have a chance to make such statements. I think I have raised consciousness about these issues. Some of the products belong to MAA [Mathematical Association of America], and some belong to commercial publishers. I don’t think there is any need for a new product, and there is no reason for the AMS to have its own product competing with others. I think if we just encourage our members to use one of these products, they can take their pick. So the real role is to facilitate a climate whereby people will evaluate computer homework-grading systems and presumably come to use them. If the systems work as promised, then there will be an uptick in the quality of education and the satisfaction of students.

**Notices:** Many people are using clickers in mathematics classrooms. We will have an article on this topic in the Notices [the article appears in this issue].

**Glimm:** There is a certain amount of ferment about these different technology tools. I’m not trying to advocate any particular one of them. I just think that we can make some progress by adopting some of these tools. While the tools are in an evaluation stage, different people will decide to do different things. Eventually the community will more or less make a collective decision and cluster around some set of technologies that are beneficial.

**Notices:** Is there anything else you wanted to mention?

**Glimm:** One thing I would like to note, with pleasure, is the fact that there are private donors for mathematics. I don’t recall this at other points in my professional lifetime. We have a new privately funded institute at Stony Brook [the Simons Center for Geometry and Physics; see Notices, June/July 2008, page 685–686]. There is the American Institute of Mathematics in Palo Alto, which is also privately funded. There have been private donations to the Mathematical Sciences Research Institute in Berkeley. Another example is the Clay Mathematics Institute. We have been more successful with private donors than at any time I can recall in my professional lifetime.

**Notices:** Why do you think that is?

**Glimm:** Well, I don’t have an answer to that. Maybe some mathematicians have gone into the private sector and become wealthy. I don’t have a complete list of these things, but it seems to me to be a huge explosion compared to what used to be the case.

**Notices:** What did you enjoy most about being president?

**Glimm:** I’ve watched the math community over many years wring its hands over the “spilled milk” decisions of the past. There is no way to recover the past, but these decisions are being made all the time. Boundaries between subjects look very obvious when you are at the center of the subject looking out into the distance, where there is some boundary seemingly off at infinity. But when you go out to the boundary, these areas are very lively. We can take actions to promote mathematics and not repeat actions that will make people complain twenty years from now about decisions made at the present time.

The Society seems to me to be a particularly well-run organization. I don’t want to say it runs on auto-pilot, but there is a structure for how things are done, and the structure seems to suit people and leads naturally to decisions that are constructive. I had a few more committee meetings than I would normally have volunteered for, but that goes with the game. You can’t do this kind of thing without being immersed in the committees.
Dear Professor Nescio,

I got my Ph.D. as a good graduate student at a respectable university. Yet I find 80–90% of the articles and reviews in the Bulletin that the AMS sends me to be simply incomprehensible; within a page or two, sometimes already from the first sentence on, it might as well be Slovenian. I don’t know what those words mean. Am I an idiot? Do other people have the same trouble? What can or should I do to increase my comprehension?

—Sincerely
R. H.

Dear R. H.,

If I am doing the mathematics correctly, this means you understand 10–20% of the items in the Bulletin. Congratulations! You are better educated than Professor Nescio.

I try to read many abstracts from areas close to my research interests and often even that proves daunting. The plain fact is that mathematics is highly specialized. That’s something you probably already knew, but what you are finding out is that it is even more specialized than you had previously thought. Be assured this lack of comprehension is not your fault. It is not the “fault” of mathematics either. It is just a fact of life. We can lament the specialization of mathematics and wish that things were different, but that is nonsense. The specialization is just part of the nature of the subject and a requirement for its development.

The late Paul Halmos advised colloquium speakers to make the first 15 minutes of their talks accessible to the entire audience. Do you know how difficult that is? Surely if you have attended many colloquia (and as someone who tries to read Bulletin articles, I am assuming you wish to be widely informed of mathematics and are therefore a faithful attendee at your department’s colloquia), you have seen how miserably most speakers fail to do this. Many, for whatever reason, do not try; but even those who heed this sage advice often fail because the task is so challenging.

With time you will probably discover that you comprehend more, provided the term “comprehend” is suitably understood. If you seek complete mastery, forget it; things will never get better. If you seek, however, to place the subject matter in some context, to get a general idea what is happening in the given specialty, to see where some area is headed, then you will get some satisfaction. Trying to increase the breadth of your view of mathematics is a worthy undertaking. It is also fun. So many of my colleagues narrow their view so that it barely escapes their immediate research. Professor Nescio frequently bemoans this lack of peripheral vision. So I salute your desire and wish you well.

—Respectfully,
Professor Nescio

Dear Professor Nescio,

I have published a joint paper with another author, and the reviewer of Math Reviews wrote in her review in MathSciNet that we had to mention her book in the paper. Since her book has no connection at all with our paper (and with the field in which our paper belongs), there is no other explanation than that she wrote her review in that way just to increase her citation index in MathSciNet or to sell her book or both. As soon as I saw that review in MathSciNet I wrote to her and to Math Reviews as well but the problem has not been solved yet. That review should not remain in MathSciNet as it is. Could you please help me to solve that problem? Thanking you for your time,

—Sincerely yours,
Professor N. K.

Dear Professor N. K.,

This is a rather irritating situation. I am afraid, however, that Professor Nescio’s powers are quite limited. I certainly have no influence over MathSciNet. I do have some appreciation of the fact that the MR editors have no desire or inclination to act
as a referee in such matters as deciding whether you or the reviewer has the most legitimate case. For one thing they have only enough staff to do their normal work. (And perhaps you will not object if I say at this juncture that MathSciNet is one of the greatest applications of computers and human intelligence to help us in our work.) To enter into a dispute like this would consume enormous amounts of their time since, as I am sure you can appreciate, they cannot merely accept your word that the reference is irrelevant.

Professor Nesio's interest in human nature is as great as his interest in mathematics, but unlike in mathematics he often sees things that are so disheartening. Why someone, presumably an established mathematician who is asked to write reviews, would want such a small aggrandizement and be willing to pay the coinage of public intellectual dishonesty is perplexing. Could it be that some egos are so great that they actually believe such statements? Perhaps such a question is exactly what is so fascinating about the study of people.

Unfortunately the incident that personally affects you is not the first such example that Professor Nesio has heard about. You might take a bit of satisfaction that the aficionados in your area will recognize the irrelevance of her comment and reach the same critical judgment that you did.

—Respectfully,
Professor Nesio

Dear Professor Nesio,

I've been asking several mathematicians and other non-math academic friends what their perception is of the concept of "postdoc".

What is the purpose of a postdoc? Why would a recent Ph.D. (or soon-to-be-graduating Ph.D.) want to take a postdoc? Does completing a postdoc improve one's chances for a "better job"? What's the role of the host institution—are they providing some sort of benefit to the postdoc that a person taking a tenure-track position would not normally get? How does a postdoc position differ from a "Visiting Assistant Professor" position? Thanks.

—Confused about academic paths for mathematicians

Dear Confused,

I love this question. It will give Professor Nesio a chance to discuss a topic that he frequently and usually enjoys but that also occasionally reveals abuse of language, young mathematicians, and the profession.

Here is what I think a postdoc means (or should mean) and is associated with the term by most professional mathematicians: a temporary position for new or almost new Ph.D.'s that lasts two or three years and carries a reduced teaching load of two or three courses per academic year. The idea is that the postdoc has a chance to work with more senior faculty on research and ripen their talents. The benefit for the host is that there is a constant infusion of "young blood" into the intellectual life of the department.

The time spent in graduate school is not sufficient to fully launch a robust research career. The intellectual growth of a postdoc can be enormous. After two or more years under the supervision of a thesis adviser, it helps to be exposed to a new viewpoint and a different current to propel you into that vast open sea of mathematical research. This is also a good reason for attending conferences and speaking about your research, but there is more intensity in the postdoctoral experience and it lasts for a longer time. With a reduced teaching load and, presumably, less service activity on committees, there is ample time to pursue research and benefit from this intensity. This type of benefit also accrues to the more senior host; we all benefit from discussion and input about our ideas.

I think you can see that if this is what happens, what the position is called is of little importance. Whether you are called an instructor, lecturer, or assistant professor has no relevance. Below I'll talk a bit more about the title when I discuss abuse.

If you have a successful postdoc experience, this will help you obtain a position at a research department. In fact, few such departments hire tenure-track faculty straight from graduate school. If you are on a search committee and examine a batch of applications for an assistant professorship, when you place the folder of a fresh Ph.D. next to that of someone in the third year of a postdoc, the difference is enormous. The postdoc has more achievements, and there are fewer questions about their personal contribution to their research. The letters of recommendation are usually stronger, with heavier discussions about accomplishment rather than promise. If your ambition is to teach at a four-year institution, however, taking a postdoc has less merit. It can still benefit you but I suspect in most cases it will not make you a more attractive candidate.

You said you consulted academics outside mathematics. Be aware that postdoc positions in the physical and biological sciences have been around longer than in mathematics and there are far more of them. There are some enormous differences: In these sciences, postdocs last much longer and there are usually no teaching duties. The experimental sciences depend on postdocs and graduate students to staff laboratories.

Now for the abuse, which can take many forms but usually occurs when the institution wants cheap, temporary teaching power or when the "postdoc" lasts only a year. Some institutions at least have the decency to give these positions a different name such as Visiting Assistant Professor or Teaching Postdoc. In my opinion this is not a good way for a young person to launch a career.
I have seen such positions with a teaching load of three courses per semester. What sort of extra training and education you are supposed to get from teaching a lot of courses escapes me. Where is the valued-added? If the appointment is for only a year, you will begin applying for another position almost as soon as you enter the campus. If a postdoc is never allowed to teach an advanced course, that’s abuse. If he/she teaches a large class with no grading or GTA assistance, that’s abuse. The purpose of a postdoc is not to make life easier for faculty at the host department. (Professor Nescio must approach this topic gingerly; he is getting very upset.) Accept such a job only if you must. When you leave such a position after a few years, you are no longer a new Ph.D. and for the extra time you will have little to add to your CV. You may look less attractive to employers.

What is the role of the host institution? Let’s first ask what it should be, which is to help you launch your career. This means providing you with some travel money, allowing you to teach some advanced courses, ideally including a seminar in your area, and mentoring you into the next phase of your career. Should you ever interview for such a position, ask about the teaching. Can you teach a seminar? (There is nothing like teaching a graduate seminar to give you perspective and discover research problems.) Will you have a paper grader for the elementary courses, especially the larger classes? Will they give you the option of doing more teaching one semester for less the next?

What should you do while a postdoc? Of course you should pour yourself into your research. Go to conferences, talk about your research whenever you can, make as many contacts as possible. Take your teaching seriously. Professor Nescio would be most disappointed to hear that a postdoc did otherwise as this would abuse the students, abuse the profession, and reflect badly on you when you enter the job market. You might also search for a tenure-track job in a highly selective way. From the start, keep your eye open for very attractive positions and apply for them. Discuss this with your host before doing it (and I am not talking about sending out a hundred applications or even a dozen). But if a very appealing position becomes available, you should try for it. It is unlikely to be available when your postdoc ends; and you can enter the search without the pressure of having to find a job but actually looking for an opportunity.

Several things were unclear from your letter, for example whether you are a student, whether you are personally trying to decide whether to apply for a postdoc, etc. I hope that whatever the case, Professor Nescio has provided some information you will find useful. Whatever your status, he wishes you the best of good fortune.

—Respectfully,
Professor Nescio
A Clicker Approach to Teaching Calculus

Martina Bode, Denise Drane, Yifat Ben-David Kolikant, and Mary Schuller

Clickers (electronic voting systems) are all the buzz in higher education these days as many universities and colleges invest significant sums of money to integrate these systems into their classrooms. But what are clickers? Are they just another high-tech gimmick, or can they really be used to improve learning? Can clickers be used efficiently in calculus classes?

In an ideal world, students would take calculus for the sheer love of it. The reality is, however, that calculus is a service course, and most students take it to fulfill university requirements. Engaging students in calculus classes thus can be a challenge. Furthermore, in traditional lectures, students passively take notes, at times barely processing the material as they struggle to keep their attention focused for an hour. Students often fear that they are alone in not understanding the material and are at times afraid of asking questions in class. At the end of class, both students and instructor may leave without knowing whether the material has been understood.

Clickers can be used to address these challenges. The term "clickers" refers to the student input devices (see Figure 1) of electronic voting systems. These systems allow for two-way communication (generally radio frequency) between an instructor and a group of students. In classrooms with clickers, instructors can pose questions during class, usually on a PowerPoint slide, and the students respond anonymously using the keypad on their clickers. Responses to the question can then be displayed on a screen so both students and the instructor can see the percentage of the class that chose each response. Questions can range from multiple-choice, true/false, matching items, and ranking items, to numerical and short text answers. Clickers can be used in a variety of ways, from checking conceptual understanding, testing skills, provoking discussion, all the way to teaching and motivating new material. The benefits are manyfold:

1. Instructors receive instant feedback on the students’ comprehension and misconceptions.
2. Students receive instant feedback regarding their understanding and how they compare to the rest of the class.
3. Students are more focused and are actively engaged in learning during class time.

To encourage peer-to-peer interactions, a clicker can be assigned to a group of students who must discuss their answer before responding to the question. In our experience, the small group setting provides a more intimate and non-threatening environment for students to admit difficulties with
A batter hits the ball and runs towards first base.

Example 5. A multi-step problem

A baseball diamond is a square with sides of 90 ft. A batter hits the ball and runs towards first base with a speed of 18 ft/s. At what rate is the distance from second base decreasing when he is halfway to first base?

Although this is a great standard calculus textbook problem ([1]) to ask on a quiz or test, this problem might be too complex to ask in the middle of class using clickers. However, a problem of this type can be divided into several parts as follows.

(i) Students are asked to draw a picture modeling the situation. With their clickers students indicate:
   (a) done drawing the picture
   (b) more time needed

Students click when they have completed the task, and in their groups, select a student to put the picture on the classroom board.

(ii) The next PowerPoint slide includes a picture modeling the situation where \( x \) is the distance from the runner to first base, and \( z \) the distance from the runner to second base. Then students are asked what quantity this question is asking to find:
   (a) \( x'(t) \), (b) \( z'(t) \), (c) None of the above, (d) I don’t know

(iii) The last part of this problem can then be posed as a multiple choice question to evaluate \( z'(t) \), or, with more advanced clickers, students can enter the correct quantity for \( z'(t) \).

All textbooks have great questions that can be modified to use with clickers. Some books, in addition, contain conceptual questions specifically designed to use with clickers, for example ConcepTests ([2], [3], [4]).

What do students think about clickers, and what is the evidence for better learning in classrooms with clickers? The following tables present survey data from 348 students in six different calculus classes taught by the same instructor at Northwestern University, 2005–2008.

### Conceptual Understanding

<table>
<thead>
<tr>
<th>Question</th>
<th>Response</th>
<th>Percent</th>
</tr>
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<tbody>
<tr>
<td>[Q1] I am more aware of my misunderstandings/difficulties than in traditional classes.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>[Q2] Using the clickers helps me to understand the concepts behind problems.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>[Q3] The questions asked during clicker sessions help me to understand what is expected from me in this class.</td>
<td></td>
<td></td>
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</tbody>
</table>
Learning

[Q4] Using clickers helps the teacher to become more aware of student difficulties with the subject matter.

[Q5] I have to think more in classes with clickers than in traditional lecture classes.

[Q6] Hearing other students explain problems in their own words when working in our small groups helps me to learn.

[Q7] I remember less after a class with clickers than after other classes.

Interaction and Discussion

[Q8] I got to know fewer students than I usually do in a traditional class.

[Q9] I think that anonymous participation is a good idea.

[Q10] I am more actively involved during classes with clickers than during traditional classes.

[Q11] Discussing clicker questions with other students in the class helps me to understand better the subject matter.

[Q12] Team members were actively involved in solving the questions.

Enjoyment

[Q13] Collaborative work among group members contributed to a better quality solution to the problems.

[Q14] Using the clickers helps me enjoy this class more than I enjoy traditional lecture classes.

[Q15] Seeing the class responses to a concept question (histogram) helps increase my confidence.

[Q16] The clicker approach should be used for other subjects.

[Q17] I am more likely to attend class because of using the clicker system.
In the surveys at Northwestern, and several other published studies ([5],[6],[7]), students believed that the use of clickers made them more aware of their misunderstandings and helped them to understand what is expected in class. They also felt that they were more involved in classes using clickers than traditional classes. Moreover, discussion with other students helped students to understand and learn the material. Finally, they reported that clickers made class more enjoyable. Another advantage from the instructor’s perspective is that students are more eager to participate in “follow up” class-wide discussions after engaging in peer-to-peer discussions.

Several studies have found increased interest, motivation, and retention in classes that use clickers ([7],[8]). Harvard physicist Eric Mazur compared learning gains in his classes with and without clickers. In clicker-classes, students discussed their answers with their neighbors before and after responding to clicker questions. Mazur found that physics students within the clicker setting made larger gains on standardized physics tests than the control group without clickers [9]. A recent study by Lasry [10] found students who used flashcards to respond made gains equal to those made by students using clickers. This suggests that it is not the technology itself that is responsible for gains in learning but the pedagogy of engaging students during class, requiring them to engage in peer-to-peer discussion before responding with the clicker, and giving them immediate feedback.

The use of clickers is not without its limitations. Mid-range clickers generally cost between US$20–US$60 per unit. As with all technology, trouble shooting problems can be frustrating and time-consuming. For instructors, additional class planning time is needed for preparing the questions and technology. Some instructors feel that the class time spent on clicker questions reduces the amount of time available to cover additional content. In our experience, the depth of student engagement with the content compensates for the reduced time to cover a wider breadth of material. Despite the drawbacks, we feel the advantages of using the technology outweigh the disadvantages. Although clickers may not make students fall in love with calculus, they may help them to be more engaged in calculus classes, which in turn may enhance learning.

References

Polly Phipps, James W. Maxwell, and Colleen Rose

The preliminary report of the 2008 Annual Survey gives a broad picture of 2007–08 new doctoral recipients from U.S. departments in the mathematical sciences, including their employment status in fall 2008. This report is based on information collected from a questionnaire distributed to departments in April 2008. A follow-up questionnaire was distributed to the individual new doctoral recipients in October 2008. This questionnaire will be used to update and revise results in this report, which are based on information from the departments that produced the new doctorates. Those results will be published in the Second Report of the 2008 Annual Survey in the August 2009 issue of the Notices of the AMS. The Faculty Salary Survey report, traditionally published as part of this report, will appear in the March issue of Notices of the AMS.

Another questionnaire concerned with data on fall 2008 course enrollments, graduate students, and departmental faculty was distributed to departments in September 2008. Results from this questionnaire will appear in the Third Report of the 2008 Annual Survey in the November 2009 issue of the Notices of the AMS.

The Annual Survey series begun in 1957 by the American Mathematical Society is currently under the direction of the Data Committee, a joint committee of the American Mathematical Society, the American Statistical Association, the Institute of Mathematical Statistics, the Mathematical Association of America, and the Society of Industrial and Applied Mathematics. The current members of this committee are Richard Cleary, Richard M. Dudley, John W. Hagood, Abbe H. Herzig, Ellen Kirkman, David J. Lutzer, Joanna Mitro, James W. Maxwell (ex officio), Bart Ng, Polly Phipps (chair), Douglas Ravanel, Jianguo (Tony) Sun, and Marie Vitulli. The committee is assisted by AMS survey analyst Colleen A. Rose. Comments or suggestions regarding this Survey Report may be directed to the committee.

Table 1: Number of Departments Responding to Doctorates Granted Survey

<table>
<thead>
<tr>
<th>Group</th>
<th>Number Responding</th>
<th>2007–2008 New Doctorates</th>
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<tbody>
<tr>
<td>I (Pu)</td>
<td>20 of 25 including 0 with no degrees</td>
<td></td>
</tr>
<tr>
<td>I (Pr)</td>
<td>22 of 23 including 0 with no degrees</td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>52 of 56 including 2 with no degrees</td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>61 of 75 including 11 with no degrees</td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td>60 of 89 including 4 with no degrees</td>
<td></td>
</tr>
<tr>
<td>Va</td>
<td>19 of 21 including 1 with no degrees</td>
<td></td>
</tr>
</tbody>
</table>

See “Definitions of the Groups” on page 267.


This report presents a statistical profile of recipients of doctoral degrees awarded by departments in the mathematical sciences at universities in the United States during the period July 1, 2007, through June 30, 2008. All information in the report was provided over the summer and early fall of 2008 by the departments that awarded the degrees. The report includes a preliminary analysis of the fall 2008 employment plans of 2007–2008 doctoral recipients and a demographic profile summarizing characteristics of citizenship status, sex, and racial/ethnic group. This preliminary report will be updated in the Second Report of the 2008 Annual Survey to reflect subsequent reports of additional 2007-2008 doctoral recipients from the departments that did not respond in time for this report. No adjustments have been made to the numbers in this report for these departments. The Second Report, to appear in the August 2009 issue of Notices, will also reflect additional information.
provided by the new doctoral recipients themselves, including their starting salaries.

Table 1 provides the number of departments responding to the 2008 Survey of New Doctoral Recipients in time for this report. This year’s response rates were above 80% for all groups except Group IV and increased over last year in all groups except Group I (Pu). Overall, nineteen more departments responded in time for the First Report this year than responded in time for last year’s First Report. Efforts continue to obtain data from as many of the non-responding departments as possible.

Table 2: New Doctoral Degrees Awarded by Group, Preliminary Count

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<tr>
<th>Group</th>
<th>I (Pu)</th>
<th>I (Pr)</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>Va</th>
<th>TOTAL</th>
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<tr>
<td>1998–99</td>
<td>292</td>
<td>152</td>
<td>241</td>
<td>136</td>
<td>243</td>
<td>69</td>
<td>1133</td>
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<td>1999–00</td>
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<td>223</td>
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<td>284</td>
<td>67</td>
<td>1119</td>
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<td>2000–01</td>
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<td>129</td>
<td>203</td>
<td>125</td>
<td>237</td>
<td>81</td>
<td>1008</td>
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<td>2001–02</td>
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<td>164</td>
<td>124</td>
<td>222</td>
<td>81</td>
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<td>170</td>
<td>121</td>
<td>239</td>
<td>91</td>
<td>1017</td>
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<tr>
<td>2003–04</td>
<td>195</td>
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<td>1041</td>
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<tr>
<td>2004–05</td>
<td>243</td>
<td>146</td>
<td>203</td>
<td>153</td>
<td>285</td>
<td>86</td>
<td>1116</td>
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<tr>
<td>2005–06</td>
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<td>216</td>
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<tr>
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<td>119</td>
<td>234</td>
<td>138</td>
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<td>87</td>
<td>1157</td>
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<tr>
<td>2007–08</td>
<td>234</td>
<td>172</td>
<td>290</td>
<td>142</td>
<td>291</td>
<td>106</td>
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Highlights

There were 1,235 new doctoral recipients reported for 2007–08 by departments responding in time for the 2008 First Report. The number of departments responding in time for this year’s report increased by 18 and in every group except Group I (Pu). There were 540 U.S. citizens reported among this year’s new doctoral recipients, 44% of the total. Last year’s figure was 43%.

Based on responses from departments alone, the fall 2008 unemployment rate for the 1,083 new doctoral recipients whose employment status is known is 5.4%, up from 4% for fall 2007.

Sixty-nine new doctoral recipients hold positions at the institution that granted their degree, although not necessarily in the same department. This is 7% of the new doctoral recipients who are currently known to have jobs and 11% of those who have academic positions in the U.S. Eighteen new doctoral recipients have part-time positions.

The number of new doctoral recipients employed in the U.S. is 886, up 22 from last year. The number of new doctoral recipients employed in academic positions in the U.S. remains relatively stable at 650, it was 651 last year.

Of the 886 new doctoral recipients taking positions in the U.S., 207 (23%) have jobs in business and industry, increasing for the fifth consecutive year. The fall 2008 number is up 11% from fall 2007, and is up 108 (109%) from fall 2004. The number of new doctoral recipients taking jobs in government is up 3 (11%) over fall 2007.

Among the 886 new doctoral recipients having employment in the U.S., 426 (48%) are U.S. citizens (up from 405 (47%) last year). The number of non-U.S. citizens having employment in the U.S. is 460; last year it was 459.

Among the 307 new doctoral recipients hired by U.S. doctoral-granting departments, 49% are U.S. citizens (up from 48% last year). Among the 342 having other academic positions in the U.S., 57% are U.S. citizens (up from 53% last year).

Of the 1,235 new doctoral recipients, 31% (388) are female, the same percentage reported in fall 2007. Of the 540 U.S. citizen new doctoral recipients, 31% (166) are females, up from 29% in fall 2007.

Among the 540 U.S. citizen new doctoral recipients, 4 are American Indian or Alaska Native, 23 are Asian, 22 are Black or African American, 19 are Hispanic or Latino, 5 are Native Hawaiian or Other Pacific Islander, 461 are White, and 6 are of unknown race/ethnicity.

Group IV produced 291 new doctorates, of which 151 (52%) are females, compared to all other groups combined, where 237 (25%) are females. In Group IV, 89 (31%) of the new doctoral recipients are U.S. citizens (while in the other groups 48% are U.S. citizens).

Twenty-seven percent of the new doctorates had a dissertation in statistics/biostatistics (334). The next highest percentage was in algebra and number theory with 16% (195).

The Faculty Salary Survey report, traditionally published as part of this report, will appear in the March issue of Notices.
Doctoral Degrees Granted in 2007–08

Table 2 shows the number of new doctoral degrees granted by the different doctoral groups surveyed in the Annual Survey for the past ten years. The preliminary count of 1,235 new doctorates granted by these departments in 2007–08 is an increase of 78 from the preliminary count for 2006–07.

From Table 2 we see that all groups except Group I (Pu) reported an increase in the number of doctoral recipients from the previous year. The decrease reported for Group I (Pu) is almost certainly the result of the four departments in Group I (Pu) that responded in time for last year’s report but not this year’s report. These departments have awarded an average of 55 doctoral recipients each year over the past four years. The final count for 2007–08 is likely to be very close to the final count for 2006–07 of 1,333.

The 2007–08 numbers in Table 2 will be broken down in various ways, such as by sex, in later sections of this report. The names of the 1,235 new doctoral recipients are found on pages 276–96 of this issue of the Notices.

By way of background to this report on new doctoral recipients, Table 3 gives historical information about various types of full-time graduate students in Groups I, II, III, and Va combined. These data are reprinted from Table 6B of the Third Report of the 2007 Annual Survey (Notices, November 2007).

Employment Plans of 2007–08 New Doctoral Recipients

Tables 4A, 4B, and 4C each provide a different cross-tabulation of the 1,235 new doctoral recipients in the mathematical sciences. These tables contain a wealth of information about these new doctoral recipients, some of which will be discussed in this report. Note that these tables give a breakdown by sex for type of employer, type of degree-granting department, and field of thesis. Keep in mind that the results in this report come from the departments giving the degrees and not from the degree recipients themselves. These tables will be updated using information from the doctoral recipients themselves in the 2008 Second Report in the August 2009 issue of Notices.

The last column (Total) in Table 4A can be used to find the overall unemployment rate. In this and other unemployment calculations in this report, the individuals whose employment status is not known (Unknown (U.S.) and Unknown (non-U.S.)) are first removed, and the unemployment fraction is the number still seeking employment divided by the total number of individuals left after the “Unknowns” are removed. The preliminary unemployment rate for these data is 5.4%. This preliminary rate will be updated later with information gathered.

Table 3: Full-Time Graduate Students in Groups I, II, III, & Va by Sex and Citizenship, Fall 1998 to Fall 2007
(Data Reprinted from Table 6B in Third Report, 2007 Annual Survey)

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<td>54%</td>
<td>55%</td>
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</tr>
<tr>
<td>% Underrepresented minorities</td>
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<td>9%</td>
<td>9%</td>
<td>9%</td>
<td>9%</td>
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<td>32%</td>
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<tr>
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<td>53%</td>
<td>54%</td>
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<td>56%</td>
<td>60%</td>
<td>59%</td>
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<td>% Underrepresented minorities</td>
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<td>10%</td>
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<td>10%</td>
<td>10%</td>
<td>10%</td>
</tr>
</tbody>
</table>

1 Underrepresented minorities includes any person having origins within the categories American Indian or Alaska Native, Black or African American, Hispanic or Latino, and Native Hawaiian or Other Pacific Islander.

2 Numbers in this column reflect corrections of those previously reported. For further information visit our website at [http://www.ams.org/employment/surveyreports.html](http://www.ams.org/employment/surveyreports.html).
### Table 4A: Employment Status of 2007–08 New Doctoral Recipients in the Mathematical Sciences by Field of Thesis

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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Group I (Public)</td>
<td>Algebra/ Number Theory</td>
<td>27</td>
<td>6</td>
<td>13</td>
<td>3</td>
<td>5</td>
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<td>6</td>
<td>5</td>
<td>3</td>
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<td>6</td>
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<th>Field of Thesis</th>
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<th>Research Institute/ Other Nonprofit</th>
<th>Government</th>
<th>Business and Industry</th>
<th>Non-U.S. Academic</th>
<th>Non-U.S. Nonacademic</th>
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<th>Still Seeking Employment</th>
<th>Unknown (U.S.)</th>
<th>Unknown (non-U.S.)*</th>
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<td>Algebra/ Number Theory</td>
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<td>3</td>
<td>6</td>
<td>1</td>
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<td>1</td>
<td>4</td>
<td>3</td>
<td>54</td>
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<td>3</td>
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*Includes those whose status is reported as “unknown” or “still seeking employment”.

### Table 4B: Employment Status of 2007–08 New Doctoral Recipients in the Mathematical Sciences by Type of Degree-Granting Department

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<tr>
<th>TYPE OF DOCTORAL DEGREE-GRANTING DEPARTMENT</th>
<th>GROUP I (PUBLIC)</th>
<th>GROUP I (PRIVATE)</th>
<th>GROUP II</th>
<th>GROUP III</th>
<th>GROUP IV</th>
<th>GROUP VA</th>
<th>TOTAL</th>
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</thead>
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<td>Funct. &amp; Harmonic Analysis</td>
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<td>83</td>
<td>46</td>
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<td>388</td>
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</table>

*Includes those whose status is reported as “unknown” or “still seeking employment”.
from the individual new doctoral recipients. The additional information from prior years is reflected in the final unemployment rates displayed in Figure 2. The preliminary rate for fall 2007 was 4.0%. The unemployment rates, calculated by type of doctoral degree-granting department using Table 4B, vary from group to group, with a high of 9.8% for Group I (Pu) and a low of 1.1% for Group IV.

There are 886 new doctoral recipients employed in the U.S. Table 5A gives a breakdown of type of employer by type of degree-granting department for these 886 new doctoral recipients. Of these, 649 (73%) hold academic positions, 30 (3%) are employed by government, and 207 (23%) hold positions in business and industry. In the First Report for 2006–07, there were 864 new doctoral recipients employed in the U.S., of which 650 (75%) held academic positions, and 236 (27%) held positions in business and industry. The number of new doctoral recipients employed in the U.S. increased in all categories except Group I–Va which decreased 4%. "Business and Industry" and "Government" showed the largest increase at 11%.

Table 5B shows the number of new doctoral recipients who took positions in business and industry in the U.S. by type of degree-granting department, Fall 2004 to Fall 2008. The number of new doctoral recipients entering the business and industry sector more than doubled, from 99 to 207, an increase of 108. In addition, the fall 2008 number is up 11% from fall 2007.

Among the 886 new doctoral recipients known to have employment in the U.S. in fall 2008, Group I (Pu) has the smallest percentage taking jobs in business and industry at 16% and Group IV the highest at 37%.

Table 5C shows the number of new doctoral recipients who took academic positions in the U.S. by type of department granting their degree for fall 2004 to fall 2008. The total number of new doctoral recipients taking academic employment in fall 2008 is relatively unchanged from fall 2007. Among the 886 new doctoral recipients employed in the U.S. in fall 2008, 73% have academic positions. This
percentage is highest for Group II at 83% and lowest for Groups IV at 56%.

Table 5D shows the number of positions filled with new doctoral recipients for each type of academic employer. Increases in positions filled by new doctoral recipients were realized only by Groups IV and Other. The biggest increase in hires of new doctorates into academic positions was in Group Other (13%). Hires of new doctorates into positions at research institutes remained relatively unchanged from 30 in fall 2007 to 29 in fall 2008.

In fall 2008, 69 new doctoral recipients held positions in the institution that granted their degree, although not necessarily in the same department. This represents 7% of new doctoral recipients who are currently employed in the U.S. and 11% of the U.S. academic positions held by new doctoral recipients. In fall 2007 there were 78 such individuals making up 8% of the new doctoral recipients who were employed at the time of the First Report. Eighteen new doctoral recipients have taken part-time positions in fall 2008 compared with 22 in fall 2007.

**Information about 2007–08 Female New Doctoral Recipients**

Tables 4A and 4B give male and female breakdowns of the new doctoral recipients in 2007–08 by Field of Thesis, by Type of Degree-Granting Department, and by Type of Employer.

Overall, 388 (31%) of the 1,235 new doctoral recipients in 2007–08 are female. In 2006–07, 365 (32%) of the new doctoral recipients were female. This percentage varies over the different groups, and these percentages are given in the first row of Table 5E. This year the percentage of females produced is highest again for Group IV at 52%,
The second row of Table 5E gives the percentage of the new doctoral recipients hired who are female for each of the Groups I, II, III, IV, and Va. In addition, 28% of the new doctoral recipients hired in Group M, master’s departments, are female; 40% of the new doctoral recipients hired in Group B, bachelor’s departments, are female, up from 37% last year. This year, Group IV hired the highest percentage of women with 50%, while Groups I, II, III ranged from 19 to 30%, and Group Va hired no women.

The unemployment rate for female new doctoral recipients is 4%, compared to 6% for males and 5.4% overall.

The percentage of female new doctoral recipients within fields of thesis ranged from 10% in probability, to 50% in mathematics education and 51% in statistics.

Later sections in this First Report give more information about the female new doctoral recipients by citizenship and the female new doctoral recipients in Group IV.

### Employment Information about 2007–08 New Doctoral Recipients

**New Doctoral Recipients by Citizenship and Type of Employer**

Table 5F shows the pattern of employment within employer categories broken down by citizenship status of the new doctoral recipients.

The unemployment rate for the 540 U.S. citizens is 5.3% compared to 5.1% in fall 2007. The unemployment rate for non-U.S. citizens is 5.4%. This varies by type of visa. The unemployment rate for non-U.S. citizens with a permanent visa is 5.2%, while that for non-U.S. citizens with a temporary visa is 5.6%. Among U.S. citizens whose employment status is known, 87% are employed in the U.S. Among non-U.S. citizens with a permanent visa whose employment status is known, 90% have jobs in the U.S. (last year this percentage was 95%), while the similar percentage for non-U.S. citizens with a temporary visa is 76% (last year the percentage was 77%). The number of non-U.S. citizens having employment in the U.S. is 460, relatively unchanged from last year (459).

Table 5G is a cross-tabulation of the 886 new doctoral recipients who have employment in the U.S. by citizenship and broad employment categories, using numbers from Table 5F. Of the 886 new doctoral recipients having jobs in the U.S., 48% are U.S. citizens (up from 47% last year). Of the 307 new doctoral recipients who took jobs in U.S. doctoral-granting departments, 49% are U.S. citizens (up from 48% last year). Of the 342 who took other academic positions, 57% are U.S. citizens (up from 53% last year). Of the 237 who took nonacademic positions, 35% are U.S. citizens. Of the 426 U.S. citizens employed in the U.S., 35% have jobs in a doctoral-granting department, 46% are in other academic positions, and 19% are in nonacademic positions. For the 460 non-U.S. citizens employed in the U.S., the analogous percentages are 34%, 32%, and 34% respectively.

### Sex, Race/Ethnicity, and Citizenship Status of 2007–08 New Doctoral Recipients

Table 6 presents a breakdown of new doctoral recipients according to sex, racial/ethnic group, and citizenship status. The information reported in this table was obtained in summary form from the departments granting the degrees.

There were 540 (44%) U.S. citizens among the 1,235 new doctoral recipients in 2007–08. Among U.S. citizens, 4 are American Indian or Alaska Native (2 male and 2 female), 23 are Asian (11 males and 12 females), 22 are Black or African American (11 males and 11 female), 19 are Hispanic or Latino (males), 5 are Native Hawaiian or Other Pacific Islander (males), 461 are White (324 males and 137 females), and 6 are of unknown race/ethnicity (2...
males and 4 females). Among non-U.S. citizens, there are 1 American Indian or Alaska Native, 432 Asians, 27 Blacks or African Americans, 31 Hispanics or Latinos, 1 Native Hawaiian or Other Pacific Islander, 193 Whites, and 10 are of unknown race/ethnicity.

Table 7 (and Figure 3) gives the number of new U.S. doctoral recipients and the number of U.S. citizens back to 1997–98. The 540 U.S. citizen new doctoral recipients is up by 46 (8%) from 2000–01. The percentage of U.S. citizen new doctoral recipients has increased this year to 44% from 43% in fall 2007.

Females make up 31% of the 540 U.S. citizens receiving doctoral degrees in the mathematical sciences in 2007–08. Last year this percentage was 29%. Among the 695 non-U.S. citizen new doctoral recipients, 32% (222) are female, down from last year's 33%.

Table 8 (and Figure 4) gives the historical record of U.S. citizen new doctoral recipients, broken down by male and female for past years, going back to 1997–98. The number of female U.S. citizen new doctoral recipients is up 15 (10%) from 151 in 2000–01 and down 11% from an all-time high of 187 in 1998–99. Figure 4 also displays the percentage of females among U.S. citizen (full-time) graduate students beginning in fall 1988.
Table 9: Sex and Citizenship of 2007–08 New Doctoral Recipients by Type of Degree–Granting Department

<table>
<thead>
<tr>
<th>CITIZENSHIP</th>
<th>I (Pu)</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>Va</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
<td>Male</td>
<td>Female</td>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td>U.S.</td>
<td>79</td>
<td>26</td>
<td>105</td>
<td>43</td>
<td>39</td>
<td>25</td>
</tr>
<tr>
<td>Non-U.S.</td>
<td>105</td>
<td>24</td>
<td>102</td>
<td>40</td>
<td>57</td>
<td>21</td>
</tr>
<tr>
<td>TOTAL</td>
<td>184</td>
<td>50</td>
<td>143</td>
<td>29</td>
<td>96</td>
<td>46</td>
</tr>
</tbody>
</table>

Table 9 gives a sex and citizenship breakdown of the new doctorates within each of the six groups of doctoral-granting departments. Among all 1,235 new doctoral recipients, 44% of the males and 43% of the females are U.S. citizens.

2007–08 New Doctoral Recipients with Dissertations in Statistics/Biostatistics and Probability

Group IV contains U.S. departments (or programs) of statistics, biostatistics, and biometrics reporting a doctoral program. In the Annual Survey Reports, Group IV is referred to as the Statistics Group. In addition, other groups in the Annual Survey produce new doctoral recipients with dissertations in statistics/biostatistics or probability. The other groups produced 101 new doctoral recipients with dissertations in statistics/biostatistics or probability in 2007–08 and have averaged 84.4 per year over the ten-year period reported in Table 10. Information about these 101 new doctoral recipients and the 281 new doctoral recipients in Group IV is found in this section of the report.

Table 10 contains information about new doctoral recipients in Group IV as well as those with dissertations in statistics/biostatistics and probability in other groups for this year as well as for the past nine years. In addition, the last two rows of Table 10 give a split of the 2007–08 results between the 57 statistics departments and the 32 biostatistics and biometrics departments in Group IV. This year 382 new doctorates had a dissertation in statistics/biostatistics (334) or probability (48), a slight increase from last year’s number. Those with dissertations in statistics/biostatistics and probability accounted for 31% of new doctorates in 2007–08. Quite a bit of the variation in numbers from year to year in Table 10 is due to the changes made in the departments in Group IV over the ten years and to the relatively low response rate for this group. At the time of the Second Report last year, 70 of 88 (80%) of Group IV departments had responded.

Group IV has 89 departments for 2007–08, 14 more than the next largest doctoral group. It contains 31% of all doctoral departments surveyed, and the 60 Group IV departments responding to the Annual Survey reported 291 new doctoral recipients, 24% of all new doctoral recipients in 2007–08. The number of new doctoral recipients in Group IV is up 12 from the number reported at this time last year, while the number of departments responding is up 10 from the number responding by this time last year.

Because of its size, the data from Group IV have a large effect on the results when all doctoral groups are combined. Furthermore, Group IV results are often quite different from those for Groups I (Pu), I (Pr), II, III, and Va. Group IV results can

Table 10: New Doctoral Recipients with Dissertations in Statistics/Biostatistics and Probability

<table>
<thead>
<tr>
<th>Year</th>
<th>Group IV Depts Surveyed</th>
<th>Group IV Depts Responding (percent)</th>
<th>New Doctoral Recipients in Group IV only</th>
<th>New Doctoral Recipients in Statistics/Biostatistics and Probability, Group IV and Other* Groups</th>
<th>New Doctoral Recipients Hired by Group IV</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td>Female (percent)</td>
<td>Jobs in Bus &amp; Ind</td>
<td>Percentage Unemployed</td>
</tr>
<tr>
<td>1998–99</td>
<td>91</td>
<td>72 (79%)</td>
<td>243</td>
<td>87 (36%)</td>
<td>57</td>
</tr>
<tr>
<td>1999–00</td>
<td>89</td>
<td>75 (84%)</td>
<td>284</td>
<td>110 (39%)</td>
<td>79</td>
</tr>
<tr>
<td>2000–01</td>
<td>86</td>
<td>70 (81%)</td>
<td>237</td>
<td>98 (41%)</td>
<td>59</td>
</tr>
<tr>
<td>2001–02</td>
<td>86</td>
<td>72 (84%)</td>
<td>222</td>
<td>92 (41%)</td>
<td>56</td>
</tr>
<tr>
<td>2002–03</td>
<td>86</td>
<td>74 (86%)</td>
<td>239</td>
<td>98 (41%)</td>
<td>45</td>
</tr>
<tr>
<td>2003–04</td>
<td>87</td>
<td>65 (75%)</td>
<td>243</td>
<td>97 (40%)</td>
<td>50</td>
</tr>
<tr>
<td>2004–05</td>
<td>87</td>
<td>63 (72%)</td>
<td>285</td>
<td>126 (44%)</td>
<td>64</td>
</tr>
<tr>
<td>2005–06</td>
<td>88</td>
<td>60 (68%)</td>
<td>287</td>
<td>134 (47%)</td>
<td>80</td>
</tr>
<tr>
<td>2006–07</td>
<td>86</td>
<td>50 (58%)</td>
<td>279</td>
<td>127 (46%)</td>
<td>88</td>
</tr>
<tr>
<td>2007–08</td>
<td>89</td>
<td>59 (66%)</td>
<td>291</td>
<td>151 (52%)</td>
<td>87</td>
</tr>
<tr>
<td>Statistics</td>
<td>57</td>
<td>43 (75%)</td>
<td>215</td>
<td>100 (47%)</td>
<td>68</td>
</tr>
<tr>
<td>Biostatistics</td>
<td>32</td>
<td>16 (50%)</td>
<td>76</td>
<td>51 (67%)</td>
<td>18</td>
</tr>
</tbody>
</table>

* Includes other academic departments and research institutes/other nonprofits.
** Of 281, there were 277 in statistics/biostatistics and 4 in probability. For complete details, see Table 4C.
*** Of 101, there were 57 in statistics/biostatistics and 44 in probability. For complete details, see Table 4C.
mask important changes in the other doctoral groups. In the following paragraphs some of these differences are presented. The trends noted below have also been observed in past reports.

Group IV is producing a larger percentage of female doctorates than the other doctoral groups. Table 9 shows that for the Group IV new doctoral recipients, 151 of 291 (52%) are female, while 237 of 944 (25%) are female in the other doctoral groups. Among U.S. citizens, females accounted for 50 of the 89 (56%) Group IV new doctoral recipients, while for the other groups 116 of 451 (26%) were female. Overall, 166 of 540 (31%) U.S. citizen new doctoral recipients were female.

Group IV is producing a smaller percentage of U.S. citizen new doctorates than the other doctoral groups. In Group IV, 89 of 291 (31%) new doctoral recipients are U.S. citizens, while in other groups 451 of 944 (48%) are U.S. citizens. In Group IV, 101 (69%) of the 151 females were not U.S. citizens.

Group IV doctorates are more likely to take jobs in business and industry than those in other doctoral groups. Of the 236 new doctoral recipients from Group IV who found employment in the U.S., 87 (37%) took jobs in business or industry. From the other groups, 650 new doctoral recipients found employment in the U.S., of which 120 (18%) took jobs in business or industry.

Group IV doctorates have a lower unemployment rate than the other doctoral groups. The employment status for 261 Group IV new doctoral recipients is known, and 3 (1.1%) are unemployed. For the other groups, the employment status of 822 is known, and 55 (6.7%) are unemployed. Group IV is hiring a bigger percentage of females than the other doctoral groups. Twenty-one of 42 (50%) new doctoral recipients hired by Group IV departments were female, up from last year’s 38% and the first-time female hires has equaled male hires. The other doctoral groups reported that 59 of 265 (22%) new doctoral recipients hired were female, down from last year’s 30%.

Group IV had 281 new doctoral recipients with fields of thesis in statistics/biostatistics (277) and the other doctoral departments had 101 with fields of thesis in statistics/biostatistics (57) and probability (44) (last year the other doctoral departments had 60 new doctorates in statistics and 41 in probability). The distribution of these degrees among the various groups can be found in Table 4C. The number of new doctoral recipients with theses in statistics/biostatistics and probability (382) is substantially larger than any other field, with algebra and number theory next with 195.

Previous Annual Survey Reports
The 2007 First, Second, and Third Annual Survey Reports were published in the Notices of the AMS in the February, August, and November 2008 issues respectively. These reports and earlier reports, as well as a wealth of other information from these surveys, are available on the AMS website at [www.ams.org/employment/surveyreports.html](http://www.ams.org/employment/surveyreports.html)

Acknowledgments
The Annual Survey attempts to provide an accurate appraisal and analysis of various aspects of the academic mathematical sciences scene for the use and benefit of the community and for filling the information needs of the professional organizations. Every year, college and university departments in the United States are invited to respond. The Annual Survey relies heavily on the conscientious efforts of the dedicated staff members of these departments for the quality of its information. On behalf of the Annual Survey Data Committee and the Annual Survey Staff, we thank the many secretarial and administrative staff members in the mathematical sciences departments for their cooperation and assistance in responding to the survey questionnaires.

Other Data Sources


Definitions of the Groups

As has been the case for a number of years, much of the data in these reports is presented for departments divided into groups according to several characteristics, the principal one being the highest degree offered in the mathematical sciences. Doctoral-granting departments of mathematics are further subdivided according to their ranking of “scholarly quality of program faculty” as reported in the 1995 publication Research-Doctorate Programs in the United States: Continuity and Change.¹ These rankings update those reported in a previous study published in 1982.² Consequently, the departments which now compose Groups I, II, and III differ significantly from those used prior to the 1996 survey.

The subdivision of the Group I institutions into Group I Public and Group I Private was new for the 1996 survey. With the increase in number of the Group I departments from 39 to 48, the Annual Survey Data Committee judged that a further subdivision of public and private would provide more meaningful reporting of the data for these departments.

Brief descriptions of the groupings are as follows:

Group I is composed of 48 departments with scores in the 3.00–5.00 range. Group I Public and Group I Private are Group I departments at public institutions and private institutions respectively.

Group II is composed of 56 departments with scores in the 2.00–2.99 range.

Group III contains the remaining U.S. departments reporting a doctoral program, including a number of departments not included in the 1995 ranking of program faculty.

Group IV contains U.S. departments (or programs) of statistics, biostatistics, and biometrics reporting a doctoral program.

Group V contains U.S. departments (or programs) in applied mathematics/applied science, operations research, and management science which report a doctoral program.

Group Va is applied mathematics/applied science; Group Vb, which was no longer surveyed as of 1998–99, was operations research and management science.

Group M contains U.S. departments granting a master’s degree as the highest graduate degree.

Group B contains U.S. departments granting a baccalaureate degree only.

Listings of the actual departments which compose these groups are available on the AMS website at [www.ams.org/employment/groups_des.html].


²These findings were published in An Assessment of Research-Doctorate Programs in the United States: Mathematical and Physical Sciences, edited by Lyle V. Jones, Gardner Lindzey, and Porter E. Coggeshall, National Academy Press, Washington, DC, 1982. The information on mathematics, statistics, and computer science was presented in digest form in the April 1983 issue of the Notices of the AMS, pages 257–67, and an analysis of the classifications was given in the June 1983 Notices of the AMS, pages 392–3.
Mathematics People

Srinivas Receives TWAS Prize in Mathematics

VASUDEVAN SRINIVAS of the Tata Institute of Fundamental Research, Mumbai, has been named the winner of the 2008 TWAS Prize in Mathematics, awarded by the Academy of Sciences for the Developing World (TWAS). He was honored “for his basic contributions to algebraic geometry that have helped deepen our understanding of cycles, motives, and K-theory.” Srinivas will receive a cash prize of US$15,000 and will deliver a lecture at the academy’s twentieth general meeting, to be held in South Africa in September 2009.

—from a TWAS announcement

Pujals Awarded ICTP/IMU Ramanujan Prize

ENRIQUE R. PUJALS, associate researcher at the Instituto Nacional de Matemática Pura e Aplicada (IMPA), Brazil, has been awarded the 2008 Srinivasa Ramanujan Prize in recognition of “his outstanding contributions to dynamical systems, especially the characterization of robust dynamics for flows and transformations and the development of a theory of generic systems.”

The prize is awarded annually by the Abdus Salam International Centre for Theoretical Physics (ICTP), and the prizewinner is selected by ICTP through a committee of five eminent mathematicians appointed in conjunction with the International Mathematical Union (IMU). The prize recognizes a researcher from a developing country who is less than forty-five years of age on December 31 of the year of the award and who has conducted outstanding research in a developing country. Funding for the US$10,000 cash award is provided by the Niels Henrik Abel Memorial Fund through the participation of the International Mathematical Union.

—from an ICTP announcement

Strassen Awarded ACM Knuth Prize

VOLKER STRASSEN of the University of Konstanz has been awarded the 2008 Knuth Prize of the Association for Computing Machinery (ACM) Special Interest Group on Algorithms and Computation Theory (SIGACT). He was honored for his contributions to the theory and practice of algorithm design. The award carries a cash prize of US$5,000.

According to the prize citation, “Strassen’s innovations enabled fast and efficient computer algorithms, the sequence of instructions that tells a computer how to solve a particular problem. His discoveries resulted in some of the most important algorithms used today on millions if not billions of computers around the world and fundamentally altered the field of cryptography, which uses secret codes to protect data from theft or alteration.”

His algorithms include fast matrix multiplication, integer multiplication, and a test for the primality of integers. His discovery of provably fast algorithms to determine whether a number is prime or composite “profoundly changed the cryptography field.” Strassen has also proved fundamental theorems in statistics, including “Strassen’s law of the iterated logarithm” and the principle of strong invariance. He is considered the founding father of algebraic complexity theory with his work on the degree bound connecting complexity to algebraic geometry. He also introduced fundamental notions and results in bilinear complexity and tensor rank.

The Knuth Prize is given at one-and-a-half-year intervals by ACM SIGACT and the Institute of Electrical and Electronics Engineers (IEEE) Technical Committee on the Mathematical Foundations of Computer Science. It is presented in honor of Donald Knuth, professor emeritus at Stanford University, who has played a critical role in establishing and defining computer science as a rigorous intellectual discipline.

—from an ACM announcement
Principally based in a Japanese institution.

Under forty years of age either of Japanese nationality or to operator algebra theory and related areas to a person is awarded every four years for outstanding contributions to encourage young researchers in these fields. The prize initiatives and contributions from some senior Japanese researchers in operator algebra theory and related fields.

The Operator Algebra Prize was established in 1999 by initiatives and contributions from some senior Japanese researchers in operator algebra theory and related fields to encourage young researchers in these fields. The prize is awarded every four years for outstanding contributions to operator algebra theory and related areas to a person under forty years of age either of Japanese nationality or principally based in a Japanese institution.

Ozawa Receives Operator Algebra Prize

NARUTAKA OZAWA of the University of Tokyo has been awarded the third Operator Algebra Prize for his outstanding contributions to the structure theory of type II₁ von Neumann algebras related to the theory of discrete groups and thus to the advancement of operator algebra theory. The prize consists of a cash award of about US$3,000, a prize certificate, and a medal.

Ozawa has given a series of stunning results on the structure of operator algebras in connection with discrete groups. He first gave a characterization of exactness of discrete groups, which showed groups claimed by Gromov are not exact, thus solving a long-standing open problem. He has further introduced the notion of a solid von Neumann algebra, which means that the relative commutant of any diffuse subalgebra is injective, and has shown that various group von Neumann algebras are solid. This is a far-reaching generalization of a famous theorem of Gére of and other related results and has been used by many other people, who have combined this technique with Popa’s to get many very strong results on tensor product decompositions of factors and Cartan subalgebras in factors. Ozawa also has other well-known results on injective operator spaces, state spaces of C*-algebras, and nonexistence of a separable universal II₁ factor.

The Operator Algebra Prize was established in 1999 by initiatives and contributions from some senior Japanese researchers in operator algebra theory and related fields to encourage young researchers in these fields. The prize is awarded every four years for outstanding contributions to operator algebra theory and related areas to a person under forty years of age either of Japanese nationality or principally based in a Japanese institution.

—Fumio Hiai, Chair, Operator Algebra Prize Committee

Saaty Receives INFORMS Award

THOMAS L. SAATY of the University of Pittsburgh has been awarded the 2008 Impact Prize of the Institute for Operations Research and the Management Sciences (INFORMS). The prize consists of a plaque and a cash award of US$1,000.

Saaty was honored for his work in creating the analytic hierarchy process (AHP), a methodology for helping decision makers to make complex, multicriteria decisions. He developed the process based on his work at the U.S. State Department’s Arms Control and Disarmament Agency during the Kennedy and Johnson administrations. He recognized that then-current techniques for resolving complex decision problems were deficient in both mathematical rigor and relevance to real-world decision making. He developed key mathematical theories that paired comparisons with ratio-scale weights to prioritize decision criteria and alternatives. In AHP-based decisions, final weights allow alternatives to be compared and ranked.

The INFORMS Impact Prize, awarded once every two years, recognizes contributions that have had a broad practical impact on operations research and related fields, such as the decision sciences.

—From an INFORMS announcement

Vybiral Receives 2008 Information-Based Complexity Young Researcher Award

JAN VYBIRAL of the University of Jena, Germany, has been awarded the Information-Based Complexity Award for 2008. The award is given every year for significant contributions to information-based complexity by a young researcher who has not reached his or her thirty-fifth birthday by September 30 of the year of the award. The prize consists of US$1,000 and a plaque.

The award committee this year consisted of Jakob Creutzig, TU Darmstadt; Dirk Nuyens, Katholieke Universiteit, Leuven; Andreas Neuenkirch, University of Frankfurt; Friedrich Pillichshammer, University of Linz; Joseph F. Traub, Columbia University; and Henryk Woźniakowski, Columbia University and University of Warsaw.

—Joseph Traub, Columbia University

DMV Media Prizes

In November 2008 the Deutsche Mathematiker Vereinigung (DMV, German Mathematical Society) awarded its media prizes in the Leibniz Room of the Berlin-Brandenburg Academy.

The DMV Media Prize went to CHRISTOPH DRÖSSER, science journalist and editor for the weekly newspaper Die Zeit.

The DMV Journalist Prize was awarded to director and author AGNES HANDWERK for the radio feature “Geometrie und Revolte” about Alexander Grothendieck. Receiving the Cartoon Prize for the Year of Mathematics, celebrated in Germany in 2008, was the cartoonist known as “kittihawk” http://www.kittihawk.de.

—Allyn Jackson

NSF CAREER Awards Made

The Division of Mathematical Sciences (DMS) of the National Science Foundation (NSF) has honored twenty-three mathematicians in fiscal year 2008 with Faculty Early Career Development (CAREER) awards. The NSF established the awards to support promising scientists, mathematicians, and engineers who are committed to the integration of research and education. The grants provide funding...
of at least US$400,000 over a five-year period. The 2008 CAREER grant awardees in the mathematical sciences and the titles of their grant projects follow.

YURI BAKHTIN, Georgia Tech Research Corporation, Georgia Institute of Technology; Ergodicity and Random Media; SCOTT BALDRIDGE, Louisiana State University and Agricultural and Mechanical College: The Topology of Smooth and Symplectic 4-Manifolds; JOZSEF BALOG, University of Illinois, Urbana-Champaign: Methods and Outreach in Modern Combinatorics; ALINA COJOCARU, University of Illinois, Chicago: Analytic Problems in Arithmetic Geometry; LAURA DEMARCO, University of Illinois, Chicago: Algebraic Structures in Complex Dynamics; MATHIAS DRTON, University of Chicago, Statistical Inference in Algebraic Models with Singularities; SELIM ESEDOGLU, University of Michigan, Ann Arbor: Analysis and Modeling for Image Processing Problems; DAN GEBA, University of Rochester: Topics in Nonlinear Wave Equations; DAVID GlickensteiN, University of Arizona: Discrete and Generalized Riemannian Geometry and Curvature Flows; SHELLY HARVEY, Rice University: Algebraic Methods in Low-Dimensional Topology; DEMETRIO LABATE, North Carolina State University: Sparse Directional Multiscale Representations: Theory, Implementation, and Applications; MELVIN LEOK, Purdue University: Computational Geometric Mechanics: Foundations, Computation, and Applications; YUFENG LIU, University of North Carolina, Chapel Hill: Flexible Statistical Learning for Complex Data; PER-GUNNAR MARTINSSON, University of Colorado, Boulder: Fast Direct Solvers for Differential and Integral Equations; GOVIND MENON, Brown University: Scaling and Self-similarity in Nonlinear Science Education and Research; LUKE OLSON, University of Illinois, Urbana-Champaign: Multilevel Discontinuous Least-Squares Finite Element Methods; MARTIN OLSSON, University of California, Berkeley: Stacks, Moduli Spaces, and Log Geometry; JOHAN PAULSSON, Harvard University: Fluctuations and Fitness—Fundamental Limits and Selection Conflicts; FIRAS RASSOUL-AGHA, University of Utah: Random Walk in Random Environment; BENJAMIN SUDAKOV, University of California, Los Angeles: Methods and Challenges in Discrete Mathematics; MIN YANG, University of Missouri, Columbia: Optimal Design of Experiments for Generalized Randomized Models; WOTAO YIN, Rice University: Optimizations for Sparse Solutions and Applications; JI ZHU, University of Michigan, Ann Arbor: Statistical Learning from Data with Graph/Network Structures.

—Elaine Kehoe

Royal Society of London Elections

The Royal Society of London has elected forty-four new fellows and foreign associates for 2008. Among them are six whose work involves the mathematical sciences. They are: DAVID E. DEUTSCH of Oxford University for his work in quantum theory of computation, including the discovery of the first quantum algorithms and the theory of quantum logic gates and quantum computational networks; MARK Kisin of the University of Chicago for his contributions to algebraic number theory; MICHAEL C. PAYNE of the University of Cambridge for his work in computational physics; EVGENY K. SKLYANIN of the University of York for his contributions to the development of quantum inverse scattering techniques and his discoveries concerning the algebraic structure of integrable systems; ULRIKE L. TILLMANN of Oxford University for her leadership in the study of the moduli space of algebraic curves; and DAVID MUMFORD, emeritus professor at Brown University, who was elected as a foreign member for his fundamental contributions to algebraic geometry, notably his creation of geometric invariant theory and his work on moduli spaces.

—From a Royal Society announcement

Kenneth M. Hoffman (1930–2008)

Kenneth Myron Hoffman, professor emeritus of mathematics at the Massachusetts Institute of Technology, died on September 29, 2008, following a heart attack. He was seventy-seven. He was first appointed instructor at MIT in 1956 and C. L. E. Moore Instructor the following year. He joined the mathematics faculty as assistant professor in 1959 (professor in 1964) and retired in 1996 after forty years of service.

Hoffman’s primary area of research specialization was functional analysis. Along with Richard Arens and Isadore Singer, he made fundamental contributions to both complex and abstract analysis. Some of these appeared in a joint paper with Singer answering many of the questions on commutative Banach algebras raised by I. M. Gelfand.

Among his several books was an undergraduate linear algebra textbook, which he wrote jointly with Ray Kunze and which was published in 1961. The book was widely used for many decades and became a classic in the field.

As head of the MIT mathematics department, Hoffman oversaw crucial faculty appointments and developed the undergraduate faculty chair position. He crafted an affirmative action plan that was modeled elsewhere.

In 1980 Hoffman moved to Washington, D.C., where over the next ten years he worked to raise understanding of the central role of mathematics in science. Among other leadership positions, he served as executive director of the Committee on Resources for the Mathematical Sciences of the National Research Council (1981–84). The committee’s 1984 report, nicknamed the “David Report”, highlighted the imbalance between research support for the mathematical sciences and related disciplines in science and engineering. During the same period, Hoffman chaired the Committee on Science Policy of the AMS and in 1984–85 chaired the Advisory Committee for Science and Engineering Education at the National Science Foundation. From 1984 to 1989 he headed the Office of Governmental and Public Affairs of the Joint Policy Board for Mathematics, which successfully worked to implement the recommendations of the David Report.
For his extensive service and leadership, Hoffman was selected as the inaugural recipient of two national service awards in mathematics: the Public Service Award of the Joint Policy Board for Mathematics (1986) and the first AMS Award for Distinguished Public Service (1990). The citation for the latter award reads in part: “Through his efforts, the awareness of the importance of mathematics and the support of mathematical research has been significantly heightened in the general public, among makers of science policy in the government, and among university administrators.”

Born in Long Beach, California, Hoffman earned a bachelor’s degree in mathematics from Occidental College in 1952. He received an M.A. (1954) and Ph.D. (1956) in mathematics from the University of California, Los Angeles.

—From an MIT news release

Marcia P. Sward (1939–2008)

Marcia Peterson Sward died on September 21, 2008, from kidney cancer that was diagnosed just weeks before her death.

Sward served as the first associate executive director of the Mathematical Association of America (MAA) between 1980 and 1985. She returned to the MAA as executive director in 1989. Between her two periods at the MAA, she served as the executive director of the Mathematical Sciences Education Board (MSEB) at the National Research Council (NRC) of the National Academy of Sciences.

“You face all sorts of problems in a large association like the MAA, brought to you by all sorts of people,” said AMS executive director John Ewing. “Marcia was the consummate professional in dealing with both problems and people—always gracious and thoughtful. It was always a pleasure working alongside her when the AMS and MAA worked together.” Because the AMS Washington Office is right next door to the MAA, Washington Office director Samuel M. Rankin III got to know Sward well. “I remember Marcia as being very focused on improving mathematics education and being a dedicated leader of MAA,” he remarked.

Marcia Sward graduated summa cum laude and first in her class at Vassar College with a degree in mathematics. Under the direction of Edward Scott, she was awarded her Ph.D. in 1967 for her dissertation “The Mixed Boundary Value Problem along the Line of Parabolicity for a Certain Class of Hyperbolic Partial Differential Equations”.

After graduation she spent a year at Catholic University in Washington, D.C., before beginning her academic career at Trinity College, also in Washington, D.C. After a one-year visiting appointment at the National Highway Traffic Safety Administration, she accepted a newly created position as associate executive director of the MAA. The position included, among other tasks, directing publication of the organization’s three journals and creating a newsletter to serve members’ needs. In March 1981 she brought out the first issue of the FOCUS newsletter. She served as editor of FOCUS until September 1985, when she left the MAA.

She then became executive director of the MSEB, which was established by the NRC in response to the “David Report”, Renewing U.S. Mathematics: Critical Resource for the Future. She convened a stellar advisory board and raised sufficient funds to see the MSEB grow enormously in influence. The board’s seminal report, Everybody Counts: A Report to the Nation on the Future of Mathematics Education, remains to this day a key resource for K–12 mathematics education.

Sward returned to lead the MAA in 1989 on the occasion of the retirement of Alfred Willcox. Under her leadership, the MAA increased its membership, programs, and revenue. She was instrumental in initiating new programs, including the highly successful Project NExT and SUMMA (Supporting Undergraduate Minority Mathematics Achievement). She retired from the MAA in 1999 but continued her association with the MAA, regularly participating in the winter meetings, special events at the Carriage House, and MAA study tours.

—Based an article in MAA FOCUS by Linda P. Rosen

Correction

The January 2009 issue of the Notices carried an article about the retirement of AMS executive director John Ewing. Accompanying the article was a sidebar by Jonathan Borwein, the byline of which mistakenly gave Borwein’s affiliation as the University of British Columbia. He has been on the faculty of Dalhousie University since 2004; prior to that he was at Simon Fraser University in Vancouver. The Notices regrets the error.

—Allyn Jackson
Mathematics Opportunities

Mathematics Research Communities 2009

The American Mathematical Society (AMS) invites mature mathematicians just beginning their research careers to become part of Mathematics Research Communities, a new program to develop and sustain long-lasting cohorts for collaborative research projects in many areas of mathematics. Women and underrepresented minorities are especially encouraged to participate. The AMS will provide a structured program to engage and guide all participants as they start their careers. The program will include: a one-week summer conference for each topic, special sessions at the national meeting, discussion networks by research topic, ongoing mentoring, and a longitudinal study of early career mathematicians.

The summer conferences of the Mathematics Research Communities will be held in Snowbird Resort, Utah, where participants can enjoy the natural beauty and a collegial atmosphere. The application deadline for summer 2009 is March 2, 2009. This program is supported by a grant from the National Science Foundation. Advanced graduate students and postdoctoral researchers are welcome to apply to be participants.

The topics, dates, and organizers of the 2009 conferences follow.

Mathematical Challenges of Relativity, June 13–19, 2009, Mihalis Dafermos (University of Cambridge), Alexandru Ionescu (University of Wisconsin, Madison), Sergiu Klainerman (Princeton University, chair), and Richard Schoen (Stanford University).

Inverse Problems, June 20–26, 2009, Guillaume Bal (Columbia University), Allan Greenleaf (University of Rochester), Todd Quinto (Tufts University), and Gunther Uhlmann (University of Washington, chair).

Modern Markov Chains and Their Statistical Applications, June 27–July 3, 2009, Persi Diaconis (Stanford University, chair), Jim Hobert (University of Florida), and Susan Holmes (Stanford University).

Harmonic Analysis, June 27–July 3, 2009, Ciprian Demeter (Indiana University), Michael Lacey (Georgia Institute of Technology), and Christoph Thiele (University of California, Los Angeles, chair).

Situated in a breathtakingly beautiful mountain setting, Snowbird Resort provides an extraordinary environment for the MRC. The atmosphere is comparable to the collegial gatherings at Oberwolfach and other conferences that combine peaceful natural ambience with stimulating meetings.

MRC participants have access to a range of activities, such as a tram ride to the top of the mountain, guided hikes, swimming, mountain bike tours, rock climbing, plus heated outdoor pools. More than a dozen walking and hiking trails head deep into the surrounding mountains.

Participants can also enjoy the simpler pleasures of conviving on the patios at the resort to read, work, and socialize.

In the evenings colleagues enjoy informal gatherings to network and continue discussion of the day’s sessions over refreshments. Within a half hour of the University of Utah, Snowbird is easily accessible from the Salt Lake City International Airport. For more information about Snowbird Resort, see [http://www.snowbird.com](http://www.snowbird.com).

A report about the 2008 MRC conferences appears in this issue of the Notices. For information on applying for the 2009 program, please visit the website [http://www.ams.org/amsmtgs/mrc-09.html](http://www.ams.org/amsmtgs/mrc-09.html). For further information about the MRC program, please contact AMS associate executive director Ellen Maycock at ejm@ams.org.

—AMS announcement

NSF Program ADVANCE

The National Science Foundation (NSF) has instituted the ADVANCE Program in an effort to increase the representation and advancement of women in academic science and engineering careers.

In 2009 this program will support three types of projects. Partnerships for Adaptation, Implementation, and Dissemination (PAID) awards support analysis, adaptation, dissemination, and use of existing innovative materials and practices that have been demonstrated to be effective in increasing representation and participation of women in academic science and engineering careers. This category of award also supports scientific research designed to advance understanding of gender in academic science and engineering careers. The deadline for required letters of intent is January 20, 2009; the deadline for full proposals is February 24, 2009.

Institutional Transformation (IT) awards support academic institutional transformation to promote the increased participation and advancement of women scientists and engineers in academe. These awards support innovative and comprehensive programs for institution-wide change. The deadline for letters of intent for these awards is August 4, 2009; the full proposal deadline is November 12, 2009.

Institutional Transformation Catalyst (IT-Catalyst) awards are designed to support institutional self-assessment activities, such as basic data collection and analysis and policy review, in order to identify specific issues in the recruitment, retention, and promotion of women faculty in institutions of higher education. The deadline for letters of intent for these awards is August 4, 2009, and the full proposal deadline is November 12, 2009.

Proposals are sought from both men and women for creative strategies to realize the goals of the ADVANCE

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Program. Members of underrepresented minority groups and individuals with disabilities are especially encouraged to apply. Proposals that address the participation and advancement of women with disabilities and women from underrepresented minority groups are encouraged. For more information see [http://www.nsf.gov/pubs/2009/nsf09504/nsf09504.htm](http://www.nsf.gov/pubs/2009/nsf09504/nsf09504.htm).

—From an NSF announcement

NSF Partnerships for International Research and Education

The National Science Foundation (NSF) has instituted the Partnerships for International Research and Education (PIRE) program to support innovative international research and education collaborations. The program will enable U.S. scientists and engineers to establish collaborative relationships with international colleagues to advance knowledge and scientific discoveries and to promote the development of a diverse, globally engaged U.S. scientific and engineering workforce. The program aims to support partnerships that will strengthen the capacity of institutions, multi-institutional consortia, and networks to engage in and benefit from international research and education collaborations.

Proposals may involve one or more disciplines, U.S. institutions, foreign institutions, and countries. The deadline for preliminary proposals is February 26, 2009. Full proposals may be submitted by invitation only; the deadline for these is August 4, 2009. For complete information see [http://www.nsf.gov/pubs/2009/nsf09505/nsf09505.htm](http://www.nsf.gov/pubs/2009/nsf09505/nsf09505.htm).

—From an NSF announcement

Summer Program for Women Undergraduates

The 2009 Summer Program for Women in Mathematics (SPWM2009) will take place at George Washington University in Washington, D.C., from June 27 to August 1, 2009. This is a five-week intensive program for mathematically talented undergraduate women who are completing their junior years and may be contemplating graduate study in mathematical sciences. The goals of this program are to communicate an enthusiasm for mathematics, to develop research skills, to cultivate mathematical self-confidence and independence, and to promote success in graduate school.

Applicants must be U.S. citizens or permanent residents studying at a U.S. university or college who are completing their junior years or the equivalent and have mathematical experience beyond the typical first courses in calculus and linear algebra. Sixteen women will be selected. Each will receive a travel allowance, campus room and board, and a stipend of US$1,750. The deadline for applications is February 27, 2009. Early applications are encouraged. Applications are accepted only by mail. For further information, please contact the director, Murli M. Gupta, email: mmg@gwu.edu, telephone: 202-994-4857; or visit the program’s website at [http://www.gwu.edu/~spwm/](http://www.gwu.edu/~spwm/). Application material is available on the website.

—From an SPWM announcement

NSF Support for Undergraduate Training in Biological and Mathematical Sciences

The National Science Foundation (NSF) offers opportunities for support through its Undergraduate Biology and Mathematics (UBM) program. The goal of the program is to enhance undergraduate education and training at the intersection of the biological and mathematical sciences and to better prepare undergraduate biology or mathematics students to pursue graduate study and careers in fields that integrate the mathematical and biological sciences.

The program will provide support for jointly conducted long-term research experiences for interdisciplinary-balanced teams of at least two undergraduates from departments in the biological and the mathematical sciences. Projects should focus on research at the intersection of the mathematical and biological sciences and should provide students exposure to contemporary mathematics and biology addressed with modern research tools and methods. Projects must involve students from both areas in collaborative research experiences and include joint mentorship by faculty in both fields.

Between six and nine awards are expected to be made in 2009. The deadline for full proposals is February 12, 2009. For more information see [http://www.nsf.gov/pubs/2008/nsf08510/nsf08510.htm](http://www.nsf.gov/pubs/2008/nsf08510/nsf08510.htm). The UBM program is a joint effort of the Education and Human Resources (EHR), Biological Sciences (BIO), and Mathematical and Physical Sciences (MPS) directorates of the NSF.

—From an NSF announcement

Nominations for Information-Based Complexity Prize 2009

The annual Prize for Achievement in Information-Based Complexity consists of US$3000 and a plaque, and will be awarded at a suitable location. Nominations may be sent to Joseph Traub, traub@cs.columbia.edu. The deadline for nominations is March 31, 2009. The award can be based on work done in a single year, in a number of years, or over a lifetime.

—Joseph Traub, Columbia University

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Inside the AMS

From the AMS Public Awareness Office

• **Arnold Ross Lecture by David Kelly.** David Kelly (Hampshire College) gave his lecture *From Pascal’s Triangle to Sierpinski’s Triangle in Base 2* to over one hundred enthusiastic students at the Oregon Museum of Science and Industry (OMSI) in late October. Arnold Ross (1906–2002) started a mathematics enrichment program for high school teachers in 1947. He started his multi-level summer program for gifted high school students in 1957 and ran it every summer until 2000, giving the number theory lecture each morning. In keeping with this prestigious tradition, the AMS presents a lecture for talented high school mathematics students each year to stimulate their interest in mathematics beyond the traditional classroom and to show them the tremendous opportunities for careers in mathematics—as mathematics teachers and as researchers in government, industry, and university programs. The 2009 lecture will be held at the National Science Center in Augusta, Georgia. Read about the 2008 lecture and *Who Wants to Be a Mathematician* that immediately followed at [http://www.ams.org/wwtbam/archive/arl2008.html](http://www.ams.org/wwtbam/archive/arl2008.html).

• **Feature Column.** Recent columns include “From Bézier to Bernstein”, by Bill Casselman, “Inside-out Frieze Symmetries in Ancient Peruvian Weavings”, by Tony Phillips, “Gray Codes”, by Joe Malkevitch, and “Percolation: Slipping through the Cracks”, by David Austin, at [http://www.ams.org/featurecolumn/](http://www.ams.org/featurecolumn/)

• **Mathematicians in the media** over the past few months include Jason Brown (Dalhousie University) for work he did analyzing the opening chord of "A Hard Day's Night"; Donald Saari (University of California, Irvine) and John Allen Paulos (Temple University), explaining aspects of mathematics and voting; Oded Schramm, a member of the Theory Group at Microsoft Research, who died in a tragic hiking accident; Donald Clayton Spencer, who had a mountain peak in Colorado named after him; and Manil Suri (University of Maryland Baltimore County), who also writes novels. Find these and other mathematicians quoted in newspapers and interviewed on radio in the 2008 Math Digest archive at [http://www.ams.org/mathmedia/mathdigest/md-2008-toc.html](http://www.ams.org/mathmedia/mathdigest/md-2008-toc.html).

—Annette Emerson and Mike Breen
AMS Public Awareness Officers
paoffice@ams.org

AMS Email Support for Frequently Asked Questions

A number of email addresses have been established for contacting the AMS staff regarding frequently asked questions. The following is a list of those addresses together with a description of the types of inquiries that should be made through each address.

- **abs-info@ams.org** for questions regarding a particular abstract.
- **abs-submit@ams.org** for information on how to submit abstracts for AMS meetings and MAA sessions at January Joint Mathematics Meetings. Type HELP as the subject line.
- **acquisitions@ams.org** to contact the AMS Acquisitions Department.
- **ams@ams.org** to contact the Society’s headquarters in Providence, Rhode Island.
- **amsdc@ams.org** to contact the Society’s office in Washington, D.C.
- **amsmem@ams.org** to request information about membership in the AMS and about dues payments or to ask any general membership questions; may also be used to submit address changes.
- **ams-survey@ams.org** for information or questions about the Annual Survey of the Mathematical Sciences or to request reprints of survey reports.
- **bookstore@ams.org** for inquiries related to the online AMS Bookstore.
classads@ams.org to submit classified advertising for
the Notices.
cust-serv@ams.org for general information about AMS
products (including electronic products), to send address
changes, place credit cards orders for AMS products, or
conduct any general correspondence with the Society’s
Customer Services Department.
development@ams.org for information about giving
to the AMS, including the Epsilon Fund.
eims-info@ams.org to request general information
about Employment Information in the Mathematical Sciences (EIMS). For ad deadlines and rates go to
http://www.ams.org/eims
emp-info@ams.org for information regarding AMS
employment and career services.
eprod-support@ams.org for technical questions re-
garding AMS electronic products and services.
mathcal@ams.org to send information to be included
in the “Mathematics Calendar” section of the Notices.
mathrev@ams.org to submit reviews to Mathematical
Reviews and to send correspondence related to reviews or
other editorial questions.
meet@ams.org to request general information about
Society meetings and conferences.
meetreg-request@ams.org to request email meeting
registration forms.
meetreg-submit@ams.org to submit completed regis-
tration forms.
mmsb@ams.org for information or questions about
registration and housing for the Joint Mathematics Meet-
ings (Mathematics Meetings Service Bureau).
msn-support@ams.org for technical questions re-
garding MathSciNet.
notices@ams.org to send correspondence to the
managing editor of the Notices, including items for
the news columns. The editor (notices@math.ou.edu) is the
person to whom to send articles and letters. Requests for
permission to reprint from the Notices should be sent to
reprint-permission@ams.org (see below).
notices-ads@ams.org to submit electronically paid
display ads for the Notices. (Hard copy of the ad should
also be faxed or sent via postal mail.)
notices-booklist@ams.org to submit suggestions for
books to be included in the “Book List” in the Notices.
notices-letters@ams.org to submit letters and opinion
pieces to the Notices.
notices-whatis@ams.org to comment on or send sug-
gestions for topics for the “WHAT IS...?” column in the
Notices.
paoffice@ams.org to contact the AMS Public Aware-
ness Office.
president@ams.org to contact the president of the
American Mathematical Society.
prof-serv@ams.org to send correspondence about AMS
professional programs and services.
pub@ams.org to send correspondence to the AMS
Publication Division.
pub-submit@ams.org to submit accepted electronic
manuscripts to AMS publications (other than Abstracts). See
http://www.ams.org/submit-book-journal to
electronically submit accepted manuscripts to the AMS
book and journal programs.
reprint-permission@ams.org to request permission to
reprint material from Society publications.
sales@ams.org to inquire about reselling or distributing
AMS publications or to send correspondence to the AMS
Sales Department.
secretary@ams.org to contact the secretary of the
Society.
statements@ams.org to correspond regarding a bal-
ance due shown on a monthly statement.
technical-support@ams.org to contact the Society’s typeset-
ing Technical Support Group.
textbooks@ams.org to request examination copies or
inquiry about using AMS publications as course texts.
webmaster@ams.org for general information or for
assistance is accessing and using the AMS website.

Deaths of AMS Members

ANTONIO AIZPURU, professor, University of Cadiz, Spain,
died on March 1, 2008. Born on September 13, 1954, he was
a member of the Society for 10 years.

JACK M. ANDERSON, retired, from Hill City, SD, died on
August 18, 2008. Born on June 13, 1937, he was a member
of the Society for 14 years.

DAVID GOTTLEB, professor, Brown University, died on
December 6, 2008. Born on November 14, 1944, he was a member
of the Society for 19 years.

CRACIU N IANCU, associate professor, University of
Cluj-Napoca, Romania, died on March 12, 2007. Born on
September 15, 1939, he was a member of the Society for 15
years.

K IYOSHI ITO, from Kyoto-shi, Japan, died on Novem-
ber 10, 2008. Born on September 7, 1915, he was a member
of the Society for 47 years.

HENDRIK S. KONIJN, professor emeritus, University of
California, Berkeley, died on October 14, 2008. Born on
March 17, 1918, he was a member of the Society for 61
years.

WILLIAM LIGHT, professor, University of Leicester, Eng-
land, died on December 8, 2002. Born on April 19, 1950, he
was a member of the Society for 17 years.

DAVID MIDDLETON, from New York, NY, died on Novem-
ber 16, 2008. Born on April 19, 1920, he was a member of
the Society for 37 years.

KATSUMI NOMIZU, professor emeritus, Brown University,
died on November 5, 2008. Born on December 1, 1924, he
was a member of the Society for 57 years.

GEORGE PIMBLEY, retired, from Los Alamos, NM, died on
August 14, 2008. Born on March 11, 1922, he was a member
of the Society for 50 years.

ROBERT H. SMITH, from Woodbury, NJ, died on July 31,
2008. Born on March 7, 1943, he was a member of the Society for 41 years.

SUSAN WILLIAMSON, from Newton Centre, MA, died
on July 26, 2008. Born on December 29, 1936, she was a member of the Society for 41 years.
Reference and Book List

The Reference section of the Notices is intended to provide the reader with frequently sought information in an easily accessible manner. New information is printed as it becomes available and is referenced after the first printing. As soon as information is updated or otherwise changed, it will be noted in this section.

Contacting the Notices
The preferred method for contacting the Notices is electronic mail. The editor is the person to whom to send articles and letters for consideration. Articles include feature articles, memorial articles, communications, opinion pieces, and book reviews. The editor is also the person to whom to send news of unusual interest about other people's mathematics research.

The managing editor is the person to whom to send items for “Mathematics People”, “Mathematics Opportunities”, “For Your Information”, “Reference and Book List”, and “Mathematics Calendar”. Requests for permissions, as well as all other inquiries, go to the managing editor.

The electronic-mail addresses are notices@math.ou.edu in the case of the editor and notices@ams.org in the case of the managing editor. The fax numbers are 405-325-7484 for the editor and 401-331-3842 for the managing editor. Postal addresses may be found in the masthead.

Upcoming Deadlines
January 10, 2009: Applications for AAUW Educational Foundation Fellowships and Grants. See http://www.aauw.org/fga/fellowships Grants/selected.cfm or contact the AAUW Educational Foundation.


January 18, 2009: Applications for Mathematical Biosciences Institute

Where to Find It
A brief index to information that appears in this and previous issues of the Notices.
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AMS Ethical Guidelines—June/July 2006, p. 701
AMS Officers 2006 and 2007 Updates—May 2008, p. 629
AMS Officers and Committee Members—October 2008, p. 1122
Conference Board of the Mathematical Sciences—September 2008, p. 980
IMU Executive Committee—December 2008, p. 1441
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National Science Board—January 2009, p. 67
NRC Board on Mathematical Sciences and Their Applications—March 2008, p. 401
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NSF Mathematical and Physical Sciences Advisory Committee—February 2009, p. 278
Program Officers for Federal Funding Agencies—October 2008, p. 1116 (DoD, DoE); December 2007, p. 1359 (NSF); December 2008, p. 1440 (NSF Mathematics Education)
Program Officers for NSF Division of Mathematical Sciences—November 2008, p. 1297
Stipends for Study and Travel—September 2008, p. 983
Applications for Adaptation, Implementation, and Dissemination (PAID) awards. See “Mathematics Opportunities” in this issue.

**February 26, 2009:** Preliminary proposals for NSF Partnerships for International Research and Education (PIRE). See “Mathematics Opportunities” in this issue.

**February 27, 2009:** Applications for 2009 Summer Program for Women in Mathematics (SPWM2009). See “Mathematics Opportunities” in this issue.

**February 27, 2009:** Submissions for Association for Women in Mathematics (AWM) essay contest. See http://www.awm-math.org/biographies/contest.html.

**February 27, 2009:** Proposals for DMS New Institute Competition. See http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5302.

**March 1, 2009:** Applications for the June program of the Christine Mirzayan Science and Technology Policy Graduate Fellowship Program of the National Academies. See http://www7.nationalacademies.org/policyfellows; or contact The National Academies Christine Mirzayan Science and Technology Policy Graduate Fellowship Program, 500 Fifth Street, NW, Room 508, Washington, DC 20001; telephone: 202-334-2455; fax: 202-334-1667; email: policyfellows@nas.edu.

**March 2, 2009:** Applications for EDGE Summer Program. See http://www.edgeforwomen.org/?page_id=5.

**March 31, 2009:** Submissions for Plus Magazine New Writers Award. See the website http://plus.maths.org/competition/.

**April 15, 2009:** Applications for fall 2009 semester of Math in Moscow. See http://www.mccme.ru/mathinmoscow or write to: Math in Moscow, P.O. Box 524, Wynnewood, PA 19096; fax: +1720-391-65-01; email: mim@mccme.ru. For information on AMS scholarships see http://www.ams.org/outreach/mimomoscow.html or write to: Math in Moscow Program, Membership and Programs Department, American Mathematical Society, 201 Charles Street, Providence RI 02904-2294; email: student-serv@ams.org.

**May 8, 2009:** Applications for AWM Travel Grants. See http://www.awm-math.org/travelgrants.html; telephone: 703-934-0163; email: awm@awm-math.edu. The postal address is: Association for Women in Mathematics, 11240 Waves Mill Road, Suite 200, Fairfax, VA 22030.

**May 15, 2009:** Applications for National Academies Research Associateship Programs. See http://www7.nationalacademies.org/rap/ or contact Research Associateship Programs, National Research Council, Keck 568, 500 Fifth Street, NW, Washington, DC 20001; telephone 202-334-2760; fax 202-334-2759; email: rap@nas.edu.

**June 1, 2009:** Applications for the September program of the Christine Mirzayan Science and Technology Policy Graduate Fellowship Program of the National Academies. See http://www7.nationalacademies.org/policyfellows; or contact The National Academies Christine Mirzayan Science and Technology Policy Graduate Fellowship Program, 500 Fifth Street, NW, Room 508, Washington, DC 20001; telephone: 202-334-2455; fax: 202-334-1667; email: policyfellows@nas.edu.

**June 1, 2009:** Applications for the Math for America Foundation (MfA) Fellowship Program in San Diego. See http://www.mathforamerica.org/.


**June 30, 2009:** Applications for Fermat Prize for Mathematics Research. Contact Prix Fermat de Recherche en Mathématiques, Service Relations Publiques, Université Paul Sabatier, 31062 Toulouse Cedex 9, France, or see the website http://www.math.ups-tlse.fr/Fermat/.

**August 4, 2009:** Letters of intent for NSF Project ADVANCE Institutional Transformation (IT) and Institutional Transformation Catalyst (IT-Catalyst) awards. See “Mathematics Opportunities” in this issue.

**August 4, 2009:** Full proposals (by invitation only) for NSF Partnerships for International Research and Development (MfA) Early Career Visitor and post-doctoral positions. See the website http://mbi.osu.edu or call 614-292-3648.

**January 20, 2009:** Letters of intent for NSF Program ADVANCE Partnerships for Adaptation, Implementation, and Dissemination (PAID) awards. See “Mathematics Opportunities” in this issue.


**February 1, 2009:** Applications for AWM Travel Grants. See http://www.awm-math.org/travelgrants.html; telephone: 703-934-0163; email: awm@awm-math.edu. The postal address is: Association for Women in Mathematics, 11240 Waves Mill Road, Suite 200, Fairfax, VA 22030.

**February 12, 2009:** Full proposals for NSF Undergraduate Biology and Mathematics (UBM) program. See “Mathematics Opportunities” in this issue.

**February 13, 2009:** Applications for Math for America Foundation (MfA) Fellowship Program for New York City and Los Angeles. See http://www.mathforamerica.org/.

**February 15, 2009:** Applications for National Academies Research Associateship Programs. See http://www7.nationalacademies.org/rap/ or contact Research Associateship Programs, National Research Council, Keck 568, 500 Fifth Street, NW, Washington, DC 20001; telephone 202-334-2760; fax 202-334-2759; email: rap@nas.edu.


**February 24, 2009:** Full proposals for NSF Project ADVANCE Partnerships for Adaptation, Implementation, and Dissemination (PAID) awards. See “Mathematics Opportunities” in this issue.
Education (PIRE). See “Mathematics Opportunities” in this issue.

**August 15, 2009:** Applications for National Academies Research Associateship Programs. See [http://www7.nationalacademies.org/rap/](http://www7.nationalacademies.org/rap/) or contact Research Associateship Programs, National Research Council, Keck 568, 500 Fifth Street, NW, Washington, DC 20001; telephone 202-334-2760; fax 202-334-2759; email: rap@nas.edu.

**October 1, 2009:** Applications for AWM Travel Grants. See [http://www.awm-math.org/travelgrants.html](http://www.awm-math.org/travelgrants.html); telephone: 703-934-0163; email: awm@awm-math.edu. The postal address is: Association for Women in Mathematics, 11240 Waples Mill Road, Suite 200, Fairfax, VA 22030.

**November 1, 2009:** Applications for the January program of the Christine Mirzayan Science and Technology Policy Graduate Fellowship Program of the National Academies. See [http://www7.nationalacademies.org/policyfellows](http://www7.nationalacademies.org/policyfellows) or contact The National Academies Christine Mirzayan Science and Technology Policy Graduate Fellowship Program, 500 Fifth Street, NW, Room 508, Washington, DC 20001; telephone: 202-334-2455; fax: 202-334-1667; email: policyfellows@nas.edu.

**November 12, 2009:** Full proposals for NSF Project ADVANCE Institutional Transformation (IT) and Institutional Transformation Catalyst (IT-Catalyst) awards. See “Mathematics Opportunities” in this issue.

**November 15, 2009:** Applications for National Academies Research Associateship Programs. See [http://www7.nationalacademies.org/rap/](http://www7.nationalacademies.org/rap/) or contact Research Associateship Programs, National Research Council, Keck 568, 500 Fifth Street, NW, Washington, DC 20001; telephone 202-334-2760; fax 202-334-2759; email: rap@nas.edu.

**NSF/MPS Advisory Committee**

Following are the names and affiliations of the members of the Advisory Committee for Mathematical and Physical Sciences (MPS) of the National Science Foundation. The date of the expiration of each member’s term is given after his or her name. The website for the MPS directorate may be found at [http://www.nsf.gov/home/mps/](http://www.nsf.gov/home/mps/). The postal address is Directorate for the Mathematical and Physical Sciences, National Science Foundation, 4201 Wilson Boulevard, Arlington, VA 22230.

**Hector D. Abruna** (10/10) Department of Chemistry and Chemical Biology Cornell University

**James Berger** (10/11) Department of Statistical Science Duke University

**Daniela Bortolotto** (10/11) Department of Physics Purdue University

**Eric A. Cornell** (10/10) JILA University of Colorado

**Barbara J. Finlayson-Pitts** (10/11) Department of Chemistry University of California, Irvine

**Irene Fonseca** (10/11) Department of Mathematical Sciences Carnegie Mellon University

**Suzanne Hawley** (10/11) University of Washington

**Iain M. Johnstone** (chair) (10/09) Department of Statistics Stanford University

**William L. Jorgensen** (10/09) Department of Chemistry Yale University

**David E. Keyes** (10/09) Department of Applied Physics and Applied Mathematics Columbia University

**Theresa A. Maldonado** (MPSAC/CEOSE Liaison) (10/09) Department of Electrical and Computer Engineering Texas A&M University

**Dennis L. Matthews** (10/10) College of Engineering and School of Medicine University of California Davis

**Dusa M. McDuff** (10/09) Department of Mathematics State University of New York, Stony Brook

**Ramesh Narayan** (10/11) Harvard University and Harvard-Smithsonian Center for Astrophysics

**Sharon L. Neal** (10/11) Department of Chemistry and Biochemistry University of Delaware

**Monica Olivera de la Cruz** (10/09) Department of Materials Science and Engineering Northwestern University

**John Peoples Jr.** (10/11) Fermilab Batavia, IL

**Elsa Reichmanis** (10/11) Georgia Institute of Technology

**Ian M. Robertson** (10/09) Department of Materials Science and Engineering University of Illinois, Urbana-Champaign

**Winston O. Soboyejo** (10/09) Department of Mechanical and Aerospace Engineering Princeton University

**Joel E. Tohline** (10/10) Department of Physics and Astronomy Louisiana State University

**Geoffrey West** (10/11) Santa Fe Institute Santa Fe, NM

**Robert Williams** (10/09) Space Telescope Science Institute Baltimore, MD

**Book List**

The Book List highlights books that have mathematical themes and are aimed at a broad audience potentially including mathematicians, students, and the general public. When a book has been reviewed in the Notices, a reference is given to the review. Generally the list will contain only books published within the last two years, though exceptions may be made in cases where current events (e.g., the death of a prominent mathematician, coverage of a certain piece of mathematics in the news) warrant drawing readers’ attention to older books. Suggestions for books to include on the list may be sent to notices-booklist@ams.org.

*Added to “Book List” since the list’s last appearance.*

Reference and Book List


Doctoral Degrees Conferred

FEBRUARY 2009 NOTICES OF THE AMS 281

ALABAMA
Auburn University (3)

Department of Mathematics and Statistics
Ford, Robert, Path curvatures on a convex roof
Hollingsworth, Blane, Stochastic differential equations: A dynamical systems approach
Moore, Emilia, On the existence of even and K-divisible matchings

University of Alabama at Birmingham (3)

Department of Mathematics
Baker, Steven Jeffrey, Spectral properties of displacement models
Goswick, Lee, Dynamical, geometric and arithmetic properties of Euclidean lattices
Hamza, Eman, Localization properties for the unitary Anderson model

University of Alabama-Huntsville (3)

Department of Mathematical Sciences
Duehring, Dawn, Periodic traveling wave solutions for diffusion equations with time-delayed and non-local responding reaction
Hester, Anthony, Semigroups generated by pseudo-contractive mappings under the Nagumo conditions
Sinko, Anne, Generalized colorings in graphs

University of Alabama-Tuscaloosa (6)

Department of Mathematics
Raridan, Chris, Useless results for the study of magical and expander graphs
Thomas, Shawanda, An optimal hedging strategy for multiple commodities
Xu, Ming, Optimal consumption rate under certain spending behavior

Department of Information Systems
Statistics and Management Science
Natarajarathinam, Malini, Base stock policies for the stochastic inbound inventory routing problem
Upeti, Rahul, Inventory policies for containers with stochastic returns
Wang, Huaping, Missing data analysis in structural equation modeling—expectation maximization and multiple imputation methods

ARIZONA
Arizona State University (10)

Department of Mathematics and Statistics
Cates, Dennis, Edge detection using Fourier data with applications
Dar-e-ahmad, Muhammad, Structural plasticity of dendritic spines: A computational study
Erdem, Mustafa, Epidemics in structured population with isolation and cross-immunity
Gehrig, Eric, Hopf algebras, projections, and coordinates of the first kind in control theory
Malik, Tufail, Microbial quiescence, a survival strategy in environmental stress
Mendez, Guillermo, Tree-based methods to model dependent data
Sealey, Vicki, Calculus students’ assimilation of the Riemann integral into a previously established limit structure
Sutton, Karyn, Theoretical studies on pneumococcal vaccination
Thalhauser, Craig, The two-state model of cancer growth: Evolutionary implications at the local and global scales
Zhong, Zimin, Curve registration in functional data analysis

University of Arizona (8)

Department of Mathematics
Berger, Lisa, Ranks of Abelian varieties in towers of function fields
Fernandes, Anthony, A partnership between a middle school teacher and a novice mathematics educator centered around the content
Ivkovic, Milos, Characterization and coding techniques for long-haul optical telecommunication systems
McLean, Cameron, A Gold-Shafarevich equality and p-tower groups
Miller, Justin, On p-adic continued fractions and quadratic irrationals

Program in Applied Mathematics
Arpin, Sheree, Using mathematical models to investigate phenotypic oscillations in cichlid fish: A case of frequency-dependent selection
Shen, Fangfang, Approximating ideal-observer performance using Fisher information and the extreme value distribution in detection tasks
Shkarayev, Maxim, Effects of nonlinearity and disorder in communication systems

ARKANSAS
University of Arkansas at Fayetteville (3)

Department of Mathematical Sciences
Gyurov, Boyko, Maximal inverse semigroups of transformations
Haller, Erin, Comparison principles for fully non-linear parabolic equations in Carnot groups with applications to the horizontal Gauss curvature flow
Taylor, Phillip, Analytic bounded point evaluations and polynomial approximations in the mean on crescents

The above list contains the names and thesis titles of recipients of doctoral degrees in the mathematical sciences (July 1, 2007, to June 30, 2008) reported in the 2008 Annual Survey of the Mathematical Sciences by 213 departments in 154 universities in the United States. Each entry contains the name of the recipient and the thesis title. The number in parentheses following the name of the university is the number of degrees listed for that university. A supplementary list containing names received since compilation of this list will appear in a summer 2009 issue of the Notices.
 Doctoral Degrees Conferred

CALIFORNIA

California Institute of Technology (13)

DEPARTMENT OF APPLIED AND COMPUTATIONAL MATHEMATICS
Donaldson, Roger, Discrete geometric homogenisation and inverse homogenisation
Helgason, Hannes, Nonparametric detection and estimation of highly oscillatory signals
Hoch, David, Nonreflecting boundary conditions obtained from equivalent sources for time-dependent scattering problems
Morro, John, Jr., A super-algebraically convergent windowing-based approach to the evaluation of scattering from periodic rough surfaces
Sweatlock, Sarah, Asymptotic weight analysis of low-density parity check (LDPC) codes

Tian, Lexiu, Effective behavior of dielectric elastomer composites
Wang, Ke, A subdivision approach to the construction of smooth differential forms

Control and Dynamical Systems
Flores, Melvin, Real-time trajectory generation for constrained nonlinear dynamical systems using nonuniform rational B-spline basis functions
Grabits, Katalin, Low-dimensional representations of transitions in molecular systems
Waydo, Stephen, Explicit object representation by sparse neural codes

Department of Mathematics
Levaillant, Claire, Irreducibility of the Lawrence-Krammer representation of the BMW algebra of type An-1
Tsankov, Todor, Amenability, countable equivalence, relations and their full groups
Venzke, Rupert, Braid forcing, hyperbolic geometry and pseudo-Anosov sequences of low entropy

Claremont Graduate University (3)

SCHOOL OF MATHEMATICAL SCIENCES
Beasley, Joseph, Performance feedback and control of solar concentrators using wave front sensing techniques
Paolini, Christopher, A service-oriented architecture for thermochemical computation
Xu, Dong, FEMVib, an ab initio multidimensional solver for probing vibrational dynamics in polyatomic molecules and free radicals

University of California, Berkeley (6)

DEPARTMENT OF STATISTICS
Chang, George, Tools for multivariate bump hunting
Chen, Jiehua, Regression models with spatially correlated errors: Applications to urban core growth in China
Chen, Zehao, Estimation of high dimension covariance matrix and adaptive portfolio selection
Eckner, Andreas, Two essays on credit default correlation
Horel, Guillaume, Estimating integrated volatility with Markov chains
Li, Ping, Stable random projections and conditional random sampling, two sampling techniques for modern massive datasets

Spectral analysis with Markov chains
Turnbull, Brit, Empirical null distributions and local false discovery rates
Ward, Gillian, Statistics in ecological modeling; the presence-only problem and other procedures
Zhen, Wei, Greedy functional learning machine in finance

University of California, Davis (21)

DEPARTMENT OF MATHEMATICS
Breslin, William, Curvatures of surfaces in hyperbolic 3-manifolds
Farrell, Brendan, Analysis of noncommutative operator classes in information theory and harmonic analysis
Guan, Raymond, Advanced equalization techniques for wireless communications
Hodge, Andrew, The degrees of the logarithmic extension of the cotangent bundle to the moduli of pointed curves and Hitchin systems, spectral curves and KP equations
Lai, (Yuan-Juang) Yvonne, An effective compactness theorem for Coxeter groups
Lee, Jaejeong, Fundamental domains of convex projective structures
Liu, Shuang, Improving the classification of microarray data: Supervised and unsupervised methods
Rutherford, Daniel, Relationship between Legendrian knot invariants
Suh, Chan-Ho, Modified normal surface theories
Williams, Michael, Lens space surgeries on tunnel number one knots
Wilmarth, Constance, Projections of singular vectors of Verma modules over rank 2 Kac-Moody Lie algebras
Wright, Roy, Spatial and temporal heterogeneity of host-parasitoid interactions in lupine habitat
Yan, Pengchong, Broadband detection and imaging of multiple targets in clutter

Department of Statistics
Gu, Zhonghua, Model diagnostics for generalized linear mixed models
Liu, Wei, Statistical network comparison
Lu, Ruixiao, Statistical issues in detection of biological signals in the analysis of microarray gene expression data
Nguyen, Thuan, New procedures of fence methods and their applications
Tang, En-Tzu, On estimation of the mean squared error in small area estimation and related topics
Tseng, Szu-Ching, A generalized self-consistency approach to semiparametric survival models
Zhang, Zhen, Functional data analysis for densities
Zhu, Li, Modeling dynamics in two statistical problems: Longitudinal disease activity score and parasite infection

Group in Biostatistics
Bembom, Oliver, Statistical methods for causal inference when the assumption of experimental treatment assignment is violated

Group in Mathematics

Zhu, Li
University of California, Irvine (5)

DEPARTMENT OF MATHEMATICS

Li, Xiangrong, Nonlinear simulations of solid tumor growth using a mixture model: Invasion and branching
Munteanu, Ovidiu, The structure of complete manifolds with positive spectrum
Vargas, Benjamin, Mixed end conditions and morphogen gradient formation
Webster, Micah, Nonlinear stability analysis of a free boundary problem
Wong, Chiu Fai, Zeta functions of projective toric hypersurfaces over finite fields

University of California, Los Angeles (17)

DEPARTMENT OF MATHEMATICS

Brandman, Jeremy, A level set method
Busch, Joseph, Lower bounds in arithmetic complexity via asymmetric embeddings
Epstein, Inessa, Some results on orbit inequivalent actions of non-amenable groups
Hinde, Colin, The essence of Ricci curvature
Kwon, Soonik, Low regularity problem of the higher order KdV type equations and the orbital stability issues of soliton solutions
Landa, Yanina, Visibility of point clouds and exploratory path planning in unknown environments
Leo, John, Fourier coefficients of triangle functions
Ni, Kang-Yu, Variational PDE-based image segmentation and inpainting with applications in computer graphics
O'Donnol, Danielle, Intrinsically \( n \)-linked spatial graphs
Prescott, Timothy, Invariance principles for random environments and shape theorems
Roy, Tristan, Global existence of the defocusing cubic wave equation in dimension 3
Sinapova, Dima, A model for a very good scale and bad scale
Smith, S. Alex, Layered percolation on the complete graph
Soulatios, Ioannis, Characterizable cardinals and local Hanf numbers
Waelder, Robert, Elliptic genera in algebraic geometry
Yanovsky, Igor, Unbiased nonlinear image registration
Zhu, Mingqiang, Fast numerical algorithms for total variation based image restoration

University of California, Riverside (5)

DEPARTMENT OF STATISTICS

Lesch, Scott, A new class of goodness-of-fit tests based on linear functions of order statistics for the exponential distribution under general Type II censoring schemes
Liu, Junmei, Estimating the number of species from a censored sample
Wilson, Jason, On the probability of correct selection when \( k \) is large
Zhang, Qi, Different statistical tests to assess the validity of one-part software reliability models
Zhang, Wei, Logistic regression with unknown sizes

University of California, San Diego (12)

DEPARTMENT OF MATHEMATICS

Angle, Robert, Holomorphic Segre preserving maps
Buckovschi, Orest, Simple Lie algebras, algebraic prolongations and contract structures
Butler, Steven, Eigenvalues and structures of graphs
Clark, David, Functorality for the su(3) Khovanov homology
Guo, Hong Xin, The 3-dimensional steady gradient Ricci soliton
Horn, Larissa, Fun with tensor products
Liese, Jeffrey, Counting patterns in permutations and words
Nordgren, Karl, Well-posedness for the equations of motion of an inviscid, incompressible, self-gravitating fluid with free boundary
Regev, Alon, Filtered algebraic algebras
Richardson, Ross, Combinatorial and geometric problems on point processes
Riehl, Amanda, Ribbon Schur functions and permutation patterns
Robinson, Daniel, Primal-dual methods for nonlinear optimization

University of California, Santa Barbara (4)

DEPARTMENT OF STATISTICS AND APPLIED PROBABILITY

Bagasheva, Biliana, Bayesian methods in the investment management process
Kaneda, Naohisa, Fitting mixture models from kernel estimators
Vestal, Douglas, Interacting particle systems for pricing credit derivatives
Wang, Dezong, Pricing truncates of a CDO and CDX index

University of California, Santa Cruz (2)

DEPARTMENT OF APPLIED MATHEMATICS AND STATISTICS

Patil, Anand, Bayesian nonparametrics for inference of ecological dynamics

Taddy, Matthew, Bayesian nonparametric analysis of conditional distributions and inference for Poisson point processes

University of Southern California (7)

DEPARTMENT OF MATHEMATICS

Akopian, Vardan, Modeling of Earth’s ionosphere and variational approach for data assimilation
Alaghaei, Mohamad, Stochastic models for understanding and pattern recognition of molecular data
DiMuro, Joseph, On prime power elements of \( GL_d(q) \) acting irreducibly on large subspaces
Han, Yong-Ho, Commuting triples of matrices
Huatt, Christopher, Quantum traces in quantum Teichmüller space
Mayberry, John, The effects of noise on bifurcations in circle maps with applications to integrate-and-fire models in neural biology
Villalobos, Jose, Monte Carlo methods for FBSDEs in high dimensions

COLORADO

Colorado State University (13)

DEPARTMENT OF MATHEMATICS

Al-Azemi, Abdullah, Classification algorithms for graphs, digraphs, and linear spaces
Davis, Diane, Toward a type \( B_n \) geometric Littlewood-Richardson rule
Fatemeh, Emdad, Signal fraction analysis for subspace processing of high dimensional data
Jen-Mei, Chang, Classifications on the Grassmannians: Theory and applications
Mertens, Keith, Mathematical methods for fluid-solid interfaces: Meandering streams and sand ripples
Murphy, Ethan, 2-D D-bar conductivity reconstructions on non-circular domains
Muskat, Jeremy, Algebraic curves over finite fields
Peters, Pamela, Gaussian maps for double covers of smooth toric surfaces
Wildey, Timothy, A posteriori analysis of operator decomposition on interface problems
Yue, Qiao, Radial basis functions (RBFs) for solving color conversion problems

DEPARTMENT OF STATISTICS

Cao, Xiaofan, Model selection based on expected square Hellinger distance
Higgs, Megan, Clipped latent-variable spatial models for ordered categorical data
Wu, Rongning, Estimation for some linear and nonlinear time series models
University of Colorado, Boulder (9)

Department of Mathematics
Bruns, Corey, Variations of independence in Boolean algebras
Davenport, John, Analysis of American options
Ernst, Dana, A diagrammatic representation of an affine C Temperley-Lieb algebra
Formichella, Marc, Functional equations among Barnes’ integrals and hypergeometric series
Mann, Allen, Independence-friendly cylindric set algebras
Nickodemus, Matthew, Natural dualities for finite groups with Abelian Sylow subgroups
Pohlmann, Brent, Structural properties of acyclic heaps with applications to Kazhdan-Lusztig theory
Radhakrishnan, Vinod, An asymptotic formula for the number of non-Serre curves in a two parameter family of elliptic curves
Seguin, Troy, Risk measures

CONNECTICUT

University of Connecticut, Storrs (9)

Department of Mathematics
Bowers, Adam, The Grothendieck inequality: Methods and applications
Kaur, Sawinder Pal, An eigenvalue problem for some nonlinear transformation of multidimensional arrays
Kanasinhe, Sudath, Model to develop a provision for adverse deviation (PAD) for the mortality risk of impaired lives

Department of Statistics
Das, Sourish, Generalized linear models and beyond: An innovative approach from Bayesian perspective
Guo, Feng, Modeling genetic data using Bayesian hierarchical models
Li, Pengfei, A factor and vector-AR model for analyzing high dimension volatility for high frequency financial data
Mukhopadhyay, Jaydip, Mining tools for high-dimensional time series data using spectral methods
Xi, Yingmei, New development of Bayesian mixture models for survival and survey data
Yu, Fang, Bayesian methods for high-throughput gene expression data in bioinformatics

DELAWARE

University of Delaware (6)

Department of Mathematical Science
Beckham, Jon Regan, Analysis of mathematical models of electrostatically deformed elastic bodies

Howard University (3)

Department of Mathematics
Attimu, Dodzi, Linear operators on some non-Archimedean Hilbert spaces and their spectral theory
Dembele, Bassidy, Malaria model in periodic environments
Legette, Lakeshia, Maximal groups in the Stone-Cech compactification of a discrete semigroup

FLORIDA

Florida Atlantic University (1)

Department of Mathematical Sciences
Kalis, Jan, Sobolev inequalities

Florida Institute of Technology (4)

Department of Mathematical Sciences
Mamlapalle, Sameer, A study of functional differential equations with anticipation and retardation
Sartor, Kenneth, A study of variational phase estimation methods for synthetic aperture radar applications
Seetharaman, Harikaran, Adapted wavelet methods for heat equation on unbounded domains
Shaykhian, Gholam, Integration and optimization: Irrational numbers for random sequences and scope of evolutionary algorithms

Florida State University (15)

Department of Mathematics
Chan, Wan-Kan, Analysis and approximation of a two-banded Ginzburg-Landau model of superconductivity
Chen, Zheng, ANOVA for parameter dependent nonlinear PDEs and numerical methods for the stochastic Stokes equations
Culham, Andrew, Asset pricing in a Lucas framework with boundedly rational heterogeneous agents
Moreno, Juan, Impulse control problems under non-constant volatility
Nguyen, Hoa, Centroidal Voronoi tessellations for mesh generation: From uniform to anisotropic adaptive triangulations
Novocin, Andrew, Factoring univariate polynomials over the rationals
Saka, Yuki, Analysis of two PDE models in fluid mechanics: Nonlinear spectral eddy-viscosity model of turbulence and infinite-Prandtl-number model of mantle convection
Singleton, Lee, Geometric and computational generation, correction, and simplification of cortical surfaces of the human brain
Zhu, Waming, A spectral element method to price European options

Department of Statistics
Choi, Seo-eun, A statistical approach to ocean circulation inverse problem
He, Jianghua, Time-varying coefficients models for longitudinal aging data
Norton, Jon, Spatiotemporal Bayesian hierarchical models, with application to birth outcomes
Stefanov, Dimitre, Cardiovascular risk functions based on multi-state models
Tan, Fei, A method for finding the nadir of non-monotonic relationships
Uhm, Dai Ho, Flexible additive risk models using piecewise constant hazard functions

University of Central Florida (4)

Department of Mathematics
Flores, Paul, Categorical properties of lattice-valued convergence spaces
Holmquist, Sonia, An examination of the effectiveness of the Adomian decomposition method in fluid dynamic applications
Vogel, Thomas, Empirical and hierarchical Bayesian methods with applications to small area estimation
Santra, Upasana, Probability matching priors for the bivariate normal distribution

University of South Florida (12)

Department of Mathematics
Adhikari, Dhruba R., Applications of degree theories to non-linear operator equations in Banach spaces
Andreevska, Irena, Mathematical modeling and analysis of options with jump-diffusion volatility
Davis, John C., Identification of parameters when the density of the minimum is given
Genova, Daniela, Forbidding and enforcing of formal languages, graphs, and partially ordered sets
Hoare, Armando, Parametric, non-parametric and statistical modeling of stony coral reef data
Ibrahim, Boubakari, The Leray-Schauder approach for the topological degree of perturbed maximal monotone operators
Mbah, Alfred K., On the theory of records and applications
Mo, Yiming, Forecasting models for economic and environmental data
Stannicka, Ana, A theoretical model for flexible tiles self-assembly
Taylor, Rodney, Lagrange interpolation on Leja points

GEORGIA

Emory University (6)

Department of Biostatistics
Chen, Huichao, Statistical methods for modeling exposure and reproductive outcomes
Crawford, Sara, Multiple sources of informative dropout in longitudinal data
Wannemuehler, Kathleen, Likelihood-based measurement error adjustments in occupational and environmental exposure studies

University of Georgia (13)

Department of Mathematics
Cinkir, Zubeyir, The tau constant of metrized graphs
Cooper, Bobbe Jane, Support varieties for tilting modules for GL_n
Davie, Emille Kinnnae, Characterizing right-veering homeomorphisms of the punctured torus via the Burau representation of B_n
Hsu, Haipeng, Prewavelet solution to Poisson equations
Petrov, Peter Konstantinov, Nash problem on spaces of arcs
Platt, Kenyon, Classifying the representation type of infinitesimal blocks of category Os
Rusinko, Joseph Patrick, Equivalence of mirror families constructed by toric degenerations of flag varieties
Wright, Caroline, Second cohomology groups of Frobenius kernels
Wu, Jianbao, Spherical splines for Hermite interpolation and surface design

Department of Statistics
Cai, YiMei, Estimation of the seed distribution with genotypic data
Iaci, Ross, Multivariate association and dimension reduction
Park, Jin-Hong, Dimension reduction in time series
Zhang, ChenHua, Applications of smoothly varying functions and tail index estimation

ILLINOIS

Illinois Institute of Technology (2)

DEPARTMENT OF APPLIED MATHEMATICS

Erickson, John F., Generalized native spaces
Ortega, Oscar, Consensus and location: The mean function

Northern Illinois University (4)

DEPARTMENT OF MATHEMATICAL SCIENCES

Cappetta, Robert, Reflective abstraction and the concept of limit: An experimental study
Kisunzu, Phillip, Teacher instructional practices, students’ mathematical dispositions and mathematics achievement
Poljak, Cathy, Observed confidence levels for regression parameters
Santra, Sourav, Some contributions to design and analysis of crossover experiments

Northwestern University (11)

DEPARTMENT OF MATHEMATICS

Alexander, Gary Clark, Index theorems on noncommutative two-tori and Hochschild cohomology of quantum special linear groups
Bailey, Scott, Topological splittings of spectra related to tmf
Chu, Chenghao, Representing cohomology theories in the triangulated category of motives
Dhand, Vivek, Geometric Langlands duality and forms of reductive groups
Novak, Christopher, Group actions via interval exchange transformations

DEPARTMENT OF ENGINEERING SCIENCES AND APPLIED MATHEMATICS

Donovan, Graham, Rare event simulation systems using the cross-entropy method
Kao, Justin, Mathematical modeling, simulation, and analysis of two problems in interfacial fluid dynamics
Tikhomirova, Anna, Mathematical modeling of structure formation in angiogenesis
Vaughan, Benjamin, Applications of the extended finite element method in mathematical biology

DEPARTMENT OF STATISTICS

Ge, Yang, Bayesian inference with mixtures of logistic regression: Functional approximation, statistical consistency and algorithmic convergence
Rhoads, Christopher, Utilizing prior information about the variance structure

Southern Illinois University, Carbondale (3)

DEPARTMENT OF MATHEMATICS

Abuhammad, Hassan, Some transformed distributions
Lin, Yuan, High-order finite difference methods for solving heat equations
deSouza, Comlan, Periodic eigenfunctions of the Fourier transform operator

University of Chicago (22)

DEPARTMENT OF MATHEMATICS

Bremer, Christopher, An Euler integral formula for epsilon factors of connections
Cima, Nora Elizabeth, Newton-Hodge filtration for F-crystals with structure
Day, Matthew, Symplectic structures on right-angled Artin groups: Between the mapping class group and the symplectic group
Gashi, Qëndrim, A conjecture of Kottwitz and Rapoport for split groups
Geline, Michael, Modular representation theory and the Schur index
Guillou, Bertrand, On some properties of motivic cohomology
Kamgarpour, Masoud, Stacky Abelianization of connected algebraic groups
Lange, Karen, The computational complexity of homogeneous models
Lee, Benjamin, On the algebraic de Rham complex
Longo, Nicholas P. M., Quasilinear Schrödinger equations
Masson, Robert, The growth exponent for planar loop-erased random walk
Nguyen, Tu Ahn, Unique continuation for parabolic equations and local well-posedness for mKdV equation
Peng, Irine, Quasi-isometries of some solvable groups
Schedler, Travis, Differential operators and Batalin-Vilkovisky structures in noncommutative geometry
Tikaradze, Akaki, The center and representations of infinitesimal Hecke algebras
Wallace, Christopher, Galois and motivic Galois groups
Zbarsky, Boris, On some stratifications of affine Deligne-Lusztig varieties for $SL_3$

DEPARTMENT OF STATISTICS

Hugeback, Angela, Point process models for astronomy: Quasars, coronal mass ejections and solar flares

Ke, Baoguan, A method for genetic mapping of quantitative traits and related statistical problems
Kim, Su Yeon, Adaptive evolution of conserved non-coding elements
Lim, Chae Young, Characteristics of a model error in an air quality model and fixed-domain asymptotic properties of spatial cross-periodograms
Zhao, Zhibiao, Nonparametric inference for stochastic diffusion models

University of Illinois at Chicago (18)

EPIDEMIOLOGY AND BIOSTATISTICS DIVISION

Evans, Charlesnika, Blood stream infections in veterans with spinal cord injury
Fitchett, George, The role of daily spiritual experience in cardiovascular disease
Gao, Sasha, Information recovery from surrogate outcomes in incomplete longitudinal data
Mattson, Christine, Risk compensation, circumcision, and HIV prevention in Kisumu, Kenya
McIntyre, Anne, Lessons learned from surveillance for bacterial infectious diseases
Qualls-Hampton, Raquel, Health-related quality-of-life and pain in an SCI population: Descriptive and factor

MATHEMATICS, STATISTICS & COMPUTER SCIENCE DEPARTMENT

Cashen, Christopher, Quasi-isometries among tubular groups
Chan, Kungho, Local positivity and Seshadri constants
Fathallah-Shaykh, Hassan, Modeling and local filtering of noise embedded in genome-scale microarray datasets
He, Peng, The risk neutral dynamics of market implied volatility and its application
Krop, Elliot, Enumerating matchings in regular graphs
Rafalski, Shawn, Immersed turnovers in hyperbolic 3-orbifolds
Vozoris, Kathryn, The complex field with a predicate for the integers
Yuce, Iker, Decompositions of 2-generator free Kleinian groups and hyperbolic displacements
Zhang, Weiya, Designs for a toxicity-efficacy model and inference on a normal mean with known coefficient of variation
Zhao, Ailing, Newton’s method with deflation for isolated singularities of polynomial systems
Zhou, Ling, Association rule mining and quantitative association rule mining among infrequent items
Zhuang, Yan, Parallel implementation of polyhedral homotopy methods
University of Illinois, Urbana-Champaign (24)

Department of Mathematics

Azgin, Salih, Model theory of valued difference fields

Bansal, Shivi, Rational points on lattice varieties

Cao, Zhu, Product identities for theta functions

Chatya, Somjate, Complex dynamics and Salem numbers

Ferguson, Colin, Chain conditions on subnormal subgroups

Forcacs, Tamas, Interpolation of weighted \(L^2\)-holomorphic functions in higher dimensions

Hu, Yong, Localization of divisors of integers and of some arithmetical functions

Huber, Timothy, Zeros of generalized Ramanujan functions and topics from Ramanujan’s theory of elliptic functions

Kadziela, Samuel, Rigid analytic uniformization of hyperelliptic curves

Kilbourn, Timothy, Congruence properties of Fourier coefficients of modular forms

Kou, Ming, Existence and convergence of stochastic Loewner evolution in multiply connected domains

Malicki, Maciej, Topologies and metrics on Polish groups

Moreno, Javier, Iterative differential Galois theory in positive characteristic: A model theoretic approach

Pahlajani, Chetan, Stochastic averaging correctors for a noisy Hamiltonian system with discontinuous statistics

Park, Seung Kook, Applications of algebraic curves to cryptography

Prince, Noah, DeltaT-system methods in contemporary graph theory

Schoretsanitis, Konstantinos, Fraise theory for metric structures

Sinha, Malinee, Prescribing dilations in space

Suer, Onat, Model theory of differentially closed fields with several commuting derivations

Vandenbussche, Jennifer, Five topics in extremal and structural graph theory

Wang, Chunlin, On the estimator of the density of Feynman-Kac semigroups of 2-stable-like processes and the purely discontinuous Girsanov transform of 2-stable-like processes

Wu, Qingquan, Algorithmic aspects of biquadratic cubic and radical function fields

Xiong, Maosheng, Distribution of Selmer groups of quadratic twists of a family of elliptic curves

Department of Statistics

Li, Di, Markov chain marginal bootstrap for generalized estimating equations

Indiana University, Bloomington (8)

Department of Mathematics

Duncan, Jonathan, First return recovery of Baire class one functions on ultrametric spaces

Franko, Jennifer, Braid group representations via the Yang Baxter equation

Irwin, Trevor, Fraisse limits and colimits with applications to continua

Jang, Min Kyung, Statistical methods for biological applications

Pham, Du, Comparison of finite volume and finite difference methods and convergence results for finite volume schemes

She, Chunpeng, A mathematical model for power derivatives

Zhang, Siyu, Pricing caps and swaptions when bond prices follow jump-diffusion processes and have log-price volatility

Zhou, Chunlai, Complete deductive systems for probability logics with applications in Harsanyi type spaces

Indiana University-Purdue University Indianapolis (1)

Department of Mathematical Sciences

Ramsey, Bobby, Jr., A generalization of the Lyndon-Hochschild-Serre spectral sequence for polynomial cohomology

Purdue University (26)

Department of Mathematics

Azar, Monique, Some lower and upper bounds in real algebraic geometry

Blanco-Silva, Francisco, The curvelet transform. A generalized definition and approximation properties

Degert, Mustafa Ersin, A biholorphism from the Bell representative domain onto an annulus and kernel functions

Dwelle, Kayla, Some results on Hadamard closure and variation diminishing properties of totally nonnegative matrices

Gu, Nan, Some results in the problem of simultaneous resolution of singularities

Kumar, Manish, Fundamental group in positive characteristic

Lomeli, Luis, Functoriality for the classical groups over function fields

Maxin, Daniel, The interplay of isolation from reproduction with demography and sexually transmitted diseases

Mitchell, Ronald (Chris), Hochschild cohomology and the Smith resolution

Siudeja, Bartlomiej, Properties of heat kernels

Tan, Kuan, Applications of the Schwarz function to a class of multiply connected domains with symmetries

Tapp, Darren, Bernstein-Sato polynomials and Picard-Lefschetz monodromy

Validashti, Javid, Multiplicities of graded algebras

Vizcarra, Andrew, Regularity of sub-Gaussian processes and other random fields

Wang, Chunbo, Mixed finite element methods for the Stokes and Navier-Stokes equations

Yalcin, Umud, Rank three symplectic groups

Yang, Xiaofeng, Modeling, analysis and simulation of multi-phase flows

Zhang, Pei, Mathematical modeling of host-parasite dynamics

Zhao, Yanhong, On forward-backward stochastic differential equations and related numerical methods

Department of Statistics

Chen, Hui, Voice over the internet: Statistical properties and quality of service

Cheng, Ryan, Statistical methods for mapping multiple complex traits

Knapp, Shannon, Incorporating uncertainty into non-invasive DNA-based mark-recapture population estimates

Liu, Zhengqiang, Stenosis surveillance of hemodialysis patients

Xu, Hui, Some applications of the prior Bayes approach

Xu, Huiqing, Estimation of a general correlation structure for latent class and latent variable models of multivariate binary data

Zhang, Jianying, Algorithm-based statistical modeling with application to multi-sensor tracking data with missing values

University of Notre Dame (5)

Department of Mathematics

Chailuek, Kamthorn, An extension of Bergman spaces and their Toeplitz operators

Eleftheriou, Panteleimon, Groups definable in linear o-minimal structures

Harper, John, Quillen homology of modules over operads

Jones, Benjamin, On the singular Chern classes of Schubert varieties via small resolution

Quinn, Sara, Algorithmic complexity of algebraic structures

Iowa State University (11)

Department of Mathematics

Chung, Key One, Weak homomorphisms of coalgebras

Fiedler, James, Greco-Latin squares as bijections

Halverson, Matthew, Asymptotic behavior of the solutions to a family of PDE’s arising from the chemotaxis equations of Keller and Segel

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Meng, Qiang, Topics in pricing American type financial contracts
Rice, Theodore, Greedy quasigroups and greedy algebras with applications to combinatorial games
Wang, Zhongming, Development of level set method for computing the semi-classical limit in Schrödinger equations with potentials

DEPARTMENT OF STATISTICS

Chatterjee, Arindam, Applications of asymptotic expansions to some statistical problems
Huckett, Jennifer, Synthetic data methods for disclosure limitation
Lawrence, Michael, Interactive graphics, graphical user interfaces and software interfaces for the analysis of biological experimental data and networks
Ott, Ellis, Schools left behind; statistical issues with NCLB (No Child Left Behind)
Wickham, Hadley, Practical tools for exploring data and models

University of Iowa (27)

DEPARTMENT OF APPLIED MATHEMATICS AND COMPUTATIONAL SCIENCE

Choi, Yang Ho, Curvature arbitrage
Kwon, Hun, $W^2,p$ estimates for linear fourth order elliptic equations with BMO coefficients in Reifenberg flat domains
Medikonduri, Ram Kishore, Tabulation of tangles and solving tangle equations
Nicholson, Neil, On knots and their invariants
Ortiz-Rosado, Ricardo, Newton/AMG algorithm for solving complementarity problems arising in rigid body dynamics with frictional impacts
Pansera, Jerome, Local risk minimization, consistent interest-rate modeling and applications to life insurance

DEPARTMENT OF BIOSTATISTICS

Minggen, Lu, Analysis of panel count data using monotone polynomial splines
Shi, Qian, Bayesian methods of evaluation and use of surrogate endpoints in the single-trial settings
Tan, Huaming, Variable selection and estimation in the partially linear AFT model
Zhang, Suhong, Inference on association measure in copula model for bivariate survival data with hybrid censoring and application to a HIV study
Zugui, Zhang, Model selection for nearly replicated data based on conceptual predictive statistics

DEPARTMENT OF MATHEMATICS

Bennett, Lucas, Edge index and arc index of knots and links
Caprav, Carmen, An $sl(2)$ tangle homology and seamed cobordisms
Diaz, Esteban, Connections between homology group planes, and flocks of quadratic cones
Duan, Yanzheng, On some geometric and approximation properties in Banach spaces
Hamon, Suzanne, Some topics in $t$-factorizations
Llosent, Giovanna, Stable endomorphism rings and Ext groups for the symmetric group $S_n$
Ortiz-Albino, Reyes, On generalized non-atomic factorizations
Reif, Kathleen, Hyperbolicity of arborescent tangle spaces
Rivera, Joaquín, Existence of traveling wave solutions for a nonlocal reaction-diffusion equation
Stoeckel, Matthew, Computing quantum hyperbolic invariants
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Wendt, Theodore, Mixed complementarity formulations and energy balance in dynamic contact problems

DEPARTMENT OF STATISTICS AND ACTUARIAL SCIENCE

Feng, Dai, Bayesian hidden Markov normal mixture models with application to MRI tissue classification
Gao, Xiaoli, Penalized methods for high-dimensional least absolute deviation regression
Ko, Bangwon, On sums of dependent heavy-tailed random variables and valuation of equity-linked insurance products
Lee, Yeonok, A mixture of semiparametric models

Kansas State University (5)

DEPARTMENT OF MATHEMATICS

Adongo, Donald, A local extrapolation method for hyperbolic conservation laws: The ENO and Goodman-LeVeque underlying schemes and sufficient conditions for TVD
Chen, Weidong, An efficient method for an ill-posed problem—band-limited extrapolation by regularization

DEPARTMENT OF STATISTICS

Bsharat, Rebhi, Evaluation of $\tau_{CL}$ estimators
Liu, Ying, On goodness-of-fit of logistic regression model
von Borries, George Freitas, Partition clustering of high dimensional low sample size data based on $p$-values

University of Kansas (3)

DEPARTMENT OF MATHEMATICS

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University of Louisville (4)

DEPARTMENT OF MATHEMATICS

Nowrouzi, Khashan, Fariba, Cost shifting of the drug-eluting stent
Petrou, Christiana, Use of text mining to predict patient compliance
Tesfamicael, Mussie, Forecasting prescription of medications and cost analysis using time series
Wiglesworth, Lesley, A study of unit bar-visibility graphs

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Daspan, Gideon, Comparison of KP and BBM-KP models
Kim, Heon, Sign ambiguities of Gaussian sums
Laubinger, Martin, Differential geometry in Cartesian closed categories of smooth spaces
Namli, Suat, Multiplicative renormalization method for orthogonal polynomials
Wallace, Steven, Surgery description of colored knots

Yasong, Jin, Maximum queue length of a fluid model with a Gaussian input

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Harder, Theodore, Some remarks on constructive Yukawa theory in four dimensions

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University of Kentucky (7)

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Clift, Shawn, Generalized Witt vectors
Godefroy, Hugh, A study of orientation maps: Crystallographic symmetry, mean orientation, and applications
Kiteck, Daniel, Covers of models
Petrovic, Sonja, Algebraic and combinatorial properties of certain toric ideals in theory and applications
Shin Kim, Aekyoung, The $L^p$ Neumann problem for Laplace’s equation on convex domains
Slone, Michael, Homological combinatorics and extensions of the cd-index
Zhang, Wei, GMRES on a tridiagonal Toeplitz linear system

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Wallace, Steven, Surgery description of colored knots

Yasong, Jin, Maximum queue length of a fluid model with a Gaussian input

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Harder, Theodore, Some remarks on constructive Yukawa theory in four dimensions

KENTUCKY
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MATHEMATICS AND STATISTICS PROGRAM
Du, Xudong, A finite difference method for studying thermal deformation in a 3D microsphere exposed to ultrashort pulsed lasers
Liu, Chang, Stochastic modeling of retail mortgage loans based on past due, prepaid, and default states
Nilsen, Erik Alfonso, Nonlinear dynamical analysis of brain electrical activity due to exposure to weak environmentally relevant electromagnetic fields
Niu, Tianchan, A hyperbolic two-step model based finite difference method for studying thermal deformation

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DEPARTMENT OF MATHEMATICS
Aranda, Vivian, Computational modeling of peristaltic pumping using the method of regularized Stokeslets
Medina, Luis, Case studies of experimental mathematics: p-adic valuations of recurrences
Musielak, Magdalena, A computational model of nutrient transport and acquisition by diatom chains in a moving fluid

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Carrillo-Escobar, Julio, Blow-up and quenching phenomena for singular semilinear parabolic problems
Choudhury, Jayanta, Numerical and asymptotic investigation of the stationary-propagated localized solutions of the Boussinesq equation in two dimensions
Li, Xianbin, Modeling composite outcome and jointly modeling its components
Lu, Yun, Detecting and contending with the influence of “unmeasured” confounders
Luo, Sheng, Mixed effects stochastic process models of smoking cessation behavior
Manichaikul, Ani, Statistical methods for mapping quantitative trait loci in experimental crosses
McGready, John, Two studies on current issues in biostatistical education
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Su, Shu-Chih, Structure/function relationships in the analysis of anatomical and functional neuroimaging data
Wang, Weimei, Counterfactual inference from observational data: Methods and applications
Yin, Yue, Bayesian analysis of infectious disease time series data and optimal constrained Bayesian updating
Zhou, Yijie, Association of mortality rates with race and income among U.S. Medicare participants

University of Maryland, Baltimore County (4)

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An, Ming-Wen, On the importance of designs in better addressing missing data due to death and to loss-to-follow-up
Busuioc, Cecilia, Eisenstein cohomology, Milnor K-theory and special values of L-functions
Gabrielov, Afonso, Economic applications of the Morse-Novikov cochain complex
Li, Feng, Statistical inference for proteomics
Siddani, Ravi, Spatio-temporal modeling of rain rates
Soane, Ana Maria, Variational problems in weighted Sobolev spaces with applications to computational fluid dynamics
Sun, Zhibin, Geomagnetic data assimilation using ensemble methods to estimate forecast error covariance

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Boston University (7)

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Zhou, Yijie, Association of mortality rates with race and income among U.S. Medicare participants

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Johns Hopkins University (18)

DEPARTMENT OF BIOSTATISTICS
Achy-Rou, Aristide, Three novel approaches to analyzing longitudinal data: Regression on longitudinal propensity scores, enhanced sensitivity analysis framework and marked renewal stochastic processes
An, Ming-Wen, On the importance of designs in better addressing missing data due to death and to loss-to-follow-up
An, Ming-Wen, On the importance of designs in better addressing missing data due to death and to loss-to-follow-up
Busuioc, Cecilia, Eisenstein cohomology, Milnor K-theory and special values of L-functions
Carrillo-Escobar, Julio, Blow-up and quenching phenomena for singular semilinear parabolic problems
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Manichaikul, Ani, Statistical methods for mapping quantitative trait loci in experimental crosses
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Su, Shu-Chih, Structure/function relationships in the analysis of anatomical and functional neuroimaging data
Wang, Weimei, Counterfactual inference from observational data: Methods and applications
Yin, Yue, Bayesian analysis of infectious disease time series data and optimal constrained Bayesian updating
Zhou, Yijie, Association of mortality rates with race and income among U.S. Medicare participants

Boston University School of Public Health (6)

DEPARTMENT OF BIOSTATISTICS
Cho, Kelly, Handling linkage disequilibrium in linkage analysis using dense SNPs
Lee, Sophia, Analysis of correlated binary data in non-inferiority trials
Monteza-Rath, Maria, Models for non-additive interaction effects
Scaramuzza, Amy, A modified log rank test to account for left truncated survival data: A comparison with the usual log rank test
Wang, Ling, Bayesian model-based clustering of short-time series
Yin, Xiaoyan, Genetic association analyses of time-to-event data: Selection bias and imputation from the Framingham Heart Study

Harvard University (37)

DEPARTMENT OF BIOSTATISTICS
Aryee, Martin, Leveraging hidden correlations in high-dimensional biological data
Basagana Flores, Xavier, Design of observational longitudinal studies
Cheng, Xiaorong, Model-based association tests with longitudinal measurements
Loehrke, Patrick, Novel methods for efficient surveillance and monitoring
Olsthoorn, Benjamin, Using mixed effects models to integrate high-dimensional, genomic data and an array-based analysis of the evolution of brain aging
Marotta, Sebastian, The complex dynamics of singularly perturbed rational maps
Matsura, Ryota, Twisted root numbers of elliptic curves semistable at primes above 2 and 3
Mikuteno, Oleg, Applications of the resolution of singularities to asymptotic analysis of differential equations
Sawada, Ken, Estimating causal treatment effects for post-randomization marker data with failure event censoring
Wahl, Eric, Geodesics on isopotential surfaces and solutions to Newton’s N-body problem
Yeats, Karen, Growth estimates for Dyson–Schwinger equations
Zollinger, Elizabeth, A family of comets in the three-body problem
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**Wang, Rui**

**Harvey, David**

**Alvine, Amanda**

**Freer, Cameron**

**Ravichandran, Caitlin**

**Fedorchuk, Maksym**

**Chen, Dawei**

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**Massachusetts Institute of Technology** (17)

**Chebikin, Denis**

Polytopes, generating functions, and new statistics related to descents and inversions in permutations

**Fang, Chuying**

Ad-nilpotent ideals of complex and real reductive groups

**Francis, John**

Derived algebraic geometry over $\mathbb{E}_n$-rings

**Gu, Jerin**

Single-petaled K-types and Weyl group representations for classical groups

**Havlickova, Marketa**

Boundaries of K-types in discrete series

**Kamrin, Kenneth**

Stochastic and deterministic models for dense granular flow

**Konvalinka, Matjaž**

Combinatorics of determinantal identities

**Lee, Peter**

Gröbner bases in rational homotopy theory

**Lipyansky, Maksim**

A semi-infinite cycle construction of Floer homology

**Montarani, Silvia**

Finite dimensional representations of symplectic reflection algebras for wreath products

**Rubinstein, Yanir Akiva**

Geometric quantization and dynamical constructions on the space of Kähler metrics

**Rycroft, Christopher**

Multiscale modeling in granular flow

**Savva, Nikos**

Viscous fluid sheets

**Shapiro, Yakov**

An extension of the Hodge theorem to certain non-compact manifolds

**Sidonko, Sergiy**

Kac’s random walk and coupon collector’s process on posets

**Wang, Zuoqin**

Dirac operators and monopoles with singularities

**Northeastern University** (3)

**Long, David**

Alexander and Thurston norms of links and 3-manifolds

**Pelaye-Menaldo, Jose Pablo**

Multiplicative properties of the slice filtration

**Straus, Kenneth**

Validation of a probabilistic model of language acquisition in children

**Tufts University** (2)

**Department of Mathematics**

**Caterina, Gianluca**

Least action principles and additive invariants for a class of reversible cellular automata

**Munro, Erin C.**

The axonal plexus: A description of the behavior of a network of axons connected by gap junctions

**University of Massachusetts, Amherst** (8)

**Department of Mathematics and Statistics**

**Are, Sasanka**

Coarse-graining dynamics of interacting particle systems

**Beheshti, Shabnam**

Solutions of dilaton field equations with applications to the soliton-black hole correspondence in generalized JT gravity

**Damon, Elh**

Analysis of the Gauss-Green form on the moduli space of unduloids

**Diehl, Michael**

Large deviations of observables in classical and quantum lattice spin systems

**Fenn, Molly**

Generating equivalence class of B-stable ideals

**Herring, Gregory**

Some applications of computational mathematics: Tumor angiogenesis and Bose-Einstein condensates

**Oh, Choongwon**

Well-posedness theory of a one parameter family of coupled KdV-type systems and their invariant Gibbs measures

**VonRenesse, Christine**

Combinatorial aspects of toric varieties

**Worcester Polytechnic Institute** (1)

**Department of Mathematical Sciences**

**Richardson, Casey**

Some problems in the mathematics of fracture: Paths from front kinetics and a level set method

**MICHIGAN**

**Central Michigan University** (5)

**Department of Mathematics**

**Alraqad, Tariq**

Construction of non-embeddability of quasi-residual designs

**Karthikeyan, Palramani**

Compact and Hilbert-Schmidt weighted composition operators on the Bergman space

**Li, Shubiao**

The generalized Lagrangian probability distribution: Properties and applications

**Osifodunrin, Adegoke Solomon**

Investigation of difference sets with order 36
Qin, Huaizhen, Statistical approach for
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Brooks, Cara, Symplectic struc-
Baykur, Refik Inanc
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Oakland University (4)

Qin, Huaizhen, Statistical approach for
genome-wide association study and microarray analysis

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without damage or frictionless contact
Shawsh, Nart, Relationships among pop-
ular interconnection networks and their
common generalization
Wijesiri, Galbodhayage, Theta functions of
algebraic curves with automorphisms

University of Michigan (26)

Agarwal, Mahesh, p – L function for
GSp(4) × GL(2)
Bauer, Amy, A multi-scale cell-based model to simulate and elucidate
the mechanisms controlling tumor-induced angiogenesis
Cais, Bryden, Correspondences, integral
structures, and compatibilities in p-adic
cohomology
Crown, Sarah, The homology of the cyclic
coloring complex of simple graphs
Feng, Hualong, Vortex sheet simulations of
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panel/particle method
Hah, Sukmoon, Moduli spaces of stable
sheaves on a plane and an embedded
curve
Khan, Rizwanur, Non-vanishing of the
symmetric square L-function
Maruskin, Jared, On the dynamical prop-
agation of subvolumes and on the
geometry and variational principles of
nonholonomic systems
Min, Hyeyoung, Stochastic control mod-
els of optimal dividend and capital
financing
Mueller, Charles, On the varieties of pairs of
matrices whose product is symmetric
Rong, Feng, Critically finite maps, attrac-
tors and local dynamics
Sargosyan, Khachik, First passage times in
the near-continuum limit of birth-death
processes
Stein, Andrew, Mathematical models for
glioblastoma invasion in vitro
Stipins, Janis III, On finite k-nets in the
complex projective plane
Voemmet, Ellen, The computational com-
plexity of convex bodies
Wildrick, Kevin, Quasisymmetric param-
eterizations of two-dimensional metric
spaces
Zupunski, Eric, A bound on the com-
pactness of the JSJ decomposition in the bounded case

University of Minnesota (2)

Cengiz, Nesrin, What allows teachers to
extend student thinking during whole
group discussions
Cox, Dana, Understanding similarity: Bridging visual and analytical strate-
gies for proportional thinking

Wayne State University (5)

Nguyen, Mau Nam, Variational analysis of
marginal functions and set-valued
mappings with applications to opti-
mization and stability
Potsepun, Nadiya, The long-run behavior
of the replicator dynamics systems under
the Stratonovich type random
perturbations
Sun, Lijing, A CR Poincaré inequality and
fundamental solutions of generalized
subelliptic Schrödinger operators
Wei, Jinfeng, Time series modeling for
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Zhu, Chao, Asymptotic properties of
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Western Michigan
University (2)

Zhang, Yanwei, Topics on change-point esti-
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Lee, Joon Sang, Two stage sequential
estimation procedures and a convex
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Li, Youjuan, Efficient computation and
model selection of regularized quantile
regression
Somboonsavatdee, Anupap, Some contri-
butions to reliability and lifetime data
analysis
Verbiksky, Natalya, Association and
causal inference in spatial hierarchi-
cal settings: Theory and applications

MINNESOTA

University of Minnesota-Twin Cities (10)

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Cui, Yue, Smoothing analysis of variance
and extending the definition of degrees of
freedom

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Borba de Andrade, Bernardo, Topics in
nonstandard probability theory
Dong, Yingwen, Inference and model
selection
Ferrari, Davide, Maximum Lq-likelihood
method: Parametric density estimation
via nonextensive entropy minimization
Forzani, Liliana, Sufficient dimension
reduction based on normal and Wishart
inverse models
Kraker, Jessica, Penalized regression methods and validation, with particular focus on chemometric data

Lin, Chihe, Optimal combining of statistical procedures

Shao, Yongwu, Topics on dimension reduction

Strief, Jeremy, Bayesian sampling weights: An approximation to the Polya posterior

Zhao, Bo, Noncommutative differential calculus from the inner derivation

MONTANA

Montana State University-Bozeman (3)

DEPARTMENT OF MATHEMATICAL SCIENCES

Colt, Diana, Cognitive presence among mathematics teachers: An analysis of tasks and discussions in an asynchronous online graduate course

Harper, Jonathan, The use of computer algebra systems in a procedural algebra course to facilitate a framework for procedural understanding

Sharp, Julia, New statistical methods for analyzing proteomics data from affinity isolation LC-MS/MS experiments

University of Montana - Missoula (3)

DEPARTMENT OF MATHEMATICAL SCIENCES

Lambert, Scott, Spectral preserver problems in uniform algebras

Laobeul, N'Djekornom, Regularization methods for ill-posed Poisson imaging problems

VanSpronsen, Hillary, Proof processes of novice mathematics proof writers

NEBRASKA

University of Nebraska-Lincoln (12)

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Davis, Jennifer, Algebraic geometric codes on anticanonical surfaces

Dvorak, Matthew, Qualitative and quantitative analysis of a fluid-structure interactive partial differential equation model

Eubanks-Turner, Christina, Prime ideals in low-dimensional mixed polynomial/power series rings

Feller, Heidi, Solving boundary value problems using critical point theory

Gregg, Martha, C*-extreme points in the generalized state space of a commutative C*-algebra

Higgins, Raegan, Oscillation theory of dynamic equations on time scales

Luckas, Melissa, Ranks and bounds for indecomposable modules over one-dimensional Noetherian rings

Milan, David, C*-algebras of inverse semigroups

Sakuntasathien, Sawanya, Global well-posedness for systems of nonlinear wave equations

Weiss, Jacob, Second order dynamic equations on time scales

DEPARTMENT OF STATISTICS

Schmid, Kendra, Analysis of landmark data using multi-dimensional regression

Wang, Yi, Semiparametric mixed-effects analysis on PK/PD models using differential equations

NEW HAMPSHIRE

University of New Hampshire (1)

DEPARTMENT OF MATHEMATICS AND STATISTICS

Fang, Junsheng, Unitarily invariant norms and tensor products of maximal injective von Neumann subalgebras

NEW JERSEY

New Jersey Institute of Technology (4)

DEPARTMENT OF MATHEMATICAL SCIENCES

Chandrasekaran, Lakshmi, Role of plasticity in temporal coding of neuronal networks

Ha, Joon, Roles of gap junctions in neuronal networks

Murisic, Nebojsa, Instabilities of volatile films and drops

Posta, Filippo, Signal transmission in epithelial layers

Princeton University (9)

DEPARTMENT OF MATHEMATICS

Arguin, Louis-Pierre, The structure of correlation in quasi-stationary competing particle systems

Carlsson, Erik, Vertex operators and moduli spaces of sheaves

Gornik, Bojan, Duality of Khovanov-Rozansky link homology

Juhasz, Andras, Floer homology and sutured manifolds

Li, Ye, Smoothing Riemannian metrics in dimension 4 and its applications

Sorrentino, Alfonso, On the structure of action-minimizing sets for Lagrangian systems

Sullivan, Blair D., Extremal problems in digraphs

Xu, Chenyang, Topics on rationally connected varieties

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Kryazhimskiy, Sergey, Pathogen evolution under natural selection: The influenza A case study
Rutgers University-Newark (1)
Department of Mathematics and Computer Science
McDonald, Keith Tim, On p-adic zeta functions and their derivatives at s = 0

NEW MEXICO
New Mexico State University, Las Cruces (1)
Department of Mathematical Sciences
Noussi, Hubert, Stabilization of competition models in the chemostat via feedback linearization

University of New Mexico (2)
Department of Mathematics and Statistics
Gomez, Ralph, On Lorentzian Sasaki-Einstein geometry

NEW YORK
Clarkson University (4)
Department of Mathematics and Computer Science
Sanitissadeekorn, Naratip, Transport analysis and motion estimation of dynamical systems of time-series data

Columbia University (16)
Department of Mathematics
Baldwin, John, Heegaard Floer homology, contact structures, and open books
Fabre, Alexander, Topics in arithmetic geometry over function fields
Gillam, William, Hyperelliptic Gromov-Witten theory
Gkigkitzis, Ioannis, On the cross curvature tensor and the cross curvature flow
Hanson, Nels, Sobolev norms of holomorphic sections and variations of the density of states
Hsieh, Ming-Lun, Construction of p-adic ordinary Eisenstein series on certain unitary groups
Kontorovich, Alex, The hyperbolic lattice point count in infinite volume with applications to sieves
Li, Qi, Energy functional and their applications to Monge-Ampère equations
Mezhericher, Borislav, Computational aspects of Maass forms for SL(3, Z)
Swinarski, David, Geometric invariant theory and moduli spaces of pointed curves
To, Tung, A free boundary problem for the evolution p-Laplacian equation with a combustion boundary condition
Yuan, Xinyi, Equidistribution theory over algebraic dynamical systems
Zhang, Bei, Fourier-Jacobi coefficients of Eisenstein series on unitary group
Zickert, Christian, Hyperbolic 3-manifolds and the Cheeger-Chern-Simons class

Department of Statistics
Abayomi, Kobi Ako, Diagnostics for multivariate imputation copula based independent component analysis and a motivating example
Lee, Yi Hsuan, Contributions to the statistical analysis of item response time in educational training

Cornell University (12)
Center for Applied Mathematics
Lyles, Danielle, Chromaffin cell excitability and BK channel gating: Data, modeling, simulation, and experiment
Robinson, Michael, Eternal solutions and heteroclinic orbits of a semilinear parabolic equation
Schmidt, Deena, A mathematical look at DNA regulatory sequence evolution
Sherwood, William Erik, Response in networks of bursting neurons: Modeling central pattern generators
Yamada, Richard Yujiro, Quantitative models of transcriptional elongation
Zhang, Wenjie, Measure of serial dependence and testing for conditional quantile models

Department of Mathematics
Eshmatov, Farkhod, The Calogero-Moser correspondence for noncommutative deformations of Kleinian singularities
Gyrya, Pavel, Heat kernel estimates for inner uniform subsets of Harnack-type Dirichlet spaces
Johnston, Henri, The trace map and Galois module structure of rings of integers for absolutely abelian number fields
Scheweig, Jay, Poset convex-eam decompositions and applications to the flag h-vector
Simeakopoulos, Achilleas, On some classes of Borel fixed ideals and their cellular resolutions
Velasco, Mauricio Fernando, Monomial resolutions and the Cox rings of del Pezzo surfaces

Graduate Center, City University of New York (7)
PhD Program in Mathematics
Mumm, Michael, Volume growth and the topology of manifolds with nonnegative Ricci curvature
Nechayeva, Marina, Asymptotics of weighted lattice point counts inside dilating domains
Serme, Abramane, On iterative refinement/improvement of the solution to an ill conditioned linear system
Wojciechowski, Radoslaw, Stochastic completeness of graphs
Won, Dong Wook, Word problems on balanced semigroups and groups
Yuan, Shenglan, Dynamics of certain families of transcendental meromorphic functions
Zyman, Marcos, IA-automorphisms and localization of nilpotent groups

New York University, Courant Institute (20)
Courant Institute of Mathematical Sciences
Bramham, Barney, Pseudoholomorphic foliations for area preserving disc maps
Cousot, Laurent, Constructions of martingales and of increasing processes with constrained marginal distributions
Diaz-Alban, Jose, The high frequency and inviscid limit of acoustic waves in a porous medium
Fish, Joel, Compactness results for pseudo-holomorphic curves
Hammond, David, Representing and modeling images with multiscale local orientation
Hasha, Alexander, Gravity wave refraction by three-dimensionally varying winds and the global transport of angular momentum in the atmosphere
Heymann, Matthias, The geometric minimum action method: A least action principle on the space of curves
Hryniewicz, Umberto, Finite energy foliations of convex sets in R^4
Huang, Shih-Ting, On the mechanism of forward motion during flapping flight: Numerical simulation by the immersed boundary method
Kadota, Minoru, The Madden-Julian oscillation and its seasonal impact on mid-latitude weather predictability
Kargin, Vladislav, Limit theorems in free probability theory
Koiller, José, Invariant measures for coupled map graphs
Kuptsov, Alexey, REM universality for random Hamiltonians
Lee, Pilhwa, The immersed boundary method with advection-electrodiffusion
Royzman, Roman, Randomly trapped random walks
Shen, Haiping, Two PDE problems from electromagnetics
Spagnolie, Saverio, Flapping, ratcheting, bursting and tumbling: A selection of problems in fluid-body interaction dynamics

Stechmann, Samuel, Models of convectively coupled waves in the tropical atmosphere

Tice, Ian, Lorentz space estimates and applied boundary current dynamics for Ginzburg-Landau

Vilenky, Yevgeny, Large deviation bounds for the totally asymmetric simple exclusion process

Polytechnic University (3)

Department of Mathematics

Centonze, Paolina, An algebra for access control

Lenchner, Jonathan, Sylvester-Gallai results and other contributions to combinatorial and computational geometry

Morgan, Thomas, Concentration and sparsity in space and frequency

Rensselaer Polytechnic Institute (7)

Department of Mathematical Sciences

Agius, Phaedra, Mathematical models for biological data

Andersen, Timothy, Trapped slender vortex filaments in statistical equilibrium

Dediu, Simona, Analysis of frequency dependent attenuation in shallow water

Gershogorin, Boris, Characterization of thermalyzed Fermi-Pasta-Ulam chains

Kunapuli, Gautam, A bi-level optimization approach to machine learning

Yan, Fu, Two-stage Nash equilibrium problems

Zhao, Jinye, Recent applications of Nash equilibria

State University of New York at Albany (2)

Department of Mathematics and Statistics

Clark, Timothy, Poset resolutions of monomial ideals

Madsen, Alpheus, Symbolic powers and Gorenstein grade-3 ideals

State University of New York at Binghamton (6)

Department of Mathematics and Science

Atanasov, Risto, Groups of geometric dimension 2

Chen, Cuixian, Asymptotic properties of the Buckley-James estimator for a bivariate interval censorship regression model

Du, Jichang, Covariate-matched estimator of the error variance in nonparametric regression

Loftus, John, Powers of words in language families

Millan-Vossler, Silvia, The Whitehead and the lower algebraic K-theory of braid groups on $S^2$ and $\mathbb{RP}^2$

Wassink, Bronlyn, Subgroups of R. Thompson's group $F$ that are isomorphic to $F$

State University of New York at Buffalo (5)

Department of Mathematics

Han, Xiaoying, Interlayer mixing in thin film growth

Li, Jinglai, Estimating the reliability of optical fiber communication systems

Mastroberardino, Antonio, Three-dimensional equilibrium crystal shapes with corner energy regularization

Yu, Chih-Chien, Conditions for the existence of a steady state solution for a competition system of plankton population

Department of Biostatistics

Pak, Younju, Multivariate linear path models

State University of New York at Stony Brook (31)

Department of Applied Mathematics and Statistics

Brady, Christine, Power analysis of finite mixtures of Poisson distributions

Braunstein, Janet, Analysis of task mapping for parallel supercomputers

Du, Jian, Simulations of magnetohydrodynamics multiphase flow

Fazzari, Melissa, Classification ensembles with applications to genomics

Huang, Zhuying, The power of linkage analysis of a quantitative disease endophenotype

Ji, Chen, Joint analysis of gene and protein data

Jia, Xicheng, Applications of front tracking to multiple scientific problems

Lawrence, Paul, Thermonuclear flame studies in rectangular geometry

Lee, Hyunsun, Compressible multiphase multisppecies flow models

Li, Yuanhua, Enhanced 3D front tracking method with locally grid based interface

Lim, Noha, Classification ensembles from random partitions using logistic regression models

Ma, Yeming, Step density function and bootstrap resampling

Manu, Manu, Canalization of gap gene expression during early development in Drosophila melanogaster

Masser, Thomas, Breaking temperature equilibrium for mixed cell hydrodynamics

McQuown, Joseph, Multi-scale, geometric algorithm for non-parametric data exploration with an application to genomic data

Polishchuk, Valentia, Non-crossing paths and minimum-cost flows in polygonal domains

Tung, Lin, The impact of genotype misclassification errors on the power to detect a genetic association and gene-environment interaction with Cox proportional modeling

Wang, Shuqiang, Solving elliptic interface problem using mixed finite element method

Wu, Xiangfeng, Optimal designs for segmented polynomial models and web-based implementation of optimal design software

Zhang, Yue, Path analysis of multivariate time series data with subject-level covariates

Department of Mathematics

An, Daniel, Complete set of eigenfunctions of the quantum periodic Toda chain

Chen, Je-Wei, Neighborly properties of simple convex polytopes

Chen, Xiaojun, On general chain model of the free loop space and string topology

Dupon, Emiko, A symplectic isometry of a product of projective spaces

Dutta, Satyaki, Rigidity of conformally compact manifolds

Kalafat, Mustafa, Self-dual metrics on 4-manifolds

Li, Tao, A monotonicity conjecture for the entropy of Hubbard trees

Mustopa, Yusuf, The effective cone on symmetric powers of curves

Prince, Tanvir, On the Lego-Teichmüller game for finite G cover

Shu, Yu-Jen, Compact complex surfaces and cscK metrics

Unal, Ibrahim, Phi-critical submanifolds and convexity in calibrated geometry

Syracuse University (5)

Department of Mathematics

Adamowicz, Tomasz, On the geometry of $p$-harmonic mappings

Dickerson, David, High school mathematics teachers’ understandings of the purposes of mathematical proof

Kinnamon, Patrick, Calculus students’ understandings of the concepts of function transformation, function composition, function inverse, and the relationships among the three concepts

Nzuki, Francis, Investigating African American students’ identity and agency in a mathematics and graphing calculator environment at a low-SES school

Struble, Dale, Wavelets on manifolds and multiscale reproducing kernel Hilbert spaces

University of Rochester (7)

Department of Biostatistics and Computational Biology

He, Hua, Correcting verification bias in the assessment of the accuracy of diagnostic tests
Wagner-Georges, Lesley, Some skew models for quantal response analysis

DEPARTMENT OF MATHEMATICS

Bian, Ji, The pair correlation of zeros of $\xi^{(k)}(s)$
Liang, Lei, Comparison principle for stochastic heat equations
Lu, Naiji, Models based on pure birth and branching process
Milovich, Micah, Mean-value estimates for the derivative of the Riemann zeta function
Xue, Heng, Extensions of stochastic integrals as distributions and applications to SPDEs

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Duke University (13)

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Belov, Sergei, Breaking in the semiclassical solution of the focusing nonlinear Schrödinger equation
Gratton, Michael, Coarsening of thin fluid films
Narkawicz, Anthony, Cohomology jumping loci and the relative Malcev completion
Nicholas, Michael, A third order numerical method for 3D doubly periodic electromagnetic scattering problems
Robbins, Nicholas, Negative point mass singularities in general relativity
Spivey, Joseph, Twisted cohomology of hyperelliptic mapping class groups
Xu, Feng, SU(3) structures and special Lagrangian geometries

DEPARTMENT OF STATISTICAL SCIENCE

Chu, Jen-Hwa, Bayesian function estimation using overcomplete dictionaries with application in genomics
Kinney, Satkartar, Model selection and multivariate inference using data matrix imputed for disclosure limitation and nonresponse
Pillai, Nateesh, Levy random walks: Posterior consistency and applications
Sang, Huiyan, Extreme value modeling for space-time data with meteorological applications
Shen, Haige, Bayesian analysis in cancer pathway studies and probabilistic pathway annotation
Woodard, Dawn, Conditions for rapid and torpid mixing of parallel and simulated tempering on multimodel distributions

North Carolina State University (30)

DEPARTMENT OF MATHEMATICS

Beier, Julie, Crystals for Demazure modules of special linear quantum affine type
Beun, Stacy, On the classification of orbits of minimal parabolic $k$-subgroups acting on symmetric $k$-varieties of $\text{SL}(n, k)$
Braun, Tom, High speed model implementation and inversion techniques for smart material transducers
Brown, Jonathan, N-symplectic quantization
Cook, James, Foundations of supermathematics with applications to $N = 1$ supersymmetric field theory
David, John, Estimation and shape design: Analysis and applications
De Valt, Kristen, Numerical study of two problems in fluid flow: Cavitation and cerebral circulation
Dillard, Karen, An application of implicit filtering to water resources management
Gong, Yan, Immersed-interface finite-element methods for elliptic and elasticity interface problems
Grove, Sarah, Optimization problems in the presence of uncertainty
Osborne, Jason, On geometric control design for holonomic and nonholonomic mechanical systems
Petersen, Richard, Transformation semigroups over groups
Sweetingham, Kelly, Auxiliary signal design for fault detection in nonlinear systems
Wills, Rebecca, When rank trumps precision: Using the power method to compute Google’s pagerank

DEPARTMENT OF STATISTICS

Chang, Sheng-Mao, A stationary stochastic approximation algorithm for estimation in GLMM
Chiswell, Karen, Model diagnostics for the nonlinear mixed effects model with balanced longitudinal data
Griffith, Emily, Catch curve and capture recapture models: A Bayesian combined approach
Gu, Jiezhu, Nonparametric and semiparametric inference about ROC curves
Huang, Lingkang, Variable selection in multiclass support vector machine and application in genomics data analysis
Jones, Martha, A retrospective method for inference on haplotype main effects and haplotype-environment interactions using clustered haplotypes
Liu, Jiajun, Domain enhanced analysis of microarray data using the gene ontology annotations
Liu, Shufang, Modeling mean residual life function using scale mixtures
Lu, Xiaomin, Improving the efficiency of test and estimates of treatment effect with auxiliary covariates in the presence of censoring
Nail, Amy, Quantifying local creation and regional transport using a hierarchical space-time model of ozone as function of observed NOx, a latent space-time VOC process, emissions, and meteorology
Ni, Xiaohan, Variable selection in partial linear models and semiparametric mixed models

Tang, Lihua, “Smooth” inference for clustered survival data
Yang, Hongmei, Variable selection procedures for generalized linear mixed models in longitudinal data analysis
Yoshizaki, Jun, Use of natural tags in closed population capture-recapture studies: Modeling misidentification
Yu, Miao, Quantitative trait loci (QTL) mapping with longitudinal traits
Zhang, Min, Semi-parametric methods for analysis of randomized clinical trials and arbitrarily censored time-to-event data

University of North Carolina at Chapel Hill (24)

DEPARTMENT OF MATHEMATICS

Hague, Charles, Cohomology of flag varieties and the BK-filtration
Jablonski, Michael, Real geometric invariant theory and Ricci soliton metrics on two-step nilmanifolds
Lee, Joohee, Mathematical descriptions of nematic polymers in the monolayer limit
Lin, Zhi, Passive scalar intermittency in random flows
Lindley, Brandon S., Linear and nonlinear shear wave propagation in viscoelastic media
Marangell, Robert, The general quadruple point formula
Richmond, Edward, Recursive structures in the cohomology of flag varieties
Todd, Abby, Inclusion of a glycolen regulation mathematical model into a contextual metabolic framework
Yang, Gao, Short time behavior of solutions to nonlinear Schrödinger equations in $N$ space dimensions
Yao, Lingxing, Viscoelasticity at microscopic and macroscopic scales characterization and prediction

DEPARTMENT OF STATISTICS AND OPERATION RESEARCH

Bai, Ping, Temporal-spatial modeling in FMRI
Didier, Gustavo, Adaptive wavelet decompositions of time series
Gaydos, Travis, Data representation and basis selection to understand variation of function valued traits
Huang, Tao, Continuous optimization approaches to the quadratic assignment problem
Lee, Chihoon, Long time asymptotics for constrained diffusions in polyhedral domains
Lee, Myung Hee, Continuum direction vectors in high dimensional low sample size data
Liu, Lijiang, Queueing models with workload-based balking applications to call center
Liu, Xiaxin, New statistical tools for microarray data and comparison with existing tools

DEPARTMENT OF STATISTICS

Cook, James, U. S. E. O. F. N. T. U. R. A. L. T. A. G. S. Microarray data and comparison with existing tools

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case Western Reserve
University
Department of Mathematics
Li, Zhuo Bin, Schistosomiasis transmission and control in a distributed heterogeneous human-snail environment in coastal Kenya
Zachlin, Paul, On the field of values of the inverse of a matrix

Department of Epidemiology and Biostatistics
Bajunirwe, Francis, Effectiveness of antiretroviral therapy in rural Uganda
Jun, Gyungah, Identification of genes associated with age-related cataract
Kiwanuka, Noah, The effect of HIV-1 subtypes on HIV transmission and disease progression in Rakai district, Uganda
Kou, Tsuyang Doug, Watchful waiting and active surveillance in prostate cancer patients—a population-based study using the SEER-Medicare linked database
Liu, Constance, Evaluating measures of geographic accessibility in urban diabetics in Cuyahoga County

Kent State University
Department of Mathematical Sciences
Abramov, Vilen, Stopping times related to trading strategies
Li, Hongcheng, Multivariate extension of CUSUM procedure
Rollick, Mary Elizabeth, Puzzling over spatial reasoning: A phenomenological study of pre-service elementary teachers

Ohio State University, Columbus
Department of Mathematics
Balachandran, Niranjan, The 3-design problem
Hambrock, Richard, Evolution of conditional dispersal: A reaction-diffusion-advection approach
Hur, Suhjung, The Kuratowski covering conjecture for graphs of order less than 10
Lennon, Craig, On the likely number of stable marriages
McClain, Christopher, Edge colorings of graphs and multigraphs

NORTH DAKOTA
North Dakota State University, Fargo
Department of Mathematics
Matson, Amanda, Results regarding finite generation, near finite generation, and the catenary degree

Ohio University, Athens
Department of Mathematics
Srivastava, Ashish, Rings characterized by properties of direct sums of modules and on rings generated by units

University of Akron
Department of Theoretical and Applied Mathematics
Childers, Carey, Effective properties of a fiber reinforced composite with a functionally graded transition zone

University of Cincinnati
Department of Mathematical Sciences
Camfield, Christopher, Comparison of BV norms in weighted Euclidean spaces and metric measure spaces
Hunter, Tina, Gibbs sampling and expectation maximization methods for estimation of censored values from correlated multivariate distributions
Jiang, Dongming, Objective Bayesian testing and model selection for Poisson models
Oraby, Tamer, Spectra of random block-matrices and products of random matrices

Maroulan, Vasileios, Small noise large deviations for infinite dimensional stochastic dynamical systems
Shamseldin, Elizabeth C., Asymptotic multi-variate kriging using estimated parameters with Bayesian prediction methods for non-linear predicaments
Sun, Xing, Significance and recovery of block structures in binary and real-valued matrices with noise
Trovero, Michele A., Effects of aggregation on estimators of long-range dependence
Zhang, Lingsong, Functional singular value decomposition and multi-resolution anomaly detection
Zhou, Jie, High dimensional spatial modeling of extremes: With application to U.S. rainfalls

University of North Carolina at Charlotte
Department of Mathematics and Statistics
Fan, Kai, A generalized discontinuous Galerkin (DG) method and its applications
Hyun, Jeungyoun, Statistical analysis of competing risk models
Jalali, Mohammadreza, Central limit theorem for Markov chains on compact abelian groups
Jeong, Jae-Woo, Implementation of reproducing polynomial particle (RPP) shape functions in meshless particle methods for two-dimensional elliptic partial differential equations
McNair, Dawn, Duals of ideals and trace properties in rings with zero divisors
Squartini, Nicola, Global limit theorems for sums of independently identically distributed random variables using quasicumulants
Ruth, Harry L., Jr., Conformal densities and deformations of uniform Loewner metric spaces
Usman, Muhammad, Forced oscillations of the Korteweg-de Vries equation and their stability

University of Toledo (1)
Department of Mathematics
Liu, Nanshan, Theory and applications of Legendre polynomials and wavelets

OKLAHOMA

Oklahoma State University (1)
Department of Statistics
Wagler, Amy, Simultaneous inference in generalized linear model settings

University of Oklahoma (3)
Department of Mathematics
Martinez, Eduardo, Combination of quasiconvex subgroups in relatively hyperbolic groups
Okaya, Pedro, Orbital integral correspondence for the pair \((G_2, S_3(1, R))\) via the Cauchy Harish-Chandra integral
Seo, Arim, Torus leveling of \((1, 1, 1)\)-knots

OREGON

Oregon State University (5)
Department of Mathematics
Strowbridge, Jessica, Middle school teachers’ use of a formative feedback guide in mathematical problem solving instruction

Department of Statistics
Giovanini, Jack, Generalized linear mixed models with censored covariates
Henry, John, III, Extreme value index estimation with applications to modeling extreme insurance losses and sea surface temperatures
Irvine, Kathy, Graphical models for multivariate spatial data
Lu, Lin, Unconditional estimating equation approaches for missing data

Portland State University (2)
Department of Mathematics and Statistics
Ciancetta, Matthew, Statistics students’ reasoning when comparing distributions of data
Noll, Jennifer, Graduate teaching assistants’ statistical knowledge for teaching

University of Oregon (5)
Department of Mathematics
Archey, Dawn, Crossed product C*-algebras by infinite group actions with a generalized tracial Rokhlin property
Jordan, Alexander, A super version of Zhu’s theorem
Kronholm, William, The RO(G)-graded Serre spectral sequence
Miller, Matthew, The rational homotopy types of configuration spaces of three-dimensional lens spaces
Wilson, James, Group decompositions, Jordan algebras, and algorithms for p-groups

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Bryn Mawr College (3)
Department of Mathematics
Battiste Presutti, Cathleen, Determining lower bounds for packing densities of non-layered patterns using weighted templates
Dalton, Jennifer, Legendrian torus links
Teti, Sherry, The existence of elliptic periodic orbits in the smoothed Bunimovich stadium

Carnegie Mellon University (6)
Department of Mathematical Science
Anthony, Barbara, Approximation algorithms for network design with uncertainty
Carita, Graca, Relaxation in SBV for constrained-valued fields
Cohen, Albert, A probabilistic analysis of grain growth
Towsner, Henry, Some results in logic and ergodic theory
Young, Michael, Triangle problems in extremal graph theory

Department of Statistics
Serban, Mihaela, Derivative pricing under multivariate stochastic volatility models with application to equity options

Lehigh University (3)
Department of Mathematics
Gorman, Jennifer, Nested traveling salesperson problems
Mformbele, Akongwi Clement, Time dependent and steady state interaction among capillaries in skeletal muscle
Panofsky, Ellen, Graph labeling problems with distance conditions

Pennsylvania State University (18)
Department of Mathematics
Bang, Seunghoon, Rarefaction wave of pressure-gradient system
Barton, James, Generalized complex structures on Courant algebroids
Cho, Durkbin, Multilevel methods for the generalized finite element method discretizations
Kang, Haneok, Dynamics of the local map of a discrete Brusselator model

Keith, William, Ranks of partitions and Durfee symbols
Rowell, Michael, The Bailey transform and conjugate Bailey pairs
Stojanovic, Gordana, Embedding with certain non-degeneracy conditions
Wang, Jiakou, Stochastic and deterministic coagulation models, their numerical approximations and applications to cell aggregation
Zhang, Ke, Thermodynamic formalism for maps with inducing schemes

Department of Statistics
Han, Bing, A Bayesian approach to false discovery rate for large scale simultaneous inference
Hui, Guodong, Matrix distances with their application to finding directional deviations from normality in high-dimensional data
Jung, Hyekyung, A latent-class selection model for nonignorable missing data
Li, Yan (Maggie), Some contributions to nonparametric modeling with correlated data
Seo, Byungtae, Doubly-smoothed maximum likelihood estimation
Tang, Zhihui, Three topics on dimension reduction
Yang, Jinyuan, Measurement of agreement for categorical data
Young, Derek, A study of mixtures of regression

Temple University (4)
Department of Mathematics
Bitew, Worku, Sufficient conditions and higher-order regularity for local minimizers in the calculus of variations
DeSario, David, Polyhedral sums and theta series
Elhashash, Abdul Rahman (Abed), Perron-Frobenius properties of general matrices and generalized M-matrices which may not have nonnegative inverses
Liu, Zhongzhi, Quantum random walks under decoherence

University of Pennsylvania (4)
Department of Mathematics
Bagdasarov, Pavelescu, Elena, Braids and open book decompositions
Dalakov, Peter, Higgs bundles and opers
Fithian, David, Pseudomodular Fricke groups
Kerin, Martin, Biquotients with almost positive curvature

University of Pittsburgh, Pittsburgh (7)
Department of Mathematics
Day, Jerry, On Banach function spaces and the fixed point property
Day, Judy, Mathematical approaches to modeling, understanding, and controlling the acute inflammatory response to pathogen and endotoxin

Hancioglu, Baris, Mathematical modeling of virus dynamics in immunology

Mi, Qi, Modelling wound healing in necrotizing enterocolitis and diabetic foot ulcer

Neda, Monika, Numerical analysis and phenomenology of homogeneous, isotropic turbulence generated by higher order models of turbulence

Pejić, Bojana, On the uniqueness of Polish group topologies

Xie, Dejun, Optimal prepayment strategy of mortgages

RHODE ISLAND

Brown University (15)

Department of Mathematics

Kwon, Hyun-Kyoung, Similarity of operators and geometry of eigenvector bundles

Miller, Stephen Francis, The calculus of equivariant spectra and a classification of degree 2 endofunctors

Stange, Katherine Elisabeth, Elliptic nets and elliptic curves

Wise, Jonathan Samuel Dennis, The genus zero Gromov-Witten theory of \([\text{Sym}^2 \mathbb{P}^2]\) and the enumerative geometry of hyperelliptic curves in \(\mathbb{P}^2\)

Yasufuku, Yu, Vojtěch’s conjecture and blowups

Division of Applied Mathematics

Chun, Seun, High-order accurate methods for solving Maxwell’s equations; modeling photonic crystals and thin layer approximations

Dean, Thomas Anthony, A subsolutions approach to the analysis and implementation of splitting algorithms in rare event simulation

Feizizadeh, Matt, Conformal shape representation

Foo, Jasmine, Multi-element probabilistic collocation in high dimensions: Applications to systems biology and physical systems

Keaveny, Eric, Dynamics of structures in active suspensions of paramagnetic particles and applications to artificial micro-swimmers

Leder, Kevin, Large deviations and importance sampling for queuing systems with discontinuous service policies

Li, Zheng, Approximation to random process by wavelet basis

Libertini, Jessica, Determining tumor blood flow parameters using dynamic imaging data

Micheli, Mario, The differential geometry of landmark shape manifolds: Metrics, geodesics, and curvature

Wang, Wei, Multiscale discontinuous Galerkin methods and applications

SOUTH CAROLINA

Clemson University (6)

Department of Mathematical Sciences

Beeler, Robert, Automorphic decompositions of graphs

Faulkner, Bryan, Estimates related to the arithmetic of elliptical curves

Howell, Jason, Numerical approximation of shear-thinning and Johnson-Segalman viscoelastic fluid flows

Kraft, Christine, Planning, scheduling, and timetabling in a university setting

Seneviratne, Padmapani, Permutation decoding of the codes from graphs and designs

Zhao, Meng, Issues in model selection, minimax estimation, and censored data analysis

Medical University of South Carolina (7)

Department of Biostatistics, Bioinformatics & Epidemiology

Hedden, Sarra, Methods in substance abuse clinical trials

Howard, Virginia, Nativity and interstate migration patterns and their effect on stroke risk factors

Jaffa, Miran, Development and application of models for slope estimation for univariate and bivariate longitudinal outcomes in the presence of informative right censoring

Johnson, Shayna, Racial disparities in living kidney donations among South Carolinians: The effect of health conditions, individual behavior, and family attributes

Karpievitch, Yuliya, Computational tools for MS-based proteomics

Mountford, William, Racial variation in long-term risk of cardiovascular disease mortality with regards to diabetes and hypertension

Rastogi, Amal, Arterial compliance and periodontal inflammation in adults

University of South Carolina (12)

Department of Mathematics

Jordan, Kelly, The necklace poset is a symmetric chain order

Kozer, Mark, Applications of covering systems of integers and Goldbach’s conjecture with monic polynomials

Owens, Luke, Multigrid methods for two weakly over-penalized interior penalty methods

Rusu, Anamaria, Determining starlike bodies by their curvature integrals

Sanacory, Frank, The richness of the space of operators on a Banach space

DEPARTMENT OF STATISTICS

Adekpedjou, Akim, Estimation of the gap-time distribution with recurrent event data under an informative monitoring period

Autin, Melanie, Nonparametric methods in the analysis of estuarine water quality data

Deutsch, Roland, Benchmark analysis for two predictor variables

Ignatova, Iliana, Multistage samples and the minimum sum method for Medicare fraud investigations

Ni, Jun, Extensions of hierarchical Bayesian shrinkage estimation with applications to a marketing science problem

Quiton, Jonathan, General outlier detection and goodness of fit for recurrent event data

Zhang, Litong, The estimation of multidimensional item response theory model

TENNESSEE

University of Memphis (2)

Department of Mathematical Sciences

Wheeler, Jeffrey Paul, The Cauchy-Davenport theorem and the Erdős-Heilbronn problem for finite groups

Zhang, Lijuan, Stochastic and state space models of carcinogenesis with applications

University of Tennessee, Knoxville (2)

Department of Mathematics

LaGrange, John, Zero-divisor graphs, commutative rings of quotients, and Boolean algebras

Phillippi, R. David, A comparison of the deck group and the fundamental group of uniform spaces obtained by gluing

Vanderbilt University (7)

Department of Mathematics

Callender, Hannah, Mathematical modeling of species-specific diacylglycerol dynamics in the RAW 264.7 macrophage following P2Y2 receptor activation by uridine 5’-diphosphate

Hinow, Peter, Partial differential equation models for intranuclear diffusion, inverse problems in nanobiology and cell cycle specific effects of anticancer drugs

Jennings, David, Topological algebras and \(q\)-undemanding varieties

Lambert, Thomas Paul, On the classification of closed flat four-manifolds

Nowak, Piotr Wojciech, Property A as metric amenability and its applications to geometry

Spakula, Jan, \(K\)-theory of uniform Roe algebras
Yatsyukev, Maxym Leonidovich, Non-Hermitean orthogonality and meromorphic approximation

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Baylor University (2)

DEPARTMENT OF MATHEMATICS

Jackson, Billy Joe, A general linear systems theory on time scales: Transforms, stability, and control
Rogers, James W., Adaptive methods for the Helmholtz equation with discontinuous coefficients at an interface

Rice University (16)

DEPARTMENT OF COMPUTATIONAL AND APPLIED MATHEMATICS

Castillo, Edward, Optical flow methods for the registration of compressible flow images and images containing large voxel displacements of artifacts
Eydelzon, Anatoly, A study on conditions for sparse solution recovery in compressive sensing
McClosky, Benjamin, Independence systems and stable set relaxations
Turner, Jesse, Multi-scale behavior in chemical reaction systems: Modeling, applications, and results
Young, Joseph, Program analysis and transformation in mathematical programming

DEPARTMENT OF MATHEMATICS

Jennings, Landan, Sufficient conditions for Hamiltonian paths
Jorgensen, Jamie, Surface homeomorphisms that do not extend to any handlebody and the Johnson filtration
Ralston, David, Heaviness: An extension of a lemma of Yuval Peres
Simpson, Matthew, On log canonical models of the moduli space of stable pointed genus zero curves

DEPARTMENT OF STATISTICS

Fox, Garrett, A Bayesian hierarchical model for detecting associations between haplotypes and disease using unphased SNPs
Gershman, Jason, Classification of time-course gene expression array data
Jabri, Hannah, Term structures and conditional probabilities of corporate default in an incomplete information setting
Kyi, Lada, Estimating realized covariance using high frequency data
Noyola-Martinez, Josue, Investigation of the Tau-leap method for stochastic simulation
Papkov, Galen, Locally-adaptive polynomial-smoothed histograms with application to massive and pre-binned data sets
Williams, Talithia, A dynamic spatio-temporal model for real-time estimation of rainfall data

Southern Methodist University (5)

DEPARTMENT OF MATHEMATICS

Cao, Guanghua (Kenny), Pricing and risk management of variable annuities and equity indexed annuities
Chaturvedi, Praveen, Single phase multi-component flow simulation in porous media
Lam, Kwan, Pattern formation in non-linear chemical systems

DEPARTMENT OF STATISTICS

Robertson, Steve, Generalizations and applications of linear chirp stationary processes
Xu, Mengyuan, Filtering analysis of non-stationary time series by time deformation

Texas A&M University (17)

DEPARTMENT OF MATHEMATICS

Abbott, Kevin, Applications of algebraic geometry to object/image recognition
Bondarenko, levgen, Groups generated by bounded automata and their Schreier graphs
Celik, Mehmet, Contributions to the compactness theory of the Neumann operator
Dobrev, Veselin, Preconditioning of discontinuous Galerkin methods for second order elliptic problems
Dostert, Paul, Multiscale simulation methods for stochastic porous media flows and applications
Fuselier, Jenny, Hypergeometric functions over finite fields and relations to modular forms and elliptic curves
Ivanov, Nikolay, On the structure of some free products of \( C^* \)-algebras
Kannan, Lavenya, Densities in graphs and matroids
Kostic, Dimitrije, Graph searching and a generalized parking function
Moreira, Rivera, Products of representations of symmetric group and non-commutative versions
Ruffo, James, A straightening law for the Drinfel’l d Lagrangian Grassmannian
Zheng, Bentuo, Embeddings and factorizations of Banach spaces

DEPARTMENT OF STATISTICS

Gold, David, Bayesian learning in bioinformatics
Jin, Lei, Generalized score tests for missing covariate data
Lee, Sang Han, Estimating and testing of functional data with restrictions
Liu, Lian, Topics in measurement error and missing data problems
Liu, Yingxue, Estimation of circadian parameters and investigation in cyanobacteria via semiparametric varying coefficient periodic models

Texas Tech University (6)

DEPARTMENT OF MATHEMATICS AND STATISTICS

Cupidon, Jean Rene, Functional data analysis
Ji, Xiao Yi, Fréchet differentiation of functions of operators with application to functional data analysis
Pang, Wai Kong Johnny, Some statistical methods for directly and indirectly observed functional data
Talukder, Mohammed H., Order-restricted analysis for repeated measures
Wang, Keyi, Variance reduction methods based on smoothing spline estimator for non-parametric regression model
Wesley, Curtis, Discrete time and continuous time epidemic models with applications to the spread of hantavirus in wild rodent and human populations

University of Houston (5)

DEPARTMENT OF MATHEMATICS

Linsenmann, Christopher, Adaptive multi-level-based shape optimization for stationary Stokes flows by path-following primal-dual interior point methods
Gucciardi, Barbara, Subgroupoids in coupled cell systems
Hao, Jiao, Numerical methods and simulations for fluid/particle interactions: Sedimentation in a viscoelastic fluid and cell lifting in shear flow
Nguyen, Ha, Whitney regularity for solutions to the Livsic coboundary equation on Cantor sets in dimension three
Patel, Swabhimita, Global existence for solutions of diffusively coupled reaction diffusion equations

University of North Texas (2)

DEPARTMENT OF MATHEMATICS

Atim, Alexander, Uniqueness results for the infinite unitary, orthogonal and associated groups
Pudipeddi, Sridevi, Localized radial solutions for nonlinear \( p \)-Laplacian equation in \( R^n \)

University of Texas at Arlington (6)

DEPARTMENT OF MATHEMATICS

Badiu, Florin, Study of multiple impacts of a rigid body with a flat surface
Busse, Theresa, Generalized inverse scattering transform for the nonlinear Schrödinger equation
Martines, Ian, Mathematical analysis of allelopathy and resource competition models
Mo, Min, Estimating absolute transcript concentration for microarrays using Langmuir adsorption theory
Stern, Paul, On progressively Koszul commutative rings
Xie, Peng, Uniform compact/noncompact schemes for shock/boundary layer interaction

University of Texas at Austin (19)

DEPARTMENT OF MATHEMATICS
Carreon, Fernando, Singular limits of reaction diffusion equations of KPP type in an infinite cylinder
Chan, Chi Hin, The De Giorgi method as applied to the regularity theory of incompressible Navier-Stokes equations
Cozzi, Elaine, Incompressible fluids with vorticity in Besov spaces
Czubak, Magdalena, Well-posedness for the space-time monopole equation and Ward wave map
Garza, John, The height in terms of the normalizer of a stabilizer
Ghosh, Rohit, Incompleteness of the Giulietti-Ughi arc
Hammond, John, Regular realizations of $p$-groups
Hitt, Laura, Genus 2 curves in pairing-based cryptography and the minimal embedding field
Klonoff, Kevin, An index theorem in differential K-theory
Luxton, Mark, The log canonical compactification of the moduli space of six lines in $P^3$
Moreira, Diego, Least supersolution approach to regularizing elliptic free boundary problems
Samuels, Charles, Auxiliary polynomials and Weil height
Van Horn-Morris, Jeremy, Constructions on open decompositions
Young, Andrea, Modified Ricci flow on a principal bundle

INSTITUTE FOR COMPUTER ENGINEERING AND SCIENCES
Bauman, Paul, Adaptive multiscale modeling of polymeric materials using goal-oriented error estimation, Arlequin coupling and goals algorithms
Cottrell, John, Isogeometric analysis and numerical modeling of the fine scale fields within the variational multiscale method
Khandelwal, Shweta, Ecology of infectious diseases with contact and percolation theory
Sokolova, Ekaterina, Indifference valuation in non-reduced incomplete models with a stochastic risk factor
Su, Qimou, Essays on derivatives pricing in incomplete financial markets

University of Texas at Dallas (2)

DEPARTMENT OF MATHEMATICAL SCIENCES
Sahi, Ramanjit, Tangle replacement moves on links

Yin, Kunshan, A Bayesian paradigm for method comparison studies

UTAH

Brigham Young University (1)

DEPARTMENT OF MATHEMATICS
Groat, Jason, The minimum rank problem over finite fields

University of Utah (8)

DEPARTMENT OF MATHEMATICS
Chamberlain, Erin, Modules with prescribed intersection properties
Iwao, Yoshihiro, Invariance of Gromov-Witten theory under a simple flop
McNulty, Meagan, Mathematical models of respiratory inflammation
Nesse, William, Random fluctuations in dynamical neural networks
Song, Qiang, Questions in local cohomology and tight closure
Thompson, Joshua, Graffing real complex projective structures
Todorov, Gueorgui, Pluricanonical map on threefolds of general type and the Gromov-Witten potential of the local
Zhang, Dalil, Inverse electromagnetic problem for microstructure media

VERMONT

University of Vermont (1)

DEPARTMENT OF MATHEMATICS AND STATISTICS
Mahassen, Hania, Weakly and strongly correlated two-dimensional layered Coulomb systems

Virginia Polytechnic Institute and State University (9)

DEPARTMENT OF MATHEMATICS
Baccouch, Mahboub, Superconvergence and a posteriori error estimation for the discontinuous Galerkin method applied to hyperbolic problems on triangular meshes
Boghes, Sharon, Born Oppenheimer expansion for diatomic molecules with large angular momentum
Temimi, Helmi, A discontinuous Galerkin method for higher-order differential equations applied to the wave equation
Timsina, Tirtha, Sensitivities in option pricing models

DEPARTMENT OF STATISTICS
Fraker, Shannon, Evaluation of scan methods used in temporal monitoring of public health surveillance data
Lee, Mi Hyun, On independent reference priors
Li, Zheng-rong, Model-based tests for standards evaluation and biological assessments
Love, Kimberly, Modeling error in geographic information systems
Wan, Wen, A semiparametric method to multi-response optimization

WASHINGTON

University of Washington (32)

DEPARTMENT OF APPLIED MATHEMATICS
Bale, Brandon, Modeling the dynamics and stability of mode-locked fiber lasers
Gomez, Miguel, Optimization-based analysis of rigid mechanical systems with unilateral contact and kinetic friction
Jeon, Jihyoun, Mathematical modeling of pre-malignant lesions in multistage carcinogenesis
Patterson, Matthew, Computing the Abel map and the Riemann constant vector
Seo, Gunog, The dynamics of simple predator-prey models with Holling functional responses
Srivastava, Santosh, Bayesian minimum expected risk estimation of distributions for statistical learning
Washington State University (2)

**DEPARTMENT OF MATHEMATICS**

Hsu, Chia-Yu, A 3D bacterial swimming model coupled with external fluid mechanics using the immersed boundary method

Jeon, Jong-Sam, Powerful ray patterns

**WEST VIRGINIA**

**West Virginia University (4)**

**DEPARTMENT OF MATHEMATICS**

Cai, Maomao, Solutions for a 2-dimensional stabilized Kuramoto-Sivashinsky system

Sathyak, Andrea, Pierce-Engel hybrid expansions

Van Vliet, Daniel, Nonlinear approximations for the X-ray transform

Zhang, Taoye, Integer flow and Petersen minor

**WISCONSIN**

**Medical College of Wisconsin (2)**

**DIVISION OF BIOSTATISTICS**

Liu, Jingxia, Utilizing propensity scores to test treatment effects in survival data

Zhang, Yinghua, Selecting between the Cox and Aalen models for right censored survival data

**University of Wisconsin, Madison (13)**

**DEPARTMENT OF MATHEMATICS**

Deng, Geng, Simulated-based optimization

Henderickson, Anders, Supercharacter theories of finite cyclic groups

Holden, Christopher, Mod 4 Galois representations and elliptic curves

Hunter, James, Higher-order reverse topology

Kieserman, Noah, The Liouville phenomenon in the deformation problem of coisotropics

Mueller, Stefan, The group of Hamiltonian homeomorphisms and co-symplectic topology

Raghavan, Dilip, Madness and other topics in set theory

Rose, Michael, On Gromov-Witten invariants of stacks

Rouse, Jeremy, Arithmetic analytic and geometric aspects of the theory of modular forms

Shallue, Andrew, Two number theoretic algorithms that illustrate the power and limitations of randomness

**Tang, Yu dong, Geodesic rays and test configurations**

**Wang, Bing, On the conditions to extend Ricci flow**

**Wang, Yue, On lower branch exact coherent structures**

**University of Wisconsin, Milwaukee (9)**

**DEPARTMENT OF MATHEMATICAL SCIENCES**

Dudek, John, A mathematical investigation of solutions for the two-component order parameter in the Ginzburg-Landau equations of superconductivity

Lee, Jae Kook, Some covers and relative covers of modules

Lehrke, Stephen, Asymptotic properties of the MLE of parameters of the multivariate O-U process

May, Margaret, Finite dimensional Z-complications

Mooney, Christopher, On boundaries of CAT(0) groups

Schroeder, Timothy, l2-homology of Coxeter groups

Sears, Christopher, Monotonicity of kneading sequences in families of one-kink maps

Shomberg, Asta, Estimation of false discovery rate under parametric assumptions with application to DNA microarrays

Zaidan, Younis, Analysis of Maxwell-systems with various nonlinear polarization mechanisms
Twice-a-month email notifications of news, announcements about programs, publications, and events, as well as deadlines for fellowship and grant applications, calls for proposals, and meeting registrations.

AMS members can sign up for the service at www.ams.org/enews
The American Mathematical Society is seeking applications and nominations of candidates for the post of Associate Treasurer. An Associate Treasurer is an officer of the Society and is appointed by the Council to a two-year term, ordinarily beginning on 01 February. In this case the term will begin as soon as possible and end 31 January 2012. Reappointments are possible and desirable. All necessary expenses incurred by an Associate Treasurer in performance of duties for the Society are reimbursed, including travel and communications.

**Duties**

The primary responsibilities of an Associate Treasurer, like those of the treasurer, are to administer or to supervise the administration of fiscal policies laid down by the Trustees. To monitor the receipt and expenditure of funds and the care of investments. To monitor budgets and trends of finance over periods of years. To review salary policy and its applications to individuals. The Associate Treasurer has all the duties of the Trustees in general. The Associate Treasurer watches over the finances of Mathematical Reviews and over the administration of salary policy up to department head.

**Applications**

An Associate Treasurer is appointed by the Council upon recommendation of the Executive Committee and Board of Trustees. Applications, consisting of a CV and a letter expressing interest and relevant background, should be sent to:

AT Search Committee  
c/o Sandy Golden  
Office of AMS Secretary  
Department of Mathematics  
University of Tennessee, Knoxville, TN  
37996-1330

email: golden@math.utk.edu

Applications received by 15 February 2009 will be assured full consideration.

The American Mathematical Society is an Equal Opportunity Employer.
2008 Election Results

In the elections of 2008 the Society elected a vice president, a trustee, five members at large of the Council, three members of the Nominating Committee, and two members of the Editorial Boards Committee.

Vice President
Elected as the new vice president is Frank Morgan from Williams College in Williamstown, MA. Term is three years (1 February 2009—31 January 2012).

Trustee
Elected as trustee is Ronald J. Stern from the University of California, Irvine. Term is five years (1 February 2009—31 January 2014).

Members at Large of the Council
Elected as new members at large of the Council are
Aaron Bertram from the University of Utah
William A. Massey from Princeton University
Panagiotis E. Souganidis from the University of Chicago
Michelle L. Wachs from the University of Miami
David G. Wright from Washington University in St. Louis
Terms are three years (1 February 2009—31 January 2012).

Nominating Committee
Elected as new members of the Nominating Committee are
Irene Fonseca from Carnegie Mellon University
Sheldon H. Katz from the University of Illinois, Urbana
Ellen E. Kirkman from Wake Forest University
Terms are three years (1 January 2009—31 December 2011).

Editorial Boards Committee
Elected as new members of the Editorial Boards Committee are
Michael T. Lacey from the Georgia Institute of Technology
Michael F. Singer from the North Carolina State University
Terms are three years (1 February 2009—31 January 2012).

Proposal for a Fellows Program of the AMS
The proposal was NOT approved.
Vice President or Member at Large

One position of vice president and member of the Council *ex officio* for a term of three years is to be filled in the election of 2009. The Council intends to nominate at least two candidates, among whom may be candidates nominated by petition as described in the rules and procedures.

Five positions of member at large of the Council for a term of three years are to be filled in the same election. The Council intends to nominate at least ten candidates, among whom may be candidates nominated by petition in the manner described in the rules and procedures.

Petitions are presented to the Council, which, according to Section 2 of Article VII of the bylaws, makes the nominations. The Council of 23 January 1979 stated the intent of the Council of nominating all persons on whose behalf there were valid petitions.

Prior to presentation to the Council, petitions in support of a candidate for the position of vice president or of member at large of the Council must have at least fifty valid signatures and must conform to several rules and operational considerations, which are described below.

Rules and Procedures

Use separate copies of the form for each candidate for vice president, member at large, or member of the Nominating and Editorial Boards Committees.

1. To be considered, petitions must be addressed to Robert J. Daverman, Secretary, American Mathematical Society, 312 D Ayres Hall, University of Tennessee, Knoxville, TN 37996-1330 USA, and must arrive by 24 February 2009.

2. The name of the candidate must be given as it appears in the *Combined Membership List* ([www.ams.org/cml](http://www.ams.org/cml)). If the name does not appear in the list, as in the case of a new member or by error, it must be as it appears in the mailing lists, for example on the mailing label of the *Notices*. If the name does not identify the candidate uniquely, append the member code, which may be obtained from the candidate’s mailing label or by the candidate contacting the AMS headquarters in Providence (amsmem@ams.org).

3. The petition for a single candidate may consist of several sheets each bearing the statement of the petition, including the name of the position, and signatures. The name of the candidate must be exactly the same on all sheets.

4. On the next page is a sample form for petitions. Petitioners may make and use photocopies or reasonable facsimiles.

5. A signature is valid when it is clearly that of the member whose name and address is given in the left-hand column.

6. The signature may be in the style chosen by the signer. However, the printed name and address will be checked against the *Combined Membership List* and the mailing lists. No attempt will be made to match variants of names with the form of name in the *CML*. A name neither in the *CML* nor on the mailing lists is not that of a member. (Example: The name Robert J. Daverman is that of a member. The name R. Daverman appears not to be.)

7. When a petition meeting these various requirements appears, the secretary will ask the candidate to indicate willingness to be included on the ballot. Petitioners can facilitate the procedure by accompanying the petitions with a signed statement from the candidate giving consent.

Editorial Boards Committee

Two places on the Editorial Boards Committee will be filled by election. There will be four continuing members of the Editorial Boards Committee.

The President will name at least four candidates for these two places, among whom may be candidates nominated by petition in the manner described in the rules and procedures.

The candidate’s assent and petitions bearing at least 100 valid signatures are required for a name to be placed on the ballot. In addition, several other rules and operational considerations, described below, should be followed.

Nominating Committee

Three places on the Nominating Committee will be filled by election. There will be six continuing members of the Nominating Committee.

The President will name at least six candidates for these three places, among whom may be candidates nominated by petition in the manner described in the rules and procedures.

The candidate’s assent and petitions bearing at least 100 valid signatures are required for a name to be placed on the ballot. In addition, several other rules and operational considerations, described below, should be followed.
From the AMS Secretary

Nomination Petition
for 2009 Election

The undersigned members of the American Mathematical Society propose the name of ________________________________

as a candidate for the position of (check one):

☐ Vice President
☐ Member at Large of the Council
☐ Member of the Nominating Committee
☐ Member of the Editorial Boards Committee

of the American Mathematical Society for a term beginning 1 February, 2010

Return petitions by 24 February 2009 to:
Secretary, AMS, 312 D Ayres Hall, University of Tennessee, Knoxville, TN 37996-1330 USA

Name and address (printed or typed)

___________________________
Signature

___________________________
Signature

___________________________
Signature

___________________________
Signature

___________________________
Signature

___________________________
Signature

___________________________
Signature

___________________________
Signature
February 2009


Description: The aim of the permanent Diffiety School is to introduce undergraduate and Ph.D. students in mathematics and physics as well as post-doctoral researchers in a recently emerged area of mathematics and theoretical physics: Secondary Calculus. A diffiety is a new geometrical object that properly formalizes the concept of the solution space of a given system of (nonlinear) PDEs, much as an algebraic variety does with respect to solutions of a given system of algebraic equations. Secondary calculus is a natural diffiety analogue of the standard calculus on smooth manifolds, and as such leads to a very rich general theory of nonlinear PDEs. It appears that it is the only natural language of quantum physics, just as the standard calculus is for classical physics.


March 2009

* 2–6 SIAM Conference on Computational Science and Engineering (CSE09), Miami Hilton Downtown, Miami, Florida.

Description: Computational Science and Engineering (CS&E) is now widely accepted, along with theory and experiment, as a crucial third mode of scientific investigation and engineering design. Aerospace, automotive, biological, chemical, semiconductor, and other industrial sectors now rely on simulation for technical decision support. For government agencies also, CS&E has become an essential support for decisions on resources, transportation, and defense. Finally, in many new areas such as medicine, the life sciences, management and marketing (e.g., data- and stream-mining), and finance techniques and algorithms from CS&E are of growing importance.

Information: For more information, see: http://www.siam.org/meetings/cse09/.

* 6–8 2nd Bluegrass Algebra Conference, University of Kentucky, Lexington, Kentucky.

Description: The conference continues a well established tradition of Commutative Algebra and Algebraic Geometry meetings in the Midwest, among which we single out MAGC97 at the University of Notre Dame in 1997, BACH’2 at the University of Kentucky in 2003, the Lipman Fest at Purdue University in 2004, MAGIC’05 at the University of Notre Dame in 2005, the Purdue-UIC Workshop at Purdue University in 2006, and the Hartshorne’s 70th birthday conference at the University of Illinois at Chicago in 2008. In order to enhance the visibility of mathematics among the diverse population of the University of Kentucky students, the conference will be preceded by a lecture aimed at the undergraduate level. The lecture will be delivered by Professor David Cox (Amherst College).

Speakers: David Cox, Amherst College, Lawrence Ein, University of Illinois at Chicago, Steven Kleiman, Massachusetts Institute of Technology, Andrew Kustin, University of South Carolina, Sonja Petrovic, University of Illinois at Chicago, Paul Roberts, University of Utah, Maria Evelina Rossi, Université di Genova (Italy), Hal Schenck, University of Illinois at Urbana-Champaign, Javid Validashiti, University of Kansas.

Support: Mathematicians at the post-doctoral stage (meaning those who are close to finishing the doctorate or have recently finished) that attend the conference will be supported through funds made available by the National Science Foundation via the Special Algebra Meetings in the Midwest grant (NSF DMS-0753127). They are encouraged to apply at the conference Website by January 31, 2009.
Information: http://www.ms.uky.edu/~algebra_uky_09.

Description: The Spring Topology and Dynamics Conference is in its 41st year and each year brings together researchers from diverse areas of topology and dynamics. Stanislav Ulam, one of the preeminent mathematician scientists of the 20th century, was a graduate research professor at the University of Florida and will turn 100 in spring, 2009. In light of Ulam's many contributions to topology, dynamics, and related fields, we are joining the annual STDC with an Ulam Centennial.
Information: http://www.math.ufl.edu/stdcullam/.

* 15–21 Spring School on Index Theory, Lie Groupoids and Boundary Value Problems, University of Regensburg, Germany.
Topics: Index theory for foliations. Around ellipticity of boundary conditions. From analysis on non-compact manifolds to boundary value problems on polyhedral domains. Index theory, bordism and rho-invariants. Index theory and positive scalar curvature.
Organizers: Bernd Ammann and Ulrich Bunke.
Speakers: Moulay-Tahar Benameur, Metz, France; Gilles Carron, Nantes, France; Victor Nistor, Penn State Univ., USA; Paolo Piazza, Rome, Italy; Thomas Schick, Goettingen, Germany.
Register: Please register as soon as possible by sending an email to us. We have reserved a number of hotel rooms for participants of the spring school. However, on December 15th, 2008, we either have to cancel the reservation or make the reservation legally binding. There is a small budget to support participants of the spring school. Please contact us until Dec. 12th, 2008, in case you want to apply for support for travel or accommodation; Bernd Ammann, Ulrich Bunke.
Information: http://www.mathematik.uni-regensburg.de/ammann/springschool/.

* 20–22 Southern Regional Algebra Conference 2009, University of South Alabama, Mobile, Alabama.
Description: The Southern Regional Algebra Conference 2009 will take place at the University of South Alabama in Mobile. All participants are invited to present 25-minute talks. The first talks will be scheduled for Friday afternoon, beginning approximately at 1:30 PM. The conference will end by noon on Sunday. As usual, no financial support will be provided for the participants by the University of South Alabama. Graduate students are strongly encouraged to participate.
Organizers: Jörg Feldvoss, Cornelius Pillen, Yorck Sommerhäuser.

Description: The meeting will start on Friday at 3 pm with a Taft lecture by Professor S.R.S. Varadhan on large deviations in a random environment. Other lectures will cover new advances in studying the structure of a stochastic process via a martingale approximation; connections to ergodic theory; limit theorems and applications in statistics, finance, and statistical inference for random processes which may exhibit strong or long-range dependence, nonlinearity, heavy tails and other features; large-dimensional random matrices. A unique feature of our symposium is a series of four talks by experts on forensic geonomics, which will take place on Saturday, March 21, 2 pm-6 pm.
Information: http://math.uc.edu/~free-gauss/CSP.htm.

* 27 Illinois/Missouri Applied Harmonic Analysis Seminar, University of Illinois, Urbana, Illinois.
Description: This half-day meeting fosters research interactions among mathematicians, engineers, and physicists who develop and apply techniques from harmonic analysis.
Theoretical topics of interest: Fourier analysis, wavelets, Gabor systems (time-frequency analysis), frames, Riesz bases, compressed sensing, approximation theory, X-ray type transforms.
Applications of interest: All kinds of signal and image analysis, processing and reconstruction, both analogue and digital.
Speakers: John J. Benedetto, Gitta Kutyniok, and Emmanuel Candès.
Support: This conference is supported in part by the Institute for Mathematics and its Application (IMA) through its Participating Institution Program. IMA members may use IMA/PI funds to support travel of their personnel to this conference. All interested researchers are welcome. There is no registration fee. Travel funding is available for participants based in the U.S.
Information: http://www.math.umn.edu/~laugesen/imaha05/imaha05.html.

April 2009

* 17–18 2009 Barrett Lectures, University of Tennessee, Knoxville, Tennessee.
Description: The scientific program of the meeting will cover a selection of applications of stochastic analysis. Professor Richard Bass proposes to lecture on potential theory and integro-differential equations while Professor Ofer Zeitouni intends to speak on problems in the study of random walks in random media. The one-hour invited speakers have not yet specified their talks but are expected to speak on filtering, partial differential equations driven by Levy processes, random polynomials, and other topics related to stochastic analysis and its applications.
Topics: Stochastic Analysis and its Applications.
Main Speakers (three lectures each): Richard Bass, University of Connecticut; Ofer Zeitouni, University of Minnesota and Weizmann Institute.
Invited Speakers (one lecture each): Amarjit Budhiraja, University of North Carolina; Dan Crisan, Imperial College; Christian Houdre, Georgia Tech; Davar Khoshnevisan, University of Utah; Wembo Li, University of Delaware.
Talks: There will be eight contributed talks (15 minutes each). If you would like to give a talk, please send the title and abstract to: jxiong@math.utk.edu by February 28, 2009. We will choose eight contributing speakers from the abstracts received.
Sponsor: The 2009 Barrett Lectures is sponsored by the National Science Foundation, the Department of Mathematics, and the University of Tennessee.
Information/Registration/Funding: Will be available for the partial support of participants. Graduate students and young researchers are particularly invited to apply for support. On-line registration will be available starting in February. You can also register by sending an email to: jxiong@math.utk.edu.

* 19–25 Spring School on Variational Analysis and its Applications, Paseky nad Jizerou, Czech Republic.
Organizing committee: Marian Fabian, Jaroslav Lukes, Jiri Outrata (Czech Republic).
Language: English.
Grants: Probably support for a limited number of students.
Deadlines: For reduced fee and support; January 15, 2009.
Information: http://www.karlin.mff.cuni.cz/katedry/kma/ss/apr09/; email: paseky@karlin.mff.cuni.cz.

* 23–25 Twelfth New Mexico Analysis Seminar, University of New Mexico, Albuquerque, New Mexico.
Goal: The goal of the conference is to provide an opportunity for scientific exchange and cooperation among broadly defined analysts. There is time allocated for shorter contributed talks. Priority will be given to graduate and postdoctoral students and those in early stages of their careers.
Organizers: Cristina Pereyray, email: crisp@math.unm.edu; Tiziana Giorgi, email: tgiorgi@nmsu.edu; Joseph Lakey, email: jlakey@nmsu.edu; Adam Sikora, email: asikora@nmsu.edu; Robert Smits, email: rsmits@nmsu.edu. This seminar is organized every year by analysts at New Mexico State University and The University of New Mexico.
Keynote Speaker: Loukas Grafakos, University of Missouri at Columbia: Lectures on “Linear and Multilinear Singular Integral Operators”.
Invited Speakers: Arpad Benyi (Western Washington University), and Diego Maldonado (Kansas State University).
Sponsor: NSF.
Information: http://www.math.unm.edu/conferences/12thAnalysis.
May 2009

* 25–29 Indam School on symmetry for elliptic PDEs (30 years after a conjecture of De Giorgi and related problems), Istituto Nazionale di Alta Matematica, Universita' di Roma La Sapienza, Rome, Italy.
  **Description:** The school is open to graduate students and young researchers. The courses will be offered by Professors Xavier Cabrè, Manuel del Pino, Ermanno Lanconelli and Ovidiu Savin. A few seminars will be also presented. The school is organized by Alberto Farina and Enrico Valdinoci.
  **Information:** http://www.mat.uniroma2.it/~valdinoc/scuola-indam.html.

  **Main speakers:** Anders Bjorn, Fernando Cobos, Thierry Coulhon, Peter A. Hästö.
  **Language:** English.
  **Information:** http://www.karlin.mff.cuni.cz/katedry/kma/ss/jun09/.

June 2009

* 1–5 Fifth Summer School in Analysis and Applied Mathematics, Department of Mathematics, Sapienza, Universita' di Roma, Rome, Italy.
  **Description:** The school is intended mainly for Ph.D. students and young researchers in analysis and applied mathematics.
  **Aim:** The aim of the school is to provide a smooth trip in two important areas of the Calculus of Variations: Minimal Surfaces and Differential Inclusions. G. Alberti will guide the audience to a quick but detailed introduction to the most important prerequisites.
  **Speakers:** The three speakers will be G. Alberti, S. Hildebrandt, and L. Szekelyhidi Jr.
  **Information:** http://www.mat.uniroma1.it/people/garroni/School2009.html.

* 8–11 The 2nd International Conference on Mathematical Modeling and Computation and The 5th East Asia SIAM Conference, Università Brunei Darussalam, Bandar Seri Begawan, Brunei.
  **Description:** The conference shall provide a venue to exchange ideas in the mathematical modelling of biological and physical systems, financial mathematics, and areas such as integral and differential operators and numerical methods, in promoting both established and newer national and international research relationships.
  **Information:** http://www.siam.org/meetings/an09/.

* 15–July 3 Summer School and Conference in Geometric Representation Theory and Extended Affine Lie Algebras, University of Ottawa, Ottawa, Ontario, Canada.
  **Description:** The summer school will consist of three mini-courses per week for two weeks. These courses will serve as an introduction to geometric representation theory, quantum groups and combinatorial representation theory (i.e., the theory of crystal bases), the structure theory of extended affine Lie algebras and the representation theory of affine and toroidal Lie algebras. They will be aimed at the graduate student/postdoctoral fellow level. Following the summer school there will be a one-week conference featuring speakers presenting recent developments in areas related to the material of the summer school. The event is sponsored by the Fields Institute (Toronto).
  **Information:** http://www.fields.utoronto.ca/programs/scientific/08-09/geomrep/.

* 16–22 Sixth International Workshop on Optimal Codes and Related Topics, OC 2009, Varna, Bulgaria.
  **Description:** This workshop gathers researchers on optimal linear codes and related problems.
  **Topics include:** Optimal linear codes over finite fields and rings, bounds for codes, spherical codes and designs, covering problems for linear and nonlinear codes, optimization problems for nonlinear codes, sets of points in finite geometries, combinatorial configurations and codes, optimality problems in cryptography, graph theory and codes, and related topics.

* 22–27 3rd Nordic EWM Summer School for Ph.D. Students in Mathematics, University of Turku, Turku, Finland.
  **Description:** Ph.D. students in pure mathematics, applied mathematics, mathematical statistics, mathematics education, or history of mathematics from the Nordic countries are invited to participate in a summer school in mathematics organized by the European Women in Mathematics (EWM). The summer school is especially aimed at encouraging female students and researchers in their early careers, but we also warmly welcome male students. Students outside the Nordic countries, post-docs or advanced undergraduates thinking of Ph.D. studies are also invited to attend. The program of the meeting is broad and will be of interest for students working in different research areas. Mini-courses will give an introduction and an overview over three chosen topics of general interest from different areas of mathematics. They will be aimed at all students with a general mathematical background, yet come to touch questions of current research.
  **Information:** http://www.math.utu.fi/projects/ewm.

* 22–27 First Conference “Application of Mathematics in Technical and Natural Sciences” (AMiTANS’09), Resort of Sozopol, Bulgaria.
  **Description:** Papers on all subjects of application of mathematics in mechanics, physics, biology, chemistry and different engineering fields are invited. We plan to have several special sessions. The conference will consist of a few plenary talks by invitation from the Program Committee, 60 minutes each. In each special session there will be a couple of keynote lectures 45 minutes each. The invited presentations in the special sessions will be 30 minutes long. All contributed talks will be 20 minutes long. If necessary, parallel sessions will be organized.
  **Information:** http://www.amitans.org.

* 22–July 3 Automorphic forms and L-functions, computational aspects, CRM, Montreal, Canada.
  **Description:** The purpose of the school is to bring together a number of experts who have been leaders in both the theoretical and more computational aspects of the theory of automorphic forms and L-functions, who will offer introductory-level courses aimed at presenting graduate students and post-doctoral fellows with the state of the art in the subject and report on new advances which have not yet been covered in a forum of this sort.
  **Information:** http://www.dms.umontreal.ca/~sms/index_e.shtml.

  **Description:** The power of synthesis of geometry, which led in the past to the formulation of "grand unification theories", has got an essential role nowadays, especially because of the growing fragmentation of knowledge due to scientific progress. In order to avoid a big dispersion, geometries need a constant dialogue. Therefore, a stable experience of personal meetings, apart from telematic interchanges, cannot be renounced. Current geometry was born to allow a periodic update about actual progresses in geometry (and its applications) on the international scene.

July 2009

* 6–10 2009 SIAM Annual Meeting (AN09), Sheraton Denver Hotel, Denver, Colorado.
  **Description:** SIAM’s Annual Meeting provides a broad view of the state of the art in applied mathematics, computational science, and their applications through invited presentation, prize lectures, mini-symposia, and contributed papers and posters.
  **Information:** http://www.siam.org/meetings/an09/.

* 16–31 XII Diffiety School — on Geometry of Partial differential Equations and Secondary Calculus, Santo Stefano del Sole, Avellino, Italy.
  **Description:** The aim of this permanent school is to introduce undergraduate and Ph.D. students in mathematics and physics as well as post-doctoral researchers in a recently emerged area of mathematics and theoretical physics: Secondary Calculus. A diffiety is a new geometrical object that properly formalizes the concept of the solution space of a given system of (nonlinear) PDEs, much as an algebraic variety does with respect to solutions of a given system of algebraic equations. Secondary calculus is a natural diffiety analogue of the standard calculus on smooth manifolds, and as such leads to a very

June 2009
Mathematics Calendar

rich general theory of nonlinear PDEs. It appears that it is the only natural language of quantum physics, just as the standard calculus is for classical physics.

**Information:** [http://school.diffiety.org/page3/page0/page93/page93.html](http://school.diffiety.org/page3/page0/page93/page93.html)

*31-August 2* 3rd Jairo Charris Seminar—Symmetries of differential and difference equations, Universidad Sergio Arboleda, Bogotá, Colombia.

**Description:** The Jairo Charris Seminar is an annual event organized by the Sergio Arboleda University. It is dedicated to Jairo Antonio Charris Castañeda (1939-2003), who was one of the fathers of the Colombian mathematical research and former professor of our university.

**Topics:** Symmetries of differential and difference equations. Algebraic methods in differential and difference equations. Integrability, solvability and reducibility of differential and difference equations.

**Information:** [http://www.usrergioarboleda.edu.co/matematicas/jairo_charris.htm](http://www.usrergioarboleda.edu.co/matematicas/jairo_charris.htm)

**August 2009**

*3-14* Pan-American Advanced Studies Institute (PASI): In Commutative Algebra and its connections to Geometry, Olinda, Brazil.

**Description:** The two week program is sponsored by a PASI grant from the Office of International Science & Engineering of the NSF. The program will consist of six mini-courses on fundamental techniques in commutative algebra and related fields during the first week (school). The second week will be devoted to a series of advanced research talks by recognized leaders in the area (international workshop). The courses will bring junior researchers up-to-speed in the more specialized topics that will be the focus of the advanced lectures and will contribute to the training of young researchers from the Americas.

**Organizers:** A. Corso, C. Huneke C. Polini, A. Simis, and B. Ulrich.

**School speakers:** David Cox, Amherst College (USA), Juergen Herzog, University of Duiburg-Essen (Germany), Craig Huneke, University of Kansas (USA), Steven Kleiman, MIT (USA), Maria Evelina Rossi, Università di Genova (Italy), Bernd Ulrich, Purdue University (USA).

**Support:** Mathematicians from the Americas at the peridoctoral stage (meaning those who are close to finishing the doctorate or have recently finished) that attend the school will be supported through funds made available by the National Science Foundation via the PASI program. They are encouraged to apply at the conference web site by March 31, 2009.

**Information:** [http://www.ms.uky.edu/~pasi2009](http://www.ms.uky.edu/~pasi2009).

*17-21* International Conference on Complex Analysis and Related Topics, University of Turku, Turku, Finland.

**Description:** This conference is the 12th one in the series of Romanian-Finnish Seminars on topics related to mathematical analysis. The conference is open to all nationalities.


**September 2009**

*2-4* Workshop in nonlinear elliptic PDEs, Université Libre de Bruxelles, Brussels, Belgium.

**Description:** The workshop is organized on the occasion of the 65th birthday of Jean-Pierre Gossez.

**Speakers:** The following lecturers have confirmed their participation: Henri Berestycki (Paris), Philippe Clément (Delft), Djairo G. de Figueiredo (Campinas), François de Thélín (Toulouse), Pavel Drábek (Pilsen), Ivar Ekeland (Vancouver), Jesús Hernández (Madrid), Bernd Kawohl (Köln), Pierre-Louis Lions (Paris), Jean Mawhin (Louvain-la-Neuve), Petru Miroscuca (Lyon), Mark Peletier (Eindhoven), Frédéric Robert (Nico), Bernhard Ruf (Milano), Michael Struwe (Zurich), Charles Stuart (Lausanne), Juan Luis Vazquez (Madrid).

**Information:** [http://wmpde09.ulb.ac.be/](http://wmpde09.ulb.ac.be/).

**October 2009**


**Description:** The SIAM conferences on Mathematics for Industry focus attention on the many and varied opportunities to promote applications of mathematics to industrial problems. From the start of plan-

**November 2009**


**Description:** The seventh bi-annual Delta conference on the teaching and learning of undergraduate mathematics and statistics (ΣP∆’09) takes place in the picturesque beach town of Gordon’s Bay, close to Cape Town, South Africa. ΣP∆’09 forms part of the series of Delta conferences, a southern hemisphere initiative.


*7-9* SIAM Conference on Analysis of Partial Differential Equations (PD09), Hilton Miami Downtown, Miami, Florida.

**Description:** This conference is organized by the SIAM Activity Group (SIAG) on Analysis of Partial Differential Equations (SIAG/APDE).

**Information:** The website will be updated as additional information becomes available. [http://www.siam.org/meetings/calendar.php](http://www.siam.org/meetings/calendar.php).

**December 2009**


**Description:** The SIAM conferences on Mathematics for Industry focus attention on the many and varied opportunities to promote applications of mathematics to industrial problems. From the start of plan-

**Information:** [http://www.siam.org/meetings/calendar.php](http://www.siam.org/meetings/calendar.php)
Algebra and Algebraic Geometry

Algebraic Geometry Seattle 2005

D. Abramovich, Brown University, Providence, RI, A. Bertram, University of Utah, Salt Lake City, UT, L. Katzarkov, University of Miami, Coral Gables, FL, R. Pandharipande, Princeton University, NJ, and M. Thaddeus, Columbia University, New York, NY, Editors

The 2005 AMS Summer Institute on Algebraic Geometry in Seattle was an enormous event. With over 500 participants, including many of the world’s leading experts, it was perhaps the largest conference on algebraic geometry ever held. These two proceedings volumes present research and expository papers by some of the most outstanding speakers at the meeting, vividly conveying the grandeur and vigor of the subject.

The most exciting topics in current algebraic geometry research receive very ample treatment. For instance, there is enlightening information on many of the latest technical tools, from jet schemes and derived categories to algebraic stacks. Numerous papers delve into the geometry of various moduli spaces, including those of stable curves, stable maps, coherent sheaves, and abelian varieties. Other papers discuss the recent dramatic advances in higher-dimensional birational geometry, while still others trace the influence of quantum field theory on algebraic geometry via mirror symmetry, Gromov–Witten invariants, and symplectic geometry.

The proceedings of earlier algebraic geometry AMS Institutes, held at Woods Hole, Arcata, Bowdoin, and Santa Cruz, have become classics. The present volumes promise to be equally influential. They present the state of the art in algebraic geometry in papers that will have broad interest and enduring value.


Part II: M. A. A. De Cataldo and I. Migliorini, Hodge-theoretic aspects of the decomposition theorem; L. Ein and M. Mustaţă, Jet schemes and singularities; H. Gangl, A. B. Goncharov, and A. Levin, Multiple polylogarithms, polygons, trees and algebraic cycles; D. Kaledin, Geometry and topology of symplectic resolutions; S. Kaliman, Actions of $C^*$ and $C_*$ on affine algebraic varieties; Y. Kawamata, Derived categories and birational geometry; K. S. Kedlaya, $p$-adic cohomology; S. A. Kovács, Subvarieties of moduli stacks of canonically polarized varieties: generalizations of Shafarevich’s conjecture; S. J. Kovács, Young person’s guide to moduli of higher dimensional varieties; F. Loeser, Seattle lectures on motivic integration; M. Manetti, Differential graded Lie algebras and formal deformation theory; M. C. Olsson, On Faltings’ method of almost étale extensions; B. Hassett and Y. Tschinkel, Weak approximation for hypersurfaces of low degree; J. Wlodarczyk, Simple constructive weak factorization.

Proceedings of Symposia in Pure Mathematics, Volume 80


"Abstract"
Homomorphisms of Split Kac-Moody Groups
Pierre-Emmanuel Caprace, Université Libre de Bruxelles, Belgium

Contents: The objects: Kac-Moody groups, root data and Tits buildings; Basic tools from geometric group theory; Kac-Moody groups and algebraic groups; Isomorphisms of Kac-Moody groups: an overview; Isomorphisms of Kac-Moody groups in characteristic zero; Isomorphisms of Kac-Moody groups in positive characteristic; Homomorphisms of Kac-Moody groups to algebraic groups; Unitary forms of Kac-Moody groups; Bibliography; Index.

Memoirs of the American Mathematical Society, Volume 198, Number 924

A Course in Approximation Theory
Ward Cheney, University of Texas at Austin, TX, and Will Light

This textbook is designed for graduate students in mathematics, physics, engineering, and computer science. Its purpose is to guide the reader in exploring contemporary approximation theory. The emphasis is on multi-variable approximation theory, i.e., the approximation of functions in several variables, as opposed to the classical theory of functions in one variable.

Most of the topics in the book, heretofore accessible only through research papers, are treated here from the basics to the currently active research, often motivated by practical problems arising in diverse applications such as science, engineering, geophysics, and business and economics. Among these topics are projections, interpolation paradigms, positive definite functions, interpolation theorems of Schoenberg and Michelli, tomography, artificial neural networks, wavelets, thin-plate splines, box splines, ridge functions, and convolutions.

An important and valuable feature of the book is the bibliography of almost 600 items directing the reader to important books and research papers. There are 438 problems and exercises scattered through the book allowing the student reader to get a better understanding of the subject.

Contents: Introductory discussion of interpolation; Linear interpolation operators; Optimization of the Lagrange operator; Multivariate polynomials; Moving the nodes; Projections; Tensor-product interpolation; The Boolean algebra of projections; The Newton paradigm for interpolation; The Lagrange paradigm for interpolation; Interpolation by translates of a single function; Positive definite functions; Strictly positive definite functions; Completely monotone functions; The Schoenberg interpolation theorem; The Micchelli interpolation theorem; Positive definite functions on spheres; Approximation by positive definite functions; Approximate reconstruction of functions and tomography; Approximation by convolution; The good kernels; Ridge functions; Ridge function approximation via convolutions; Density of ridge functions; Artificial neural networks; Chebyshev centers; Optimal reconstruction of functions; Algorithmic orthogonal projections; Cardinal B-splines and the sinc function; The Golomb-Weinberger theory; Hilbert function spaces and reproducing kernels; Spherical thin-plate splines; Box splines; Wavelets, I; Wavelets, II; Quasi-interpolation; Bibliography; Index; Index of symbols.

Graduate Studies in Mathematics, Volume 101

Communicating Mathematics
Timothy Y. Chow, Center for Communications Research, Princeton, NJ, and Daniel C. Isaksen, Wayne State University, Detroit, MI, Editors

This volume contains the proceedings of a conference held in July, 2007 at the University of Minnesota, Duluth, in honor of Joseph A. Gallian’s 65th birthday and the 30th anniversary of the Duluth Research Experience for Undergraduates.

In keeping with Gallian’s extraordinary expository ability and broad mathematical interests, the articles in this volume span a wide variety of mathematical topics, including algebraic topology, combinatorics, design theory, forcing, game theory, geometry, graph theory, group theory, optimization, and probability.

Some of the papers are purely expository while others are research articles. The papers are intended to be accessible to a general mathematics audience, including first-year or second-year graduate students. This volume should be especially useful for mathematicians seeking a new research area, as well as those looking to enrich themselves and their research programs by learning about problems and techniques used in other areas of mathematics.

This item will also be of interest to those working in discrete mathematics and combinatorics and geometry and topology.

Contents: S. S. Adams, A journey of discovery: Orthogonal matrices and wireless communications; J. Beam, Probabilistic expectations on unstructured spaces; T. Y. Chow, A beginner’s guide to forcing; E. Constantin, Higher order necessary conditions in smooth constrained optimization; D. Dunham, Hamiltonian paths and hyperbolic patterns; J. S. Foisy and L. D. Ludwig, When graph theory meets knot theory; J. Friedman and C. Parker, Can an asymmetric power structure always be achieved?; S. G. Hartke and A. J. Radcliffe, McKay’s canonical graph labeling algorithm; P. Hersh and R. Kleinberg, A multiplicative deformation of the Möbius function for the poset of partitions of a multiset; A. Higgins,
Communicating, mathematics, communicating mathematics-Joe Gallian style; D. Housman, Fair allocation methods for coalition games; D. C. Isaksen, Sums-of-squares formulas; K. S. Kedlaya, Product-free subsets of groups, then and now; K. S. Kedlaya and X. Shao, Generalizations of product-free subsets; D. W. Morris, What is a supergrid subgroup?; D. P. Moulton, Averaging points two at a time; M. M. Patnaik, Vertex algebras as twisted bialgebras: On a theorem of Borchers.

Contemporary Mathematics, Volume 479

Rings, Modules and Representations
Nguyen Viet Dung, Ohio University, Zanesville, OH, Franco Guerriero, Ohio University, Lancaster, OH, Lakhdar Hammoudi, Ohio University, Chillicothe, OH, and Pramod Kanwar, Ohio University, Zanesville, OH, Editors

This volume originated from talks given at the International Conference on Rings and Things held in June, 2007 at Ohio University-Zanesville.

The papers in this volume contain the latest results in current active research areas in the theory of rings and modules, including noncommutative and commutative ring theory, module theory, representation theory, and coding theory. In particular, papers in this volume deal with topics such as decomposition theory of modules, injectivity and generalizations, tilting theory, rings and modules with chain conditions, Leavitt path algebras, representations of finite dimensional algebras, and codes over rings. While most of these papers are original research articles, some are expository surveys.

This book is suitable for graduate students and researchers interested in noncommutative ring and module theory, representation theory, and applications.


Contemporary Mathematics, Volume 480

Algebra
A Graduate Course
I. Martin Isaacs, University of Wisconsin, Madison, WI

This book, based on a first-year graduate course the author taught at the University of Wisconsin, contains more than enough material for a two-semester graduate-level abstract algebra course, including groups, rings and modules, fields and Galois theory, an introduction to algebraic number theory, and the rudiments of algebraic geometry. In addition, there are some more specialized topics not usually covered in such a course. These include transfer and character theory of finite groups, modules overartinian rings, modules over Dedekind domains, and transcendental field extensions.

This book could be used for self study as well as for a course text, and so full details of almost all proofs are included, with nothing being relegated to the chapter-end problems. There are, however, hundreds of problems, many being far from trivial. The book attempts to capture some of the informality of the classroom, as well as the excitement the author felt when taking the corresponding course as a student.

Contents: Part One, Noncommutative Algebra: Definitions and examples of groups; Subgroups and cosets; Homomorphisms; Group actions; The Sylow theorems and p-groups; Permutation groups; New groups from old; Solvable and nilpotent groups; Transfer; Operator groups and unique decompositions; Module theory without rings; Rings, ideals, and modules; Simple modules and primitive rings; Artinian rings and projective modules; An introduction to character theory; Part Two, Commutative Algebra: Polynomial rings, PIDs, and UFDs; Field extensions; Galois theory; Separability and inseparability; Cyclotomy and geometric constructions; Finite fields; Roots, radicals, and real numbers; Norms, traces, and discriminants; Transcendental extensions; The Artin-Schreier theorem; Ideal theory; Noetherian rings; Integrality; Dedekind domains; Algebraic sets and the nullstellensatz; Index.

Graduate Studies in Mathematics, Volume 100
Analysis

Introduction to Fourier Analysis and Wavelets

Mark A. Pinsky, Northwestern University, Evanston, IL

This book provides a concrete introduction to a number of topics in harmonic analysis, accessible at the early graduate level or, in some cases, at an upper undergraduate level. Necessary prerequisites to using the text are rudiments of the Lebesgue measure and integration on the real line. It begins with a thorough treatment of Fourier series on the circle and their applications to approximation theory, probability, and plane geometry (the isoperimetric theorem). Frequently, more than one proof is offered for a given theorem to illustrate the multiplicity of approaches.

The second chapter treats the Fourier transform on Euclidean spaces, especially the author’s results in the three-dimensional piecewise smooth case, which is distinct from the classical Gibbs–Wilbraham phenomenon of one-dimensional Fourier analysis. The Poisson summation formula treated in Chapter 3 provides an elegant connection between Fourier series on the circle and Fourier transforms on the real line, culminating in Landau’s asymptotic formulas for lattice points on a large sphere.

Much of modern harmonic analysis is concerned with the behavior of various linear operators on the Lebesgue spaces $L^p(\mathbb{R}^n)$. Chapter 4 gives a gentle introduction to these results, using the Riesz–Thorin theorem and the Marcinkiewicz interpolation formula. One of the long-time users of Fourier analysis is probability theory. In Chapter 5 the central limit theorem, iterated log theorem, and Berry–Esseen theorem and the Marcinkiewicz interpolation formula. One of the long-time users of Fourier analysis is probability theory. In Chapter 5 the central limit theorem, iterated log theorem, and Berry–Esseen theorem are developed using the suitable Fourier-analytic tools.

The final chapter furnishes a gentle introduction to wavelet theory, depending only on the $L^2$ theory of the Fourier transform (the Plancherel theorem). The basic notions of scale and location parameters determine the flexibility of the wavelet approach to harmonic analysis.

The text contains numerous examples and more than 200 exercises, each located in close proximity to the related theoretical material.

Contents: Fourier series on the circle; Fourier transforms on the line and space; Fourier analysis in $L^p$ spaces; Poisson summation formula and multiple Fourier series; Applications to probability theory; Introduction to wavelets; References; Notations; Index.

Graduate Studies in Mathematics, Volume 102

Function Theory: Interpolation and Corona Problems

Eric T. Sawyer, McMaster University, Hamilton, ON, Canada

These lecture notes take the reader from Lennart Carleson’s first deep results on interpolation and corona problems in the unit disk to modern analogues in the disk and ball. The emphasis is on introducing the diverse array of techniques needed to attack these problems rather than producing an encyclopedic summary of achievements. Techniques from classical analysis and operator theory include duality, Blaschke product constructions, purely Hilbert space arguments, bounded mean oscillation, best approximation, boundedness of the Beurling transform, estimates on solutions to the $\delta$ equation, the Koszul complex, use of trees, the complete Pick property, and the Toeplitz corona theorem. An extensive appendix on background material in functional analysis and function theory on the disk is included for the reader’s convenience.

Titles in this series are co-published with The Fields Institute for Research in Mathematical Sciences (Toronto, Ontario, Canada).

Contents: Preliminaries; The interpolation problem; The corona problem; Toeplitz and Hankel operators; Hilbert function spaces and Nevanlinna-Pick kernels; Carleson measures for the Hardy-Sobolev spaces; Functional analysis; Weak derivatives and Sobolev spaces; Function theory on the disk; Spectral theory for normal operators; Bibliography; Index.

Fields Institute Monographs, Volume 25

Differential Equations

Multi-Pulse Evolution and Space-Time Chaos in Dissipative Systems

Sergey Zelik, University of Surrey, Guildford, United Kingdom, and Alexander Mielke, Weierstrass Institut für Angewandte Analysis und Stochastik, Berlin, Germany

This item will also be of interest to those working in probability.

Contents: Introduction; Assumptions and preliminaries; Weighted Sobolev spaces and regularity of solutions; The multi-pulse manifold: general structure; The multi-pulse manifold: projectors and tangent spaces; The multi-pulse manifold: differential equations and the cut off procedure; Slow evolution of multi-pulse profiles: linear case; Slow evolution of multi-pulse structures: center manifold reduction; Hyperbolicity and stability; Multi-pulse
evolution equations: asymptotic expansions; An application: spatio-temporal chaos in periodically perturbed Swift-Hohenberg equation; Bibliography; Nomenclature.

**Memoirs of the American Mathematical Society**, Volume 198, Number 925


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**What's Happening in the Mathematical Sciences**

**Dana Mackenzie**

Since 1993, the AMS has been publishing *What's Happening in the Mathematical Sciences*, a series of lively and highly readable accounts of the latest developments in mathematics. This seventh volume describes some genuine surprises, such as the recent discovery that coin tosses are inherently unfair; a mathematical theory of invisibility that was soon followed by the creation of a prototype “invisibility cloak”; and an ultra-efficient approach to image sensing that led to the development of a single-pixel camera.

The past few years have also seen deep results on some classical mathematics problems. For example, this volume describes a proof of the Sato–Tate Conjecture in number theory and a major advance in the Minimal Model Program of algebraic geometry. The computation of the character table of the exceptional Lie group $E_8$ brings “the most beautiful structure in mathematics” to public attention, and proves that human persistence is just as important as gigabytes of RAM. The amazing story of the Archimedes Palimpsest shows how the modern tools of high-energy physics uncovered the centuries-old secrets of the mathematical writings of Archimedes.

Dana Mackenzie, a science writer specializing in mathematics, makes each of these topics accessible to all readers, with a style that is friendly and at the same time attentive to the nuances that make mathematics fascinating. Anyone with an interest in mathematics, from high school teachers and college students to engineers and computer scientists, will find something of interest here. The stories are well told and the mathematics is compelling.

**Praise for Earlier Volumes:**

One can say without overstatement that the standards in these volumes are very high indeed.

The articles are very well written, and usually include quotes from the mathematicians who were involved in the work in question, giving the whole thing a more “human” feel. This book offers professionals a way to keep abreast of what’s going on in the field and also gives us a way to share with our students and colleagues some of the excitement of doing mathematics. Don’t miss it.

—MAA Online

...an excellent series transferring contemporary mathematical research in a delightful and exact manner to both non-mathematicians and mathematicians.

The mixture of hot topics and profiles of outstanding mathematicians proves a good choice. ...Hopefully it will reach teachers and educators in order to make mathematics more visible and perhaps a bit more understandable to the general public.

—Zentralblatt MATH

**Contents:** Introduction; A new twist in knot theory; Error-term roulette and the Sato-Tate conjecture; The fifty-one percent solution; Dominos, anyone?; Not seeing is believing; Getting with the (Mori) program; The book that time couldn’t erase; Charting a 248-dimensional world; Compressed sensing makes every pixel count.

**What's Happening in the Mathematical Sciences**, Volume 7

February 2009, 127 pages, Softcover, ISBN: 978-0-8218-4478-6, 2000 Mathematics Subject Classification: 00A06, AMS members US$15.95, List US$19.95, Order code HAPPENING/7

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**Circle in a Box**

**Sam Vandervelde, St. Lawrence University, Canton, NY**

Math circles provide a setting in which mathematicians work with secondary school students who are interested in mathematics. This form of outreach, which has existed for decades in Russia, Bulgaria, and other countries, is now rapidly spreading across the United States as well. The first part of this book offers helpful advice on all aspects of math circle operations, culled from conversations with over a dozen directors of successful math circles. Topics include creative means for getting the word out to students, sound principles for selecting effective speakers, guidelines for securing financial support, and tips for designing an exciting math circle session. The purpose of this discussion is to enable math circle coordinators to establish a thriving group in which students can experience the delight of mathematical investigation. The second part of the book outlines ten independent math circle sessions, covering a variety of topics and difficulty levels. Each chapter contains detailed presentation notes along with a useful collection of problems and solutions. This book will be an indispensable resource for any individual involved with a math circle or anyone who would like to see one begin in his or her community.

Sam Vandervelde teaches at St. Lawrence University. He launched the Stanford Math Circle and also writes and coordinates the Mandelbrot Competition, a math contest for high schools.

Titles in this series are co-published with the Mathematical Sciences Research Institute (MSRI).

**Contents:** Overnight: Molding a math circle; Supporting a math circle; Sustaining a math circle; Leading a math circle; Presentations: The game of Criss-Cross; Double time; King chickens; Into the unknown; Sneaky segments; Heads or tails; Circling the square; Roulette and the Sato-Tate conjecture; The fifty-one percent solution; Dominos, anyone?; Not seeing is believing; Getting with the (Mori) program; The book that time couldn’t erase; Charting a 248-dimensional world; Compressed sensing makes every pixel count.

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**Contents:** Introduction; A new twist in knot theory; Error-term roulette and the Sato-Tate conjecture; The fifty-one percent solution; Dominos, anyone?; Not seeing is believing; Getting with the (Mori) program; The book that time couldn’t erase; Charting a 248-dimensional world; Compressed sensing makes every pixel count.

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Geometry and Topology

Applications of Knot Theory

Dorothy Buck, Imperial College
London, England, and Erica Flapan, Pomona College, Claremont, CA, Editors

Over the past 20–30 years, knot theory has rekindled its historic ties with biology, chemistry, and physics as a means of creating more sophisticated descriptions of the entanglements and properties of natural phenomena—from strings to organic compounds to DNA.

This volume is based on the 2008 AMS Short Course, Applications of Knot Theory. The aim of the Short Course and this volume, while not covering all aspects of applied knot theory, is to provide the reader with a mathematical appetizer, in order to stimulate the mathematical appetite for further study of this exciting field.

No prior knowledge of topology, biology, chemistry, or physics is assumed. In particular, the first three chapters of this volume introduce the reader to knot theory (by Colin Adams), topological chirality and molecular symmetry (by Erica Flapan), and DNA topology (by Dorothy Buck). The second half of this volume is focused on three particular applications of knot theory. Louis Kauffman discusses applications of knot theory to physics, Nadrian Seeman discusses how topology is used in DNA nanotechnology, and Jonathan Simon discusses the statistical and energetic properties of knots and their relation to molecular biology.

This item will also be of interest to those working in applications.

Contents: C. Adams, A brief introduction to knot theory from the physical point of view; E. Flapan, Topological chirality and symmetries of non-rigid molecules; D. Buck, DNA topology; L. H. Kaufman, Knots and physics; N. C. Seeman, Synthetic single-stranded DNA topology; J. Simon, Long tangled filaments.

Proceedings of Symposia in Applied Mathematics, Volume 66

Mathematical Physics

Canonical Wick Rotations in 3-Dimensional Gravity

Riccardo Benedetti, Università di Pisa, Italy, and Francesco Bonsante, Università degli Studi di Pavia, Italy

Contents: General view on themes and contents; Geometry models; Flat globally hyperbolic spacetimes; Flat Lorentzian vs hyperbolic geometry; Flat vs de Sitter Lorentzian geometry; Flat vs AdS Lorentzian geometry; $Q$-$D$-spacetimes; Complements; Bibliography; Index.

Memoirs of the American Mathematical Society, Volume 198, Number 926
Number Theory

Class Field Theory
Emil Artin, and John Tate, University of Texas at Austin, TX

This classic book, originally published in 1968, is based on notes of a year-long seminar the authors ran at Princeton University. The primary goal of the book was to give a rather complete presentation of algebraic aspects of global class field theory, and the authors accomplished this goal spectacularly: for more than 40 years since its first publication, the book has served as an ultimate source for many generations of mathematicians.

In this revised edition, two mathematical additions complementing the exposition in the original text are made. The new edition also contains several new footnotes, additional references, and historical comments.

Contents: Preliminaries; The first fundamental inequality; Second fundamental inequality; Reciprocity law; The existence theorem; Connected component of idele classes; The Grunwald–Wang theorem; Higher ramification theory; Explicit reciprocity laws; Group extensions; Abstract class field theory; Weil groups; Bibliography.

AMS Chelsea Publishing, Volume 366

Brownian Brownian Motion-I
N. Chernov, University of Alabama, Birmingham, AL, and D. Dolgopyat, University of Maryland, College Park, MD

Contents: Introduction; Statement of results; Plan of the proofs; Standard pairs and equidistribution; Regularity of the diffusion matrix; Moment estimates; Fast slow particle; Small large particle; Open problems; Appendix A. Statistical properties of dispersing billiards; Appendix B. Growth and distortion properties of dispersing billiards; Appendix C. Distortion bounds for two particle system; Bibliography; Index.

Memoirs of the American Mathematical Society, Volume 198, Number 927

Probability

Moderate Deviations for the Range of Planar Random Walks
Richard F. Bass, University of Connecticut, Storrs, CT, Xia Chen, University of Tennessee, Knoxville, TN, and Jay Rosen, CUNY, College of Staten Island, NY

Contents: Preliminaries; Moments of the range; Moderate deviations for \( R_n - E R_n \); Moderate deviations for \( E R_n - R_n \); Exponential asymptotics for the smoothed range; Exponential approximation; Laws of the iterated logarithm; Bibliography.

Memoirs of the American Mathematical Society, Volume 198, Number 929
March 2009, 82 pages, Softcover, ISBN: 978-0-8218-4287-4, LC 2008047917, 2000 Mathematics Subject Classification: 60F10,

Mathematical Physics

Boltzmann's Legacy
Giovanni Gallavotti, University of Rome I, Italy, and Wolfgang L. Reiter and Jakob Yngvason, University of Vienna, Austria, Editors

Ludwig Eduard Boltzmann (1844–1906) was an Austrian physicist famous for his founding contributions in the fields of statistical mechanics and statistical thermodynamics. He was one of the most important advocates for atomic theory when that scientific model was still highly controversial. To commemorate the 100th anniversary of his death in Duino, the International Symposium “Boltzmann’s Legacy” was held at the Erwin Schrödinger International Institute for Mathematical Physics in June 2006.

This text covers a broad spectrum of topics ranging from equilibrium statistical and nonequilibrium statistical physics, ergodic theory and chaos to basic questions of biology and
historical accounts of Boltzmann’s work. Besides the lectures presented at the symposium the volume also contains contributions specially written for this occasion. The articles give a broad overview of Boltzmann’s legacy to the sciences from the standpoint of some of today’s leading scholars in the field.

The book addresses students and researchers in mathematics, physics, and the history of science.

This item will also be of interest to those working in general and interdisciplinary areas.

A publication of the European Mathematical Society (EMS). Distributed within the Americas by the American Mathematical Society.

Contents:
- G. Gallavotti, Introduction;
- J. Renn, Boltzmann and the end of the mechanistic worldview;
- E. H. Lieb, What if Boltzmann had known about quantum mechanics;
- G. Gallavotti, Entropy, nonequilibrium, chaos and infinitesimals;
- J. L. Lebowitz, From time-symmetric microscopic dynamics to time-asymmetric macroscopic behavior: An overview;
- D. Ruelle, What physical quantities make sense in nonequilibrium statistical mechanics?
- D. S. Ornstein, Boltzmann, ergodic theory, and chaos;
- C. Cercignani, 134 years of Boltzmann equation;
- C. Villani, H-theorem and beyond: Boltzmann’s entropy in today’s mathematics;
- H. Spohn, On the Boltzmann equation for weakly nonlinear wave equations;
- E. G. Cohen, Entropy, probability and dynamics;
- C. Dellago and H. A. Posch, Realizing Boltzmann’s dream: computer simulations in modern statistical mechanics;
- A. Gabrielov, V. Kellis-Borok, Ya. Sinai, and I. Zaliapin, Statistical properties of the cluster dynamics of the systems of statistical mechanics;
- P. Schuster, Boltzmann and evolution: some basic questions of biology seen with atomistic glasses;
- W. L. Reiter, Ludwig Boltzmann—the restless prophet; Chronology; List of contributors; Name index; Subject index.

ESI Lectures in Mathematics and Physics, Volume 5
October 2007, 284 pages, Hardcover, ISBN: 978-3-03719-057-9, 2000 Mathematics Subject Classification: 01-02, 82-02, 82C03, 82B40, AMS members US$62, List US$78, Order code EMSESILEC/5
Each month the Feature Column explores a mathematical topic, such as Penrose tiles, cosmology, web-searching, and networks. Each column takes full advantage of the web with graphics, links, and references. Topics are developed and written by David Austin, Bill Casselman, Joe Malkevitch, and Tony Phillips.

Read the current column and explore the archive of essays. The Feature Column is a great way to share with your students your excitement about the beauty of, and developments in, mathematics.

Sign up for Headlines and Deadlines at www.ams.org/enews to receive email notifications when each new column is posted.
Classified Advertisements

Positions available, items for sale, services available, and more

CONNECTICUT

YALE UNIVERSITY
Department of Mathematics

The Mathematics Department at Yale University intends to make one or more tenure-track assistant professor appointments beginning July 1, 2009. Positions will be open to all fields of mathematics. Evidence of strong promise of leadership in research and excellence in teaching required. Yale University is an Affirmative Action/Equal Opportunity Employer. Yale values diversity among its faculty, staff, and students and strongly encourages applications from women and underrepresented minorities. Please send curriculum vitae, description of research interests, and arrange for three letters of recommendation to be sent to: Tenure-Track Search Committee, Department of Mathematics, Yale University, P.O. Box 208283, New Haven, CT 06520-8283. Review of applications will begin February 15, 2009.

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PENNSYLVANIA

UNIVERSITY OF PITTSBURGH AT BRADFORD
Department of Mathematics

Mathematics (assistant professor, tenure-stream), beginning fall 2009. Requirements: Ph.D. or Ed.D. in math by December 2009. A strong commitment to undergraduate education on a small rural campus and potential for scholarly work are essential. Applicants with math education background or a willingness to develop this expertise will be given favorable consideration. Teaching assignment will include general education math courses, probability, and statistics. Send letter, vita, unofficial transcripts, and 3 letters of reference to: Dr. Marius Buliga, Math Search Committee, University of Pittsburgh at Bradford, 300 Campus Drive, Bradford, PA 16701. http://www.upb.pitt.edu/acadsearch.aspx. Review of completed applications will begin January 15, 2009, and continue until position is filled. Pitt-Bradford is a beautiful, friendly campus with an emphasis on teaching. While faculty have the advantage of the expansive resources and research opportunities available through the University of Pittsburgh system, they also enjoy one-on-one contact with their students in a secure, personalized environment. Individuals representing all aspects of diversity are encouraged to apply. AA/EOE.

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COLOMBIA

UNIVERSIDAD DE LOS ANDES
Department of Mathematics
Faculty and visiting positions 2009

The Department of Mathematics invites applications for positions at the tenure-track assistant professor level and visiting professor to begin in August 2009. All areas of pure and applied mathematics will be considered but preference will be given to analysis, algebra, differential and algebraic geometry, mathematical physics, probability and statistics. Applicants are required to have a Ph.D. in mathematical sciences and be able to develop a significant research program. A strong commitment to undergraduate and graduate teaching is also required. Duties include courses for undergraduate students in natural sciences, engineering, and economics; graduate courses in mathematics; and the eventual supervising of undergraduate, master, or Ph.D. thesis. The department offers internationally competitive salaries with start-up grants for research. Proficiency in Spanish is desirable. Please send an AMS standard cover sheet, curriculum vitae, research plan, teaching statement, and three letters of recommendation to:

Faculty Hiring
Department of Mathematics
Universidad de los Andes
A.A. 4976
Bogotá, Colombia

Electronic submission can also be sent to: matema@uniandes.edu.co. Applicants interested in any further information regarding the Mathematics Department at Los Andes please visit the website: http://matematicas.uniandes.edu.co/. Preference will be given to applicants whose applications are submitted by February 11, 2009. Review of applications will continue until positions are filled.

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Suggested uses for classified advertising are positions available, books or lecture notes for sale, books being sought, exchange or rental of houses, and typing services.

The 2009 rate is $110 per inch or fraction thereof on a single column (one-inch minimum), calculated from top of headline. Any fractional text of 1/2 inch or more will be charged at the next inch rate. No discounts for multiple ads or the same ad in consecutive issues. For an additional $10 charge, announcements can be placed correspondently. Correspondence will be forwarded.

Advertisements in the "Positions Available" classified section will be set with a minimum one-line headline, consisting of the institution name above body copy, unless additional headline copy is specified by the advertiser. Headlines will be centered in boldface at no extra charge. Ads will appear in the language in which they are submitted.

There are no member discounts for classified ads. Dictation over the telephone will not be accepted for classified ads.


U.S. laws prohibit discrimination in employment on the basis of color, age, sex, race, religion, or national origin. "Positions Available" advertisements from institutions outside the U.S. may not be legally bound to conform to these or similar requirements. Details may be found on page 1041 (volume 55).

Situations wanted advertisements for involuntarily unemployed mathematicians are accepted under certain conditions for free publication. Call toll-free 800-321-AMS (321-4267) in the U.S. and Canada or 401-455-4084 worldwide for further information.

Submission: Promotions Department, AMS, P.O. Box 6248, Providence, Rhode Island 02940; or via fax: 401-331-3842; or send email to classifieds@ams.org. AMS location for express delivery packages is 201 Charles Street, Providence, Rhode Island 02904. Advertisers will be billed upon publication.

320 Notices of the AMS

Volume 56, Number 2
A World Without Mathematics...

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A World With Mathematics

www.ams.org
Meetings & Conferences of the AMS

Urbana, Illinois
University of Illinois at Urbana-Champaign

March 27–29, 2009
Friday – Sunday

Meeting #1047
Central Section
Associate secretary: Susan J. Friedlander
Announcement issue of Notices: January
Program first available on AMS website: February 12, 2009
Program issue of electronic Notices: March
Issue of Abstracts: Volume 30, Issue 2

Deadlines
For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: February 3, 2009

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses
Jeffrey C. Lagarias, University of Michigan, From Apollonian circle packings to Fibonacci Numbers (Erdős Memorial Lecture).

Jacob Lurie, Massachusetts Institute of Technology, On topological quantum field theories.
Gilles Pisier, Texas A&M University, Title to be announced.
Akshay Venkatesh, New York University-Courant Institute, Title to be announced.

Special Sessions
Algebra, Geometry and Combinatorics (Code: SS 10A), Rinat Kedem, University of Illinois at Urbana-Champaign, and Alexander T. Yong, University of Minnesota.
Complex Dynamics and Value Distribution (Code: SS 11A), Aimo Hinkkanen and Joseph B. Miles, University of Illinois at Urbana-Champaign.
Concrete Aspects of Real Positive Polynomials (Code: SS 20A), Victoria Powers, Emory University, and Bruce Reznick, University of Illinois at Urbana-Champaign.
Differential Geometry and Its Applications (Code: SS 16A), Stephanie B. Alexander, University of Illinois at Urbana-Champaign, and Jang-Mei Wu, University of Illinois at Urbana-Champaign.
Geometric Function Theory and Analysis on Metric Spaces (Code: SS 6A), Sergiy Merenkov, Jeremy Taylor Tyson, and Jang-Mei Wu, University of Illinois at Urbana-Champaign.
Geometric Group Theory (Code: SS 2A), Sergei V. Ivanov, Ilya Kapovich, Igor Mineyev, and Paul E. Schupp, University of Illinois at Urbana-Champaign.
Graph Theory (Code: SS 4A), Alexander V. Kostochka and Douglas B. West, University of Illinois at Urbana-Champaign.

Holomorphic and CR Mappings (Code: SS 9A), John P. D'Angelo, Jiri Lebl, and Alex Tumanov, University of Illinois at Urbana-Champaign.

Hyperbolic Geometry and Teichmüller Theory (Code: SS 18A), Jason DeBlois, University of Illinois at Chicago, Richard P. Kent IV, Brown University, and Christopher J. Leininger, University of Illinois at Urbana-Champaign.

Local and Homological Methods in Commutative Algebra (Code: SS 13A), Florian Enescu, Georgia State University, and Sandra Spiroff, University of Mississippi.

Mathematical Visualization (Code: SS 7A), George K. Francis, University of Illinois at Urbana-Champaign, Louis H. Kauffman, University of Illinois at Chicago, Dennis Martin Roseman, University of Iowa, and Andrew J. Hanson, Indiana University.

Nonlinear Partial Differential Equations and Applications (Code: SS 21A), Igor Kukavica, University of Southern California, and Anna L. Mazzucato, Pennsylvania State University.

Number Theory in the Spirit of Erdős (Code: SS 14A), Kevin Ford and A. J. Hildebrand, University of Illinois at Urbana-Champaign.

Operator Algebras and Operator Spaces (Code: SS 8A), Zhong-Jin Ruan, Florin P. Boca, and Marius Junge, University of Illinois at Urbana-Champaign.

Probabilistic and Extremal Combinatorics (Code: SS 5A), Jozsef Balogh and Zoltan Furedi, University of Illinois at Urbana-Champaign.

The Interface Between Number Theory and Dynamical Systems (Code: SS 17A), Florin Boca, University of Illinois at Urbana-Champaign, Jeffrey Lagarias, University of Michigan, and Kenneth Stolarsky, University of Illinois at Urbana-Champaign.

The Logic and Combinatorics of Algebraic Structures (Code: SS 22A), John Snow, Concordia University, and Jeremy Alm, Illinois College.

Time, Scale, and Frequency Methods in Harmonic Analysis (Code: SS 15A), Richard S. Laugesen, University of Illinois at Urbana-Champaign, and Darrin M. Speegle, St. Louis University.

Topological Dynamics and Ergodic Theory (Code: SS 19A), Alica Miller, University of Louisville, and Joseph Rosenblatt, University of Illinois at Urbana-Champaign.

Topological Field Theories, Representation Theory, and Algebraic Geometry (Code: SS 12A), Thomas Nevins, University of Illinois at Urbana-Champaign, and David Ben-Zvi, University of Texas at Austin.

q-Series and Partitions (Code: SS 1A), Bruce Berndt, University of Illinois at Urbana-Champaign, and Ae Ja Yee, Pennsylvania State University.

Raleigh, North Carolina

North Carolina State University

April 4–5, 2009
Saturday – Sunday

Meeting #1048
Southeastern Section

Invited Addresses

Nathan Dunfield, University of Illinois at Urbana-Champaign, Surfaces in finite covers of 3-manifolds: The virtual Haken conjecture.

Reinhard C. Laubenbacher, Virginia Bioinformatics Institute, Algebraic models in systems biology.

Jonathan C. Mattingly, Duke University, Stochastically forced fluid equations: Transfer between scales and ergodicity.

Raman Parimala, Emory University, Arithmetic of linear algebraic groups over 2-dimensional geometric fields.

Michael S. Waterman, University of Southern California, Reading DNA sequences: Twenty-first century technology with eighteenth century mathematics (Einstein Public Lecture in Mathematics).

Special Sessions


Algebraic Groups and Symmetric Spaces (Code: SS 19A), Stacy Beun, Cabrini College, and Aloysius Helminck, North Carolina State University.

Applications of Algebraic and Geometric Combinatorics (Code: SS 2A), Seth M. Sullivant, Harvard University, and Carla D. Savage, North Carolina State University.

Applications of Dynamical Systems to Problems in Biology (Code: SS 16A), John E. Franke and James F. Selgrade, North Carolina State University.
Meetings & Conferences

Brauer Groups, Quadratic Forms, Algebraic Groups, and Lie Algebras (Code: SS 12A), Eric S. Brussel and Skip Garibaldi, Emory University.

Commutative Rings and Monoids (Code: SS 17A), Scott T. Chapman, Sam Houston State University, and James B. Coykendall, North Dakota State University.

Computational Methods in Lie Theory (Code: SS 10A), Eric Sommers, University of Massachusetts, Amherst, and Molly Fenn, North Carolina State University.

Deferred Correction Methods and their Applications (Code: SS 20A), Elizabeth L. Bouzarth and Anita T. Layton, Duke University.


Galois Module Theory and Hopf Algebras (Code: SS 13A), Robert G. Underwood, Auburn University Montgomery, and James E. Carter, College of Charleston.


Homotopical Algebra with Applications to Mathematical Physics (Code: SS 3A), Thomas J. Lada, North Carolina State University, and Jim Stasheff, University of North Carolina, Chapel Hill.

Kac-Moody Algebras, Vertex Algebras, Quantum Groups, and Applications (Code: SS 1A), Bojko N. Bakalov, Kailash C. Misra, and Nailian N. Jing, North Carolina State University.

Low-Dimensional Topology and Geometry (Code: SS 4A), Nathan M. Dunfield, University of Illinois at Urbana-Champaign, John B. Etnyre, Georgia Institute of Technology, and Lenhard Ng, Duke University.

Mathematical Progress and Challenges for Biological Materials (Code: SS 18A), Mansoor A. Haider, North Carolina State University, and Gregory Forest, University of North Carolina, Chapel Hill.

Mathematics of Immunology and Infectious Diseases (Code: SS 14A), Stanca M. Ciupe, Duke University.

Nonlinear Dynamics and Control (Code: SS 11A), Anthony M. Bloch, University of Michigan, Ann Arbor, and Dmitry Zenkov, North Carolina State University.


Recent Advances in Symbolic Algebra and Analysis (Code: SS 5A), Michael F. Singer and Agnes Szanto, North Carolina State University.

Rings, Algebras, and Varieties in Combinatorics (Code: SS 6A), Patricia Hersh, North Carolina State University, Christian Lenart, SUNY Albany, and Nathan Reading, North Carolina State University.


The Mathematics of Biochemical Reaction Networks (Code: SS 22A), Anne Shiu, University of California Berkeley, Manoj Gopalkrishnan, University of Southern California, and Gheorghe Craciun, University of Wisconsin-Madison.

San Francisco, California
San Francisco State University
April 25–26, 2009
Saturday - Sunday
Meeting #1049
Western Section
Associate secretary: Michel L. Lapidus

Announcement issue of Notices: February 2009
Program first available on AMS website: March 12, 2009
Program issue of electronic Notices: April 2009
Issue of Abstracts: Volume 30, Issue 3

Deadlines
For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: March 3, 2009

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Yehuda Shalom, University of California Los Angeles, Title to be announced.

Roman Vershynin, University of California Davis, Title to be announced.

Karen Vogtmann, Cornell University, Title to be announced.

Efim Zelmanov, University of California Los Angeles, Title to be announced.

Special Sessions

Advances in the Theory of Integer Linear Optimization and its Extensions (Code: SS 7A), Matthias Koepppe and Peter Malkin, University of California Davis.

Algebra and Number Theory with Polyhedra (Code: SS 11A), Matthias Beck, San Francisco State University, and Christian Haase, Freie Universität Berlin.

Applications of Knot Theory to the Entanglement of Biopolymers (Code: SS 10A), Javier Arsuaga, San Francisco State University, Kenneth Millett, University of California Santa Barbara, and Mariel Vazquez, San Francisco State University.

Aspects of Differential Geometry (Code: SS 9A), David Bao, San Francisco State University, and Lei Ni, University of California San Diego.

Banach Algebras, Topological Algebras and Abstract Harmonic Analysis (Code: SS 1A), Thomas V. Tonev, University of Montana-Missoula, and Fereidoun Ghahramani, University of Manitoba.

Concentration Inequalities (Code: SS 3A), Sourav Chatterjee, University of California Berkeley, and Roman Vershynin, University of California Davis.
Geometry and Topology of Orbifolds (Code: SS 6A), Elizabeth Stanhope, Lewis & Clark University, and Joseph E. Borzelliino, California State University San Luis Obispo.

Lie Group Actions, Teichmüller Flows and Number Theory (Code: SS 12A), Jayadev Athreya, Yale University, Yitwah Cheung, San Francisco State University, and Anton Zorich, Rennes University.

Matroids in Algebra and Geometry (Code: SS 8A), Federico Ardila, San Francisco State University, and Lauren Williams, Harvard University.

Nonlinear Dispersive Equations (Code: SS 4A), Sebastian Herr, University of California Berkeley, and Jeremy L. Marzuola, Columbia University.

Nonlinear Partial Differential Equations (Code: SS 13A), Igor Kukavica, Amjad Tuffaha, and Mohammed Ziane, University of Southern California.

Recent Progress in Geometric Group Theory (Code: SS 2A), Seonhee Lim and Anne Thomas, Cornell University.

Accommodations
Participants should make their own arrangements directly with a hotel of their choice. Rates quoted do not include sales tax. The AMS is not responsible for rate changes or for the quality of the accommodations. When making a reservation, participants should state they are with the American Mathematical Society group (AMS Meeting). None of the hotels listed are within walking distance of the meeting. Cancellation and early checkout policies vary; be sure to check when you make your reservation.


Hampton Inn, 2700 Junipero Serra Blvd, Daly City, CA; 650-755-7500 or 866-519-4851. Rates are $119 single/double plus tax. All terms and conditions are subject to availability. The Hampton Inn is located on Junipero Serra Blvd, just two miles south of the campus. All rooms include telephone with complimentary local calls, data ports, cable television, and hairdryers. Free parking on property, hot breakfast, and heated pool are also included. Deadline for reservations is March 1. Cancellation and early checkout policies vary; be sure to check when you make your reservation.

Sheraton Gateway Hotel–San Francisco Airport, 600 Airport Blvd., Burlingame, CA 94010; 650-340-8500, http://www.sheratonsfo.com. Rates are $105 single/double plus tax. There is an additional $15 fee per person for triple or quad occupancy. Deadline for reservations is April 3. Cancellation and early checkout policies vary; be sure to check when you make your reservation.

Food Service
A list of restaurants will be available at the registration desk.

Local Information
Please visit the Web sites maintained by San Francisco State University at http://www.sfsu.edu, the Department of Mathematics at http://math.sfsu.edu and the site maintained by the San Francisco Convention and Visitors Bureau at http://www.sfvisitor.org.

Other Activities
AMS Editorial Activity: An acquisitions editor from the AMS book program will be present to speak with prospective authors. If you have a book project that you would like to discuss with the AMS, please stop by the book exhibit.

Book Sales: Stop by the on-site AMS Bookstore and review the newest titles from the AMS, enjoy up to 25% off all AMS publications, or take home an AMS t-shirt! Complimentary coffee will be served courtesy of AMS Membership Services.

Parking
Parking is available in the university parking structure located on South State Street. For more information regarding parking please visit http://www.sfsu.edu/%7Eparking/text/tocampus.html.

Registration and Meeting Information
The registration desk will be located on the third (main) floor of Thornton Hall, and will be open from 7:30 a.m. to 4:00 p.m. on Saturday and 8:00 a.m. to noon on Sunday. Talks will take place in the Science Building and Thornton Hall.

Registration fees are US$40 for AMS or CMS members, US$60 for nonmembers; and US$5 for students, unemployed mathematicians, and emeritus members. Fees are payable on site by cash, check, or credit card.

Travel Information and Campus Map
San Francisco Airport (SFO): From the departure area take the I-280 North entrance. Take I-280 North, exit at 19th Avenue. Take Junipero Serra Boulevard to Holloway Avenue; turn left on Holloway Avenue to campus at 19th Avenue.

To get to the parking garage, continue on Holloway Ave. to Font Blvd. Turn right onto Font Blvd. and continue to Lake Merced Blvd. Turn right onto Lake Merced Blvd. then take an immediate right onto State Drive which is the entrance to the parking garage.

By Public Transportation: BART: Exit the Daly City BART Station then take the SFSU shuttle or the MUNI 28 bus.

SuperShuttle: Call 800-258-3826 for reservations or find SuperShuttle vans outside of Departures.

By Car:
From the North: Take Highway 101 South, cross the Golden Gate Bridge. Take 19th Avenue/Highway 1 exit. Follow 19th Avenue to campus at Holloway Avenue.

To get to the parking garage, turn right onto Holloway Ave. and continue to Font Blvd. Turn right onto Font Blvd. and continue to Lake Merced Blvd. Turn right onto Lake
Merced Blvd, then take an immediate right onto State Drive which is the entrance to the parking garage.

From the South: Take I-280 North, exit at 19th Avenue. Take Junipero Serra Boulevard to Holloway Avenue, turn left on Holloway Avenue to campus at 19th Avenue.

To get to the parking garage, continue on Holloway Ave. to Font Blvd. Turn right onto Font Blvd. and continue to Lake Merced Blvd. Turn right onto Lake Merced Blvd. then take an immediate right onto State Drive which is the entrance to the parking garage.

From the East: Take I-80 West across the Bay Bridge to Highway 101 South. Take 101 South to I-280 toward Daly City. Take the San Jose Avenue/Mission St. exit (immediately after the Ocean Avenue exit), bearing right onto Sagamore Street to Brotherhood Way to Junipero Serra Boulevard North. Take Junipero Serra Boulevard to Holloway Avenue, turn left on Holloway Avenue to campus at 19th Avenue.

To get directly to the parking garage stay on Brotherhood Way and turn right onto Lake Merced Blvd. Turn right onto State Drive which is the third light after turning onto Lake Merced Blvd. and immediately after Font Blvd.

Click here http://www.sfsu.edu/%7Eparking/images/parking_map.gif or visit http://www.sfsu.edu/%7Eparking/text/tocampus.html for a campus map.

Car Rental

Avis Rent A Car is the official car rental company for the meeting. Depending on variables such as location, length of rental, and size of vehicle, Avis will offer participants the best available rate which can range from 5%-25% discount off regular rates. Participants must use the assigned Meeting Avis Discount Number (J098887) and meet Avis rate requirements to receive the discount. (Rate discounts are available at all corporate and participating licensee locations.) Reservations can be made by calling 800-331-1600 or online at http://www.avis.com.

All car rentals include unlimited free mileage and are available to renters 25 years and older. Renters must also meet Avis’s driver and credit requirements. Return to the same rental location or additional surcharges may apply. Rates do not include any state or local surcharges, tax, optional coverages, or gas refueling charges.

Weather

The weather in April is variable, with temperatures from 70° Fahrenheit to 85° Fahrenheit. The weather can turn cold, overcast, and windy due to the close proximity of the SFSU campus to the ocean.

Special Travel Information for International Participants

Visa regulations are continually changing for travel to the United States. Visa applications may take from three to four months to process and require a personal interview, as well as specific personal information. International participants should view the important information about traveling to the U.S. found at http://www7.nationalacademies.org/visas/Traveling_to_US.html and http://travel.state.gov/visa/index.html http://travel.state.gov/visa/visa_1750.html. If you need a preliminary conference invitation in order to secure a visa, please send your request to wsd@ams.org.

If you discover you do need a visa, the National Academies website (see above) provides these tips for successful visa applications:

- Visa applicants are expected to provide evidence that they are intending to return to their country of residence. Therefore, applicants should provide proof of “binding” or sufficient ties to their home country or permanent residence abroad. This may include documentation of the following:
  - family ties in home country or country of legal permanent residence
  - property ownership
  - bank accounts
  - employment contract or statement from employer stating that the position will continue when the employee returns;

- Visa applications are more likely to be successful if done in a visitor’s home country than in a third country;

- Applicants should present their entire trip itinerary, including travel to any countries other than the United States, at the time of their visa application;

- Include a letter of invitation from the meeting organizer or the U.S. host, specifying the subject, location and dates of the activity, and how travel and local expenses will be covered;

- If travel plans will depend on early approval of the visa application, specify this at the time of the application;

- Provide proof of professional scientific and/or educational status (students should provide a university transcript).

This list is not to be considered complete. Please visit the websites above for the most up-to-date information.

Worcester, Massachusetts

Worcester Polytechnic Institute

April 25–26, 2009

Saturday - Sunday

Meeting #1050

Eastern Section

Associate secretary: Steven H. Weintraub

Announcement issue of Notices: February 2009

Program first available on AMS website: March 12, 2009

Program issue of electronic Notices: April 2009

Issue of Abstracts: Volume 30, Issue 3

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired  
For abstracts: March 3, 2009

The scientific information listed below may be outdated.  
For the latest information, see www.ams.org/amsmtgs/sectional.html

Invited Addresses

Octav Cornea, Université de Montréal, Lagrangian submanifolds: From physics to number theory.

Fengbo Hang, Courant Institute of New York University, Topology of weakly differentiable maps.

Umberto Mosco, Worcester Polytechnic Institute, Fractional spectra between Sclava and Charybdis.

Kevin Whyte, University of Illinois at Chicago, A rapid survey of coarse geometry.

Special Sessions

Algebraic Graph Theory, Association Schemes, and Related Topics (Code: SS 8A), William J. Martin, Worcester Polytechnic Institute, and Sylvia A. Hobart, University of Wyoming.

Analysis of Weakly Differentiable Maps with Constraints and Applications (Code: SS 11A), Fengbo Hang, Courant Institute, New York University, and Mohammad Reza Pakzad, University of Pittsburgh.

Discrete Geometry and Combinatorics (Code: SS 5A), Egon Schulte, Northeastern University, and Brigitte Servatius, Worcester Polytechnic Institute.

Effective Dynamics and Interactions of Localized Structures in Schrödinger Type Equations (Code: SS 10A), Fridolin Ting, Lakehead University.

Number Theory (Code: SS 4A), John T. Cullinan, Bard College, and Siman Wong, University of Massachusetts, Amherst.

Quasi-Static and Dynamic Evolution in Fracture Mechanics (Code: SS 6A), Christopher J. Larsen, Worcester Polytechnic Institute.

Real and Complex Dynamics of Rational Difference Equations with Applications (Code: SS 9A), M. R. S. Kulenovic and Orlando Merino, University of Rhode Island.


Symplectic and Contact Topology (Code: SS 1A), Peter Albers, Purdue University/ETH Zurich, and Basak Gurel, Vanderbilt University.

The Mathematics of Climate Change (Code: SS 3A), Catherine A. Roberts and Gareth E. Roberts, College of the Holy Cross, and Mary Lou Zeeman, Bowdoin College.

Topological Robotics (Code: SS 2A), Li Han and Lee N. Rudolph, Clark University.

Accommodations

Participants should make their own arrangements directly with the properties listed below. Special rates for the meeting are available at the properties shown below for Friday and Saturday nights. When making reservations participants should state that they are a guest of the American Mathematical Society or AMS. The AMS is not responsible for rate changes or for the quality of the accommodations. Hotels have varying cancellation or early checkout penalties; be sure to ask for details when making your reservation.

Because of several large events in the area at the time of our meeting, hotel availability is limited. We have secured room blocks at the following two hotels. To guarantee a room reservation, we advise making your travel plans early.

Courtyard by Marriott Worcester, 72 Grove Street, Worcester, MA 01605; 508-363-0300, toll free: 888-887-7948; fax: 508-363-3563; http://www.marriott.com/hotels/travel/boswr-courtyard-worcester/. The hotel is approximately 0.69 miles from the meeting site. Rates start at US$116 per night. Rates quoted do not include the sales and occupancy tax of 12%. Be sure to check cancellation and early checkout policies. Amenities include spacious hotel rooms featuring new luxury bedding, large workspaces, free wireless high speed Internet access, indoor pool, whirlpool, exercise room, cozy fireplace lounge, restaurant serving breakfast, and complimentary on-site parking. Deadline for reservations is April 3, 2009.

Beechwood Hotel, 363 Plantation Street, Worcester, MA 01605, 508-754-0731; toll free: 800-344-2589; fax: 508-754-0731; http://www.beechwoodhotel.com/. This luxury hotel is located approximately 2.34 miles from the meeting site. Rates start at US$149 per night. Rates quoted do not include the sales and occupancy tax of 12%. Be sure to check cancellation and early checkout policies. Amenities include complimentary continental breakfast and newspapers, free wireless high speed Internet, jogging track and fitness center. Complimentary parking and fine dining restaurant are on site. Deadline for reservations is March 27, 2009.

Below is a list of other hotels in the area that may have a small number of rooms available. No rooms were specifically reserved for participants at these hotels.

Crowne Plaza Hotel Worcester, 10 Lincoln Square, Worcester, MA 01608; 508-791-1600; toll free: 877-227-6963; fax: 508-7911796; http://www.ichotelsgroup.com/hd/cp/1/en/hotel/wrccp?_requestid=3046986. The hotel is located approximately 0.75 miles from the meeting site. Amenities include health club facilities, indoor and outdoor pools, jacuzzi/hot tub, and free wireless access; parking garage is available on site with a fee of US$5 for self parking or US$8 for valet.

Hilton Garden Inn Worcester, 35 Major Taylor Boulevard, Worcester, MA 01608, 508-753-5700; fax: 508-753-5780; http://hiltongardeninn.hilton.com/en/gi/hotels/index.jhtml;jsessionid=U500HMBPAQW0CSGBJC32EQ?ctyhocn=BEDWOGI. The hotel is located approximately one mile from the meeting site. Amenities include well-appointed guest rooms with large work desk; complimentary high speed Internet; fitness room; pool; onsite dining; Great American Grill and Uno Chicago Grill; and parking garage across from hotel with a daily fee of US$8.95. Valet parking is also available daily from 6:00 a.m.–11:00 p.m. with a fee of US$12.95.
Hampton Inn Worcester, 110 Summer Street, Worcester, MA 01608, 508-757-0400, fax: 508-831-9839; http://hamptoninn.hilton.com/en/hp/hotels/index.jhtml?ctyihocn=WORMAHX. The hotel is located approximately 1.09 miles from the meeting site. Amenities include free breakfast buffet, complimentary high speed Internet, complimentary parking, and exercise room.

Food Service
The campus center is open all day Saturday, 8:00 a.m.–1:00 a.m. and Sunday, 8:00 a.m.–12:00 midnight. Eating facilities include 48 Café Dunkin Donuts: 8:00 a.m.–6:00 p.m.; Campus Center Food Court: Saturday, 11:30 a.m.–12:00 midnight and Sunday 11:30 a.m.–11:00 p.m.; The Goat's Head Restaurant: Saturday: 11:00 a.m.–1:00 a.m. and Sunday: 11:00 a.m.–11:00 p.m. Within walking distance or a short drive one can find a variety of choices for dining at http://www.wpi.edu/About/Visitors/dining.html. Additional information and recommendations will be provided on site.

Local Information
The WPI visitors guide featuring directions and a campus map can be found at http://www.wpi.edu/About/Visitors/index.html.

Other Activities
AMS Book Sale: Stop by the on-site AMS Bookstore and review the newest titles from the AMS, enjoy up to 25% off all AMS publications, or take home an AMS T-shirt! Complimentary coffee will be served courtesy of AMS Membership Services.

AMS Editorial Activity: An acquisitions editor from the AMS book program will be present to speak with prospective authors. If you have a book project that you would like to discuss with the AMS, please stop by the book exhibit.

Parking
There are numerous campus lots available for parking on the weekends as well as on-street parking. The quadrangle area is not available on the weekend. The lots for parking are Higgins House, Gordon Library, West Street, and Stoddard Complex. Please see campus map for location and directions. http://www.wpi.edu/About/Visitors/campusmap.html.

Registration and Meeting Information
The meetings will be held in Higgins Labs and Salisbury Labs at Worcester Polytechnic Institute, Worcester, MA. The registration desk and book exhibit will be located in the Price Conference Room, Higgins Labs 102. The desk will be open Saturday, April 25, from 7:30 a.m. until 4:00 p.m. and Sunday, April 26, from 8:00 a.m. until noon. Fees are US$40/AMS or CMS members; US$60/nonmembers; US$5/emeritus members, students, or unemployed mathematicians. Fees are payable by cash, check, VISA, MasterCard, Discover, or American Express.

Transportation
By air:
Logan International Airport in Boston, MA (http://www.massport.com/logan/default.aspx) is approximately 46 miles from the Worcester campus. The approximate taxicab fare is US$120. You may also get to Worcester via the commuter rail system. For fare information, maps, and schedules, visit the MBTA Commuter Rail website http://www.mbta.com/schedules_and_maps/rail/ or call 617-222-3200.

T. F. Green Airport in Providence, R.I. (http://www.pvdairport.com/) is approximately 51 miles from the Worcester campus; approximate cab fare is US$118. See below for shuttle service information.

Manchester Airport in Manchester, N. H. (http://www.flymanchester.com) is approximately 69 miles from the Worcester campus; approximate cab fare is US$162. Renting a car is advised as there is no discount shuttle service available.

Airport Shuttles:
Knight's Airport Limousine Service (800-822-5456, http://www.knightairportlimo.com/) provides transportation to and from Logan Airport and T. F. Green Airport. One-way transportation is approximately US$66 from T. F. Green Airport and approximately US$55 from Logan Airport. Reservations should be made 24 hours prior to pickup. Visit their website for rates and reservations.

By bus:
The city of Worcester is served by two bus companies, Greyhound Lines, Inc. (http://www.greyhound.com) and Peter Pan Bus Lines (http://www.peterpanbus.com). For Greyhound fares and schedule information, call 800-231-2222. For Peter Pan fares and schedule information, call 800-343-9999.

Commuter Rail
The MBTA Commuter Rail stop located on Shrewsbury Street in Worcester is about 1.5 miles away from campus. The stop is at the end of the Worcester/Framingham line. For fare information, maps, and schedules, visit the MBTA Commuter Rail website http://www.mbta.com/schedules_and_maps/rail/ or call 617-222-3200.

Taxi Services
Two taxi services provide transportation in the Worcester area: Yellow Cab, 508-754-3211; and Red Cab, 508-792-9999 & 508-756-9000.

Trains
Amtrak services the city of Worcester from over 500 cities nationwide. The Worcester Amtrak station is located on Shrewsbury Street, about 1.5 miles from the campus. For more information, visit the Amtrak website http://www.amtrak.com or call 800-872-7245.

Driving Directions
Worcester Campus, 100 Institute Road, Worcester, MA 01609-2280.

From the East
Take Mass. Turnpike (I-90) to Exit 11A (I-495). Proceed north to exit 25B (I-290), then west into Worcester. Take Exit 18 (Lincoln Sq., Rte. 9), turn right at end of ramp,
then an immediate right before next traffic light. At next light, proceed straight through, bearing to the right on Salisbury St. At the WPI sign, turn left onto Boynton St., then right onto Institute Rd. Take your first right (Private Way). Admissions visitor parking is located on either side of Bartlett Center, the building that is directly ahead as you enter the Quadrangle area; general visitor parking is on the right as you approach the Quadrangle, adjacent to Alumni Gymnasium. Admissions visitors should pick up a visitor parking pass at the Admissions Office to display in their windshield.

From the North
Take I-495 south to I-290. Follow directions from east.

From the South and West
Take Mass. Turnpike (I-90) to Exit 10 (Auburn). Proceed east on I-290 into Worcester. Take Exit 17 (Lincoln Sq., Rte. 9), turn left at end of ramp, follow Rte. 9 west through Lincoln Sq., straight onto Highland St., then right at light onto West St. Travel one block and cross Institute Road (onto Private Way). Admissions visitor parking is located on either side of Bartlett Center, the building that is directly ahead as you enter the Quadrangle area; general visitor parking is on the right as you approach the Quadrangle, adjacent to Alumni Gymnasium. Admissions visitors should pick up a visitor parking pass at the Admissions Office to display in their windshield.

Information on public transportation is also available. Avis Rent A Car is the official car rental company for the meeting. Depending on variables such as location, length of rental, and size of vehicle, Avis will offer participants the best available rate which can range from 5%-25% discount off regular rates. Participants must use the assigned Meeting Avis Discount Number (J098887) and meet Avis rate requirements to receive the discount. (Rate discounts are available at all corporate and participating licensee locations.) Reservations can be made by calling 800-331-1600 or online at http://www.avis.com.

All car rentals include unlimited free mileage and are available to renters 25 years and older. Renters must also meet Avis’s driver and credit requirements. Return to the same rental location.

Weather
This time of year the temperature varies a good deal but typically offers mid-60° days followed by brisk evenings.

Special Travel Information for International Participants
Visa regulations are continually changing for travel to the United States. Visa applications may take from three to four months to process and require a personal interview, as well as specific personal information. International participants should view the important information about traveling to the U.S. found at http://www7.nationalacademies.org/visas/Traveling_to_US.html and http://travel.state.gov/visa/index.html http://travel.state.gov/visa/visa_1750.html. If you need a preliminary conference invitation in order to secure a visa, please send your request to wsd@ams.org.

If you discover you do need a visa, the National Academies website (see above) provides these tips for successful visa applications:

* Visa applicants are expected to provide evidence that they are intending to return to their country of residence. Therefore, applicants should provide proof of “binding” or sufficient ties to their home country or permanent residence abroad. This may include documentation of the following:
  - family ties in home country or country of legal permanent residence
  - property ownership
  - bank accounts
  - employment contract or statement from employer stating that the position will continue when the employee returns;
  * Visa applications are more likely to be successful if done in a visitor’s home country than in a third country;
  * Applicants should present their entire trip itinerary, including travel to any countries other than the United States, at the time of their visa application;
  * Include a letter of invitation from the meeting organizer or the U.S. host, specifying the subject, location and dates of the activity, and how travel and local expenses will be covered;
  * If travel plans will depend on early approval of the visa application, specify this at the time of the application;
  * Provide proof of professional scientific and/or educational status (students should provide a university transcript).

This list is not to be considered complete. Please visit the websites above for the most up-to-date information.

Waco, Texas

Baylor University

October 16–18, 2009
Friday – Sunday

Meeting #1051
Central Section
Associate secretary: Susan J. Friedlander
Announcement issue of Notices: August 2009
Program first available on AMS website: September 3, 2009
Program issue of electronic Notices: October 2009
Issue of Abstracts: Volume 30, Issue 4

Deadlines
For organizers: March 17, 2009
For consideration of contributed papers in Special Sessions: June 30, 2009
For abstracts: August 25, 2009
Invited Addresses

David Ben-Zvi, University of Texas at Austin, Title to be announced.

Alexander A. Kiselev, University of Wisconsin, Title to be announced.

Michael C. Reed, Duke University, Title to be announced.

Igor Rodnianski, Princeton University, Title to be announced.

Special Sessions

Commutative Algebra: Module and Ideal Theory (Code: SS 4A), Lars W. Christensen, Texas Tech University, Louiza Fouli, University of Texas at Austin, and David Jorgensen, University of Texas at Arlington.

Dynamic Equations on Time Scales: Analysis and Applications (Code: SS 1A), John M. Davis, Ian A. Gravagne, and Robert J. Marks, Baylor University.

Lie Groups, Lie Algebras, and Representations (Code: SS 6A), Markus Hunziker, Mark Sepanski, and Ronald Stanke, Baylor University.

Mathematical Models of Neuronal and Metabolic Mechanisms (Code: SS 3A), Janet Best, Ohio State University, and Michael Reed, Duke University.

Numerical Solutions of Singular or Perturbed Partial Differential Equation Problems with Applications (Code: SS 2A), Peter Moore, Southern Methodist University, and Qin Sheng, Baylor University.

Topological Methods for Boundary Value Problems for Ordinary Differential Equations (Code: SS 5A), Richard Avery, Dakota State University, Paul W. Eloe, University of Dayton, and Johnny Henderson, Baylor University.

For consideration of contributed papers in Special Sessions: July 7, 2009
For abstracts: September 1, 2009

Invited Addresses

Michael K. H. Kiessling, Rutgers University, Title to be announced.

Kevin R. Payne, Universita degli di Milano, Title to be announced.

Laurent Saloff-Coste, Cornell University, Title to be announced.

Robert C. Vaughan, Penn State University, Title to be announced.

Special Sessions

Homotopy Theory (code: SS 1A), James Gillespie and Mark W. Johnson, Pennsylvania State University, Simona Paoli, University of Haifa, Donald Yau, Ohio State University.

Difference Equations and Applications (code: SS 2A), Michael A. Radin, Rochester Institute of Technology.

Boca Raton, Florida

Florida Atlantic University

October 30 – November 1, 2009
Friday – Sunday

Meeting #1053
Southeastern Section
Associate secretary: Matthew Miller
Announcement issue of Notices: August 2009
Program first available on AMS website: September 17, 2009
Program issue of electronic Notices: October 2009
Issue of Abstracts: Volume 30, Issue 4

Deadlines
For organizers: March 30, 2009
For consideration of contributed papers in Special Sessions: July 14, 2009
For abstracts: September 8, 2009

Invited Addresses

Spyros Alexakis, Princeton University, Title to be announced.

Kai-Uwe Bux, University of Virginia, Title to be announced.

Dino J. Lorenzini, University of Georgia, Title to be announced.
Eduardo D. Sontag, Rutgers University, Title to be announced.

Special Sessions
Commutative Ring Theory (Code: SS 3A), Alan Loper, Ohio State University, and Lee C. Klingler, Florida Atlantic University.

Concentration, Functional Inequalities, and Isoperimetry (Code: SS 2A), Mario Milman, Florida Atlantic University, Christian Houdré, Georgia Institute of Technology, and Emanuel Milman, Institute for Advanced Study.

Constructive Mathematics (Code: SS 1A), Robert Lubarsky, Fred Richman, and Martin Solomon, Florida Atlantic University.

Enumerative Combinatorics (Code: SS 4A), Christian Krattenthaler, University of Vienna, and Aaron D. Meyerowitz, Heinrich Niederhausen, and Wandi Wei, Florida Atlantic University.

Harmonic Analysis (Code: SS 5A), Galia D. Dafni, Concordia University, and J. Michael Wilson, University of Vermont, Burlington.

Riverside, California
University of California
November 7–8, 2009
Saturday – Sunday

Meeting #1054
Western Section
Associate secretary: Michel L. Lapidus
Program first available on AMS website: September 24, 2009
Program issue of electronic Notices: November 2009
Issue of Abstracts: Volume 30, Issue 4

Deadlines
For organizers: To be announced
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Invited Addresses
Christopher Hacon, University of Utah, Title to be announced.

Birge Huisgen-Zimmerman, University of California Santa Barbara, Title to be announced.

Jun Li, Stanford University, Title to be announced.

Joseph Teran, University of California Los Angeles, Title to be announced.

Special Sessions
Algebraic Geometry (Code: SS 1A), Christopher Hacon, University of Utah, and Ziv Ran, University of California Riverside.

Fluid Mechanics (Code: SS 5A), James Kelliher and Qi Zhang, University of California Riverside.

History and Philosophy of Mathematics (Code: SS 4A), Shawnee L. McMurran, California State University San Bernardino, and James J. Tattersall, Providence College.

Noncommutative Geometry (Code: SS 2A), Vasily Dolgushev and Wei Liang Gan, University of California Riverside.

Representation Theory (Code: SS 3A), Vyjayanthi Chari, Wei Liang Gan, and Jacob Greenstein, University of California Riverside.

Seoul, Korea
December 16–20, 2009
Wednesday – Sunday

Meeting #1055
Associate secretary: Georgia Benkart
Program first available on AMS website: Not applicable
Program issue of electronic Notices: Not applicable
Issue of Abstracts: Not applicable

Deadlines
For organizers: To be announced
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

San Francisco, California
Moscone Center West and the San Francisco Marriott
January 13–16, 2010
Wednesday – Saturday

Joint Mathematics Meetings, including the 116th Annual Meeting of the AMS, 93rd Annual Meeting of the Mathematical Association of America (MAA), annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association for Symbolic Logic (ASL), with sessions contributed by the Society of Industrial and Applied Mathematics (SIAM).

Associate secretary: Matthew Miller
Program first available on AMS website: November 1, 2009
Program issue of electronic Notices: January 2010
Issue of Abstracts: Volume 31, Issue 1
Meetings & Conferences

**Deadlines**
For organizers: April 1, 2009
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

**Lexington, Kentucky**
*University of Kentucky*

**March 27–28, 2010**
*Saturday – Sunday*
Southeastern Section
Associate secretary: Matthew Miller
Announcement issue of Notices: To be announced
Program first available on AMS website: To be announced
Program issue of electronic Notices: To be announced
Issue of Abstracts: To be announced

**Deadlines**
For organizers: August 28, 2009
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

**St. Paul, Minnesota**
*Macalester College*

**April 10–11, 2010**
*Saturday – Sunday*
Central Section
Associate secretary: Susan J. Friedlander
Announcement issue of Notices: To be announced
Program first available on AMS website: To be announced
Program issue of electronic Notices: To be announced
Issue of Abstracts: To be announced

**Deadlines**
For organizers: September 10, 2009
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

**Albuquerque, New Mexico**
*University of New Mexico*

**April 17–18, 2010**
*Saturday – Sunday*
Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of Notices: To be announced
Program first available on AMS website: To be announced
Program issue of electronic Notices: To be announced
Issue of Abstracts: To be announced

**Deadlines**
For organizers: September 17, 2009
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

**Hoboken, New Jersey**
*New Jersey Institute of Technology*

**May 22–23, 2010**
*Saturday – Sunday*
Eastern Section
Associate secretary: Steven H. Weintraub
Announcement issue of Notices: To be announced
Program first available on AMS website: To be announced
Program issue of electronic Notices: To be announced
Issue of Abstracts: To be announced

**Deadlines**
For organizers: November 23, 2009
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

**Berkeley, California**
*University of California Berkeley*

**June 2–5, 2010**
*Wednesday – Saturday*
Eighth Joint International Meeting of the AMS and the Sociedad Matemática Mexicana.
Associate secretary: Susan J. Friedlander
Announcement issue of Notices: February 2010
Program first available on AMS website: To be announced
Program issue of electronic Notices: To be announced
Issue of Abstracts: To be announced
Meetings & Conferences

Deadlines
For organizers: To be announced
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Notre Dame, Indiana
Notre Dame University

September 18–19, 2010
Saturday - Sunday
Central Section
Associate secretary: Susan J. Friedlander
Announcement issue of Notices: To be announced
Program first available on AMS website: To be announced
Program issue of electronic Notices: To be announced
Issue of Abstracts: To be announced

Deadlines
For organizers: February 19, 2010
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Los Angeles, California
University of California Los Angeles

October 9–10, 2010
Saturday - Sunday
Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of Notices: To be announced
Program first available on AMS website: To be announced
Program issue of electronic Notices: To be announced
Issue of Abstracts: To be announced

Deadlines
For organizers: March 10, 2010
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

New Orleans, Louisiana
New Orleans Marriott and Sheraton New Orleans Hotel

January 5–8, 2011
Wednesday - Saturday
Joint Mathematics Meetings, including the 117th Annual Meeting of the AMS, 94th Annual Meeting of the Mathematical Association of America, annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association for Symbolic Logic (ASL), with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).
Associate secretary: Steven H. Weintraub
Announcement issue of Notices: October 2010
Program first available on AMS website: November 1, 2010
Program issue of electronic Notices: January 2011
Issue of Abstracts: Volume 32, Issue 1

Deadlines
For organizers: April 1, 2010
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Statesboro, Georgia
Georgia Southern University

March 12–13, 2011
Saturday - Sunday
Southeastern Section
Associate secretary: Matthew Miller
Announcement issue of Notices: To be announced
Program first available on AMS website: To be announced
Program issue of electronic Notices: To be announced
Issue of Abstracts: To be announced

Deadlines
For organizers: August 12, 2010
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced
Boston, Massachusetts

John B. Hynes Veterans Memorial Convention Center, Boston Marriott Hotel, and Boston Sheraton Hotel

January 4–7, 2012
Wednesday – Saturday
Joint Mathematics Meetings, including the 118th Annual Meeting of the AMS, 95th Annual Meeting of the Mathematical Association of America, annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association for Symbolic Logic (ASL), with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).
Associate secretary: Michel L. Lapidus
Announcement issue of Notices: October 2011
Program first available on AMS website: November 1, 2011
Program issue of electronic Notices: January 2012
Issue of Abstracts: Volume 33, Issue 1

Deadlines
For organizers: April 1, 2011
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

San Diego, California

San Diego Convention Center and San Diego Marriott Hotel and Marina

January 9–12, 2013
Wednesday – Saturday
Joint Mathematics Meetings, including the 119th Annual Meeting of the AMS, 96th Annual Meeting of the Mathematical Association of America, annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association for Symbolic Logic (ASL), with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).
Associate secretary: Susan J. Friedlander
Announcement issue of Notices: October 2012
Program first available on AMS website: November 1, 2012
Program issue of electronic Notices: January 2012
Issue of Abstracts: Volume 34, Issue 1

Deadlines
For organizers: April 1, 2012
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Baltimore, Maryland

Baltimore Convention Center

January 15–18, 2014
Wednesday – Saturday
Joint Mathematics Meetings, including the 120th Annual Meeting of the AMS, 97th Annual Meeting of the Mathematical Association of America, annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association for Symbolic Logic, with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).
Associate secretary: Matthew Miller
Announcement issue of Notices: October 2013
Program first available on AMS website: November 1, 2013
Program issue of electronic Notices: January 2014
Issue of Abstracts: Volume 35, Issue 1

Deadlines
For organizers: April 1, 2013
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

San Antonio, Texas

Henry B. Gonzalez Convention Center and Grand Hyatt San Antonio

January 10–13, 2015
Saturday – Tuesday
Joint Mathematics Meetings, including the 121st Annual Meeting of the AMS, 98th Annual Meeting of the Mathematical Association of America, annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association of Symbolic Logic, with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).
Associate secretary: Steven H. Weintraub
Announcement issue of Notices: October 2014
Program first available on AMS website: To be announced
Program issue of electronic Notices: January 2015
Issue of Abstracts: To be announced

Deadlines
For organizers: April 1, 2014
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced
Meetings and Conferences of the AMS

Associate Secretaries of the AMS
Western Section: Michel L. Lapidus, Department of Mathematics, University of California, Surge Bldg., Riverside, CA 92521-0133; e-mail: lapidus@math.ucr.edu; telephone: 951-827-5910.

Central Section: Susan J. Friedlander, Department of Mathematics, University of Illinois at Chicago, 851 S. Morgan (M/C 249), Chicago, IL 60607-7045; e-mail: susanj.math.nwu.edu; telephone: 312-996-3041.

Eastern Section: Lesley M. Sibner (until January 31, 2009), Department of Mathematics, Polytechnic University, Brooklyn, NY 11201-2990; e-mail: lsibner@duke.poly.edu; telephone: 718-260-3505. Steven H. Weintraub (after January 31, 2009), Department of Mathematics, Lehigh University, Bethlehem, PA 18105-3174; e-mail: steve.weintraub@lehigh.edu; telephone: 610-758-3717.

Southeastern Section: Matthew Miller, Department of Mathematics, University of South Carolina, Columbia, SC 29208-0001; e-mail: miller@math.sc.edu; telephone: 803-777-3690.

2009 Seoul, Korea Meeting: Georgia Benkart, University of Wisconsin-Madison, Department of Mathematics, 480 Lincoln Drive, Madison, WI 53706-1388; e-mail: benkart@math.wisc.edu; telephone: 608-263-4283.

The Meetings and Conferences section of the Notices gives information on all AMS meetings and conferences approved by press time for this issue. Please refer to the page numbers cited in the table of contents on this page for more detailed information on each event. Invited Speakers and Special Sessions are listed as soon as they are approved by the cognizant program committee; the codes listed are needed for electronic abstract submission. For some meetings the list may be incomplete. Information in this issue may be dated. Up-to-date meeting and conference information can be found at www.ams.org/meetings/.

Meetings:
2009
March 27–29 Urbana, Illinois p. 322
April 4–5 Raleigh, North Carolina p. 323
April 25–26 San Francisco, California p. 324
April 25–26 Worcester, Massachusetts p. 326
October 16–18 Waco, Texas p. 329
October 24–25 University Park, Pennsylvania p. 330
October 30–Nov. 1 Boca Raton, Florida p. 330
November 7–8 Riverside, California p. 331
December 6–20 Seoul, Korea p. 331

2010
January 13–16 San Francisco, California p. 331
March 27–28 Lexington, Kentucky p. 332
April 10–11 St. Paul, Minnesota p. 332
April 17–18 Albuquerque, New Mexico p. 332
May 22–23 Hoboken, New Jersey p. 332
June 2–5 Berkeley, California p. 332
September 18–19 Notre Dame, Indiana p. 333
October 9–10 Los Angeles, California p. 333

2011
January 5–8 New Orleans, Louisiana p. 333
March 12–13 Statesboro, Georgia p. 333

2012
January 4–7 Boston, Massachusetts p. 334

2013
January 9–12 San Diego, California p. 334

2014
January 15–18 Baltimore, Maryland p. 334

2015
January 10–13 San Antonio, Texas p. 334

Important Information Regarding AMS Meetings
Potential organizers, speakers, and hosts should refer to page 89 in the January 2009 issue of the Notices for general information regarding participation in AMS meetings and conferences.

Abstracts
Speakers should submit abstracts on the easy-to-use interactive Web form. No knowledge of \LaTeX\ is necessary to submit an electronic form, although those who use \LaTeX\ may submit abstracts with such coding, and all math displays and similarly coded material (such as accent marks in text) must be typeset in \LaTeX. Visit http://www.ams.org/cgi-bin/abstracts/abstract.pl. Questions about abstracts may be sent to abs-info@ams.org. Close attention should be paid to specified deadlines in this issue. Unfortunately, late abstracts cannot be accommodated.

Conferences: (see http://www.ams.org/meetings/ for the most up-to-date information on these conferences.) Co-sponsored conferences:
February 12–16, 2009: AAAS Meeting in Chicago, IL (see page 86, January 2009 issue for more information).
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