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Through the Legendrian looking glass (see page 1301)

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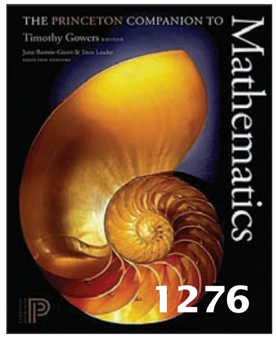

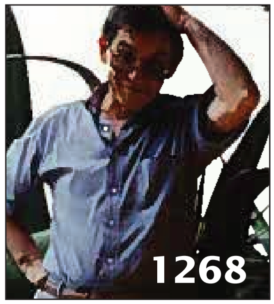

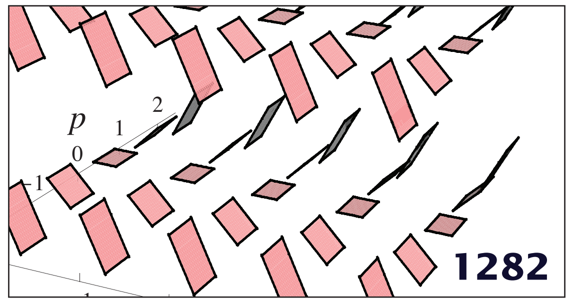

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of the American Mathematical Society

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Departments

From the AMS Secretary

The Employment Market for Early Career Mathematicians

In January 2009, motivated by concern about the impact of current economic conditions on the job market for recent Ph.D.s, AMS President James Glimm appointed a Task Force on Employment Prospects chaired by Linda Keen and including broad representation of the mathematics community. The goal of the task force was to provide information and recommendations to departments, individual job seekers, and professional societies to help them with challenges of the difficult market. In mid-May, the Task Force reported to the Society's Executive Committee and Trustees, and the report was then sent to all Ph.D.-granting mathematical sciences departments in the U.S.

We encourage everyone to review the Task Force report, available at `http://www.ams.org/prof-services/employtaskforce/ETF.html`.

Results of the 2009 Annual Survey are not yet final, but it seems that the number of people receiving doctoral degrees will be close to last year's number, 1,378. Excluding doctoral degrees from statistics departments, there were 1,061 new Ph.D.s in 2007–08. Analysis of a quick survey of representative departments in February 2009 forecasts that the total number of academic positions available for these new doctoral candidates is 918, down about 39% from the previous year. The responses also indicate that these students are applying primarily for academic positions. Typically (based on Annual Survey reports) more than 10% of new doctoral recipients take positions outside the U.S., and about 75% of those employed in the U.S. take academic positions.

It is important to note that there are young mathematicians exiting postdoctoral and instructorship positions who are also candidates for the estimated 918 positions being recruited. To put the count of 918 in perspective, the 2007 Annual Survey reported 1,543 academic positions open to new mathematics doctoral recipients in 2006–07. Academic recruitment has been severely affected by the economic crisis.

The profession has experienced difficult employment markets in previous recessions and earlier task forces have helped the community weather those crises.

In the mid-1990s, the Society adopted a statement of supportive practices for the employment of young mathematicians. The policy statement was revisited by the Council in 2007 and can be found at `http://www.ams.org/secretary/supportivepractices.html`. The practices are designed to increase as much as possible the stability of academic jobs in an unstable market.

The last prolonged period of a difficult job market was 1991 to 1996. We should be prepared for the possibility of another prolonged downturn now simply because it takes several years for state tax revenues to return to pre-recession levels.

The Task Force report makes several recommendations related to employment in business, industry, and government. In particular, it recommends that graduate students include some course work in mathematical areas that are recognized in nonacademic settings as being applicable. It also recommends that departments (i) encourage their students to broaden their employment options and (ii) improve their advising resources related to nonacademic employment. The Society will make a concerted effort to provide information resources to Ph.D.-granting departments to help them with career advising.

While the majority of new Ph.D.s has always taken employment in the academic sector, there have been two significant changes in patterns of employment since the early 1990s.

First, there are many more postdoctoral and named instructorship positions today than there were then. It is now common for a new Ph.D.'s first position to be a postdoctoral position. Further, as soon as the downturn in academic recruitment this past year was recognized, the National Science Foundation responded with a big increase in postdoctoral support for 2009.

Second, the proportion of new Ph.D.s taking nonacademic employment has increased substantially. Before 1995 the proportion of new Ph.D.s taking nonacademic employment was typically 16% to 18%. In contrast, in all three of the years 2006, 2007, and 2008, the proportion taking nonacademic employment exceeded 24%.

Both of these changes mean that today's job market is more flexible and has more dimensions that are capable of adapting to economic conditions. This is important because, through these times, we want to sustain vibrant graduate programs to nurture the best young talent, with reasonable assurance of rewarding career opportunities when the new graduates enter the job market.

—Linda Keen
AMS Associate Treasurer and Chair
Employment Prospects Task Force

—Donald E. McClure
AMS Executive Director

Letters to the Editor

Deligne/Zimin Initiative to Support Young Mathematicians

As Russian mathematicians and members of the American Mathematical Society, the undersigned feel it is their pleasant duty to inform fellow members via the *Notices* of a remarkable philanthropic initiative supporting young Russian research mathematicians undertaken by Pierre Deligne and continued by the Russian philantropist D. B. Zimin. In 2004 Deligne wrote in a letter to one of us: "I just won the Balzan Prize. Half the prize amount is for me to spend on a research project agreed to by the Balzan Foundation. I believe that one of the most useful ways to spend this money (500,000 Swiss francs) would be for the benefit of the struggling Russian school of mathematics."

Together with several collaborators of the Independent University of Moscow, Deligne implemented this idea by organizing the "Pierre Deligne Contest for Young Mathematicians", a yearly individual competition of research projects for young Russian, Ukrainian, and Byelorus mathematicians, whose laureates are granted a sizable three-year fellowship. Together with Victor Vassiliev, Deligne heads the jury of the contest, which is run along lines similar to those used by the American NSF. Since 2005 Deligne comes to Moscow each December to supervise the final deliberations. During the past four years, sixteen fellowships have been granted, and the money coming from the Balzan foundation (having in mind the future payments to recent winners) has been entirely exhausted, but Deligne intends to continue the contest by using his personal funds.

In 2006 the Russian philanthropic foundation "Dynasty" has organized the "D. B. Zimin Dynasty Foundation Contest for Young Mathematicians" with the same jury and according to the same rules. According to the corresponding agreement, this contest will run for two more years, after which it may be continued. The continuation of these two contests will undoubtedly play a crucial role in preserving the Russian mathematical school.

We are deeply grateful to Pierre Deligne for his noble initiative, which has already done a great deal to help young Russian mathematicians to survive without giving up research. This initiative is a continuation of the generous international solidarity to Russian scientists which the American Mathematical Society implemented in the 1990s and is continuing today.

We are extremely grateful to Dmitry Zimin for his chivalrous support of Russian fundamental science, in particular mathematics. D. B. Zimin is one of the very few Russian businessmen contributing money for the support of Russian mathematics.

—Yu. Ilyashenko
Moscow Independent University,
Steklov Math. Institute

—A. Sossinsky
Moscow Independent University,
Institute of Mechanics

—A. Vershik
St. Petersburg Branch of Steklov
Math. Institute

(Received February 20, 2009)

Response to David Ruelle

Tien-Yien Li and I were delighted to read Freeman Dyson's beautiful article in the February *Notices* that refers to our paper "Period three implies chaos" as "one of the immortal gems in the literature of mathematics". We prove one theorem in the paper, and Dyson reports on what we may assume is his favorite part of it. Assume there is a continuous function F from an interval J to itself, and—to be brief—we assume there is a "period three" point $a \in J$; that is, $F(F(F(a))) = a \neq F(a)$. Dyson simply wrote "An orbit is defined to be chaotic, **in this context** [emphasis added], if it diverges from all periodic orbits."

But then the June *Notices* came with a Letter to the Editor by David Ruelle that made two assertions, that our paper's result was not new, and, worse yet, that he believes that **period three does not imply chaos**!!! Ruelle seems to be aware of only the first of our three conclusions:

(I) (All Periods Exist.) For each positive integer k, there is a point of period k. The Sharkovsky (1964) Theorem stated by Ruelle is indeed a more general theorem than part (I), but our theorem does not stop here.

(II) (Mixing.) There is an uncountable set $S \subset J$ which satisfies: For every $p, q \in S$ with $p \neq q$,

$$\liminf_{n\to\infty} |F^n(p) - F^n(q)| = 0,$$

and

$$\limsup_{n\to\infty} |F^n(p) - F^n(q)| > 0.$$

(III) (Divergence from Periodic Orbits.) The above set S can be chosen so that in addition, (1) is satisfied for each $p \in S$ and each periodic point $q \in J$.

Dyson's elegant statement refers to (III). There is also a large literature that recognizes (II) and refers to it as "Chaos in the sense of Li and Yorke" or "Li-Yorke chaos". We support Dyson's view that the definition of chaos depends on the context; that is, it depends on what you know about a system or what you want to prove. There is a rich tradition of chaos in topology, where exponential divergence of trajectories is not a useful concept.

I fear that Ruelle's version of chaos would leave mathematicians without a method of dealing with the simplest situations when he asserts "chaos occurs if the exponential divergence is present for long-term behavior, i.e., on an attractor." One of the most famous examples of chaos is the map $\alpha - x^2$ which has a chaotic attractor for a set of α having positive measure (M. Jacobson). But there is also an open dense set in which there is an attracting periodic orbit. Since it can be shown that there is only one attractor for this map, such an α has no chaotic attractor. If Ruelle (who is a superb mathematician) can prove there is a chaotic attractor for $\alpha = 3/2$, then I will declare his definition usable! He simply needs to prove an infinite set of lemmas:

for each positive integer N, there is no periodic attractor of period N. I make the following conjecture in the spirit of Gödel.

Conjecture. The map $3/2 - x^2$ has a chaotic attractor and there is no proof of that fact using the usual axioms of set theory.

I believe that this impossibility of proof would apply to the large class of smooth dynamical systems that alternate densely between chaotic attractors and periodic attractors as a parameter is varied. Ruelle says "chaos" should apply only to attractors. (There are proofs for certain very special cases like $2 - x^2$.)

Attractor basins can be fractal—due to the presence of chaos on an uncountable compact invariant set on the basin boundary. He would leave us with no term for such sets!! After Ruelle said that chaos means "neighboring trajectories diverge exponentially," he asserted that period three does not imply chaos! Here is a compromise. We can define chaos in this context as "exponential divergence for *all* trajectories on some uncountable compact invariant set". In the spirit of mathematical fun, I propose the following conjecture using this concept.

Conjecture. Assume F is a continuously differentiable map from an interval J to itself. Then period three implies chaos.

This could be facet (IV) of the improved theorem. And people could still define chaos as they please.

—*James Yorke*
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(Received July 10, 2009)

Reply to Yorke

"Period three implies chaos" by Li and Yorke is a beautiful paper, and much quoted, including by myself. This paper is at the origin of the use of the word chaos in what has become "chaos theory", a multidisciplinary endeavor involving mathematical, numerical, and physical techniques, that has contributed among other things to the explanation of the "Kirkwood gaps" in the rings of asteroids between Mars and Jupiter. Li and Yorke prove that (for suitable maps of the interval) the existence of a periodic point of period three implies a complicated situation reminiscent of the homoclinic tangle discovered by Poincaré in his study of the three-body problem. Clearly, period three implies Li-Yorke chaos. But when chaos in the solar system is discussed (Wisdom, Laskar, ...), or other applications to the real world, another concept of chaos is used, which refers to "chaotic" behavior for initial conditions in a set of positive volume in the (phase) space where the dynamics takes place. This condition (rather than uncountability) must be imposed because sets of measure zero are physically invisible in the present situation. There has been a semantic shift and, if the map $x \mapsto ax(1-x)$ of $[0,1]$ to itself has, for some value of a, an attracting orbit of period 3, most people would not call this map chaotic (this is because the orbit of Lebesgue almost every point tends to the nonchaotic attracting period 3 orbit). This being said, the map under discussion not only exhibits Li-Yorke chaos, but also what Yorke at some point described as transient chaos (this is only transient, but visible on a set of positive Lebesgue measure).

As to the very interesting problem of logical decidability raised by Yorke (to decide if a point belongs to a set of physical interest in parameter space), I think it has to be reinterpreted in case one has physical applications in mind. This is because physical parameters have an interval of uncertainty attached to them. One is thus led to perturbation problems in differentiable dynamics, and Jim Yorke knows that those are usually very hard.

—*David Ruelle*
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(Received July 15, 2009)

Calculus and Computers in Mathematical Education

It could well be argued that too much has already been written about this topic. However, it is at least conceivable that some of this hyper senior citizen's memories might yield an alternative perspective of nonnegligible value for discussing the educational opportunities that have arisen from the availability of computers. As will immediately become evident, what follows is primarily oriented toward instruction through so-called "honours" undergraduate calculus classes, assuming (perhaps somewhat unrealistically) that, in such an environment, an uncompromising approach to the subject is permitted.

Most of the relevant memories have their origin in the mathematics department of the University of Capetown and date back to 1934. The offerings in that department included courses in "applied mathematics". There, you learned to formulate simple settings from classical mechanics in terms of differential equations, a pursuit leading to inspiring enlightenment about the true significance of calculus. In stark contrast to this, the introductory courses in formal calculus were as discouraging then as they are now.

In this last context, present educational practice is still operating in a conceptual desert, being focused on unenlightening manipulative tricks of formal differentiation and integration, the life of many of these being supported by the suppression of complex numbers,[1] and the need for most of them having been made obsolete by the computer.

In the context of numerical calculus, educational neglect was justifiable in view of the absurdly large requirements of time and labor. (Memories dating back to 1942 are of spending hundreds of days calculating military firing tables with the help of a Friden desk calculator.) Nowadays, computer-assisted pursuit of numerical calculus could easily be made far more enlightening than the standard introduction to calculus.

Unfortunately, even the modern mathematical computer software is mostly oriented toward applications in the precomputer style. In any case, the current products are much too big for student use.

[1] *The novelist William Styron, whose imagination is of unsurpassable breadth and analytic depth, confesses in one of his short essays that he flunked "trigonometry" four times in succession.*

The educational potential of computers can be illustrated most easily by elementary examples from classical mechanics. Construct, by simple numerical integration, orbits like that of the earth around the sun, the path of a projectile—in a vacuum or affected by velocity-dependent air resistance. More generally, explore paths generated when the acceleration depends in various ways on position, velocity, time, and path length from the origin.

Actually, in amateurish ways, I have written quite a number of old-fashioned c-programs for such purposes. It takes my low-level computer less than a second to produce an image file for a typical orbit. Significant additional benefits come from observing the effects of varying the relevant parameters and the errors resulting from large integration steps.

Instead of the annual appearance of "new" calculus texts, which are often degraded in response to the disastrous backlash from the mid-twentieth century's "New Math", mathematical education needs computer software enabling students to create simple programs for tasks like the above from recipes they can write in a computer language as close as possible to ordinary text. Surely, development of such a language and associated compilers would be a rewarding project.

—Gerhard Hochschild
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(Received July 19, 2009)

Editor's Note: In my Letter from the Editor "My First Forty" (June/July, 2009 *Notices*), I referred to a cone model for mathematical interests, which was attributed to an anonymous colleague. That colleague was Donald I. Knutson. Don, as my column indicated, had moved on from academic mathematics, but retained his connections with the mathematical community, and I wondered if he would see and recognize the reference. Don passed away in July.

—Andy Magid

Andrew M. Gleason 1921–2008

Ethan D. Bolker, coordinating editor

Photo by Bachrach.

Andrew M. Gleason

Andrew M. Gleason was one of the quiet giants of twentieth-century mathematics, the consummate professor dedicated to scholarship, teaching, and service in equal measure.

He was too modest to write an autobiography. The folder marked "memoir" in his files contains just a few outdated copies of his impressive CV. But those of us lucky to have known him will offer in the essays that follow some reflections on his mathematics, his influence, and his personality: codebreaking during the Second World War; his role in solving Hilbert's Fifth Problem; Gleason's Theorem in quantum mechanics; contributions to the study of operator algebras; work in discrete mathematics; concern for mathematics education as a teacher, author, and reformer; and his service to the profession.

Vita

Andrew Mattei Gleason was born November 4, 1921, in Fresno, California, to Eleanor Theodolinda Mattei and Henry Allan Gleason. He died in Cambridge, Massachusetts, on October 17, 2008.

He grew up in Bronxville, New York, and was graduated from Roosevelt High School, Yonkers, in 1938. He received his B.S. from Yale in 1942. While at Yale he placed in the top five in the Putnam Mathematical Competition in 1940, 1941, and 1942, and was the Putnam Fellowship winner in 1940.

In 1942 he enlisted in the navy, where he served as a cryptanalyst until the end of the war. He was recalled to active duty during the Korean War and retired from the navy in 1966 with the rank of commander.

Gleason went to Harvard in 1946 as a Junior Fellow of the Society of Fellows. He was appointed assistant professor of mathematics in 1950 and associate professor in 1953, when Harvard awarded him his highest degree, an honorary A.M. He became a full professor in 1957. From 1969 until his retirement in 1992 he was the Hollis Professor of Mathematicks and Natural Philosophy.

Throughout his time at Harvard he maintained his association with the Society of Fellows, serving as a Senior Fellow for nineteen years and as its chairman from 1989 to 1996.

In 1952 the American Association for the Advancement of Science awarded Gleason the Newcomb Cleveland Prize for his work on Hilbert's Fifth Problem. He was elected to the American Academy of Arts and Sciences in 1956, to the National Academy of Science in 1966, and to the American Philosophical Society in 1977.

From 1959 to 1964 he chaired the Advisory Board of the School Mathematics Study Group; he was cochairman of the Cambridge Conference on School Mathematics in 1963 and a member of the Mathematical Sciences Education Board from 1985 to 1989.

Gleason delivered the Mathematical Association of America's Hedrick Lectures in 1962. He was president of the American Mathematical Society in 1981–82 and served on the Council of Scientific Society Presidents 1980–83. He was chairman of the organizing committee and president of the International Congress of Mathematicians, Berkeley, 1986.

On January 26, 1959, he married Jean Berko, who is now professor emerita of psychology at Boston University. They have three daughters: Katherine, born in 1960; Pamela, born in 1961; and Cynthia, born in 1963.

Ethan Bolker is professor of mathematics and computer science at the University of Massachusetts, Boston. His email address is eb@cs.umb.edu.

Ethan D. Bolker

50+ Years...

I first met Andy in 1956, when he taught sophomore abstract algebra at nine in the morning (even on fall football Saturdays). He agreed to let me audit his course and submit homework papers.

It took me several years and two graduate courses to realize how deceptive a lecturer he was. The proofs scrolled by. You could read his writing. He literally dotted his i's and crossed his t's. I know; I recently found the purple dittoed handwritten linear algebra notes he wrote for us in the spring of 1957. Strangely, those notes were sometimes subtly hard to study from. Now I know why. He took such care preparing and searched so hard for economy and elegance that the rough places were made plain. The hard parts didn't seem so in the seamless flow, so it could be hard to find the crux of a proof. George Mackey once told me it was good that one of his teachers (I choose to forget who) was disorganized because it forced him (George) to master the material for himself. What Andy's style proves is that disorganization may be sufficient but is not necessary.

Andy was the reader for my undergraduate thesis on multiplicity theory for eigenvalues of bounded self-adjoint operators on Hilbert space. In those days (perhaps still) each senior was set a special exam on the thesis topic. One question on mine asked me to apply my theorems to the multiplication operator $g \mapsto fg$ for g in a Hilbert space $L^2(\mu)$. The function f was a cubic polynomial, and, μ was Lebesgue measure on $[0, 2]$ with an extra atom of weight 1 at 1. Fortunately, I'd thought of putting an example like that in the thesis, so I knew how to do the problem. What mattered was where the cubic was $1:1$, $2:1$, or $3:1$. But my answer seemed not to need the atom at 1. When I asked Andy later about that, he gently pointed out how he'd carefully constructed his cubic with a local maximum at 1, so there was a set of positive measure on which the cubic was $2:1$. I missed that, because when finding the critical points I calculated $2 \times 3 = 12$. He graciously said only that I'd spoiled a good problem.

When I chose Andy as a doctoral thesis advisor I had neither a topic nor a direction. I thought I was an analyst and thought he was one and knew him, so I opted to try to work with him. I struggled with p-adic groups for a year, going nowhere. But I did have one idea about a way I might prove the Radon-Nikodym theorem for measures on lattices like those that come up in quantum mechanics. The idea didn't work, but I did manage to say some new things about measures on Boolean algebras even while the generalizations to lattices eluded me. Andy encouraged that play and said after a while that what I was working on was in fact my thesis. He told me he liked it better when his students found topics than when he had to suggest one.

In the spring of 1964 I thought my thesis was done. I found the central theorem in February, wrote it up, and sent it off to Andy. When I telephoned to ask what he thought of it, he asked if I needed my degree in hand to accept my new job at Bryn Mawr. When I said "no" he said, "Work on it another year." I know that if I'd said "yes" he'd have accepted what I'd written. But then I'd have had a thesis with just a theorem. The central mechanism for producing examples and counterexamples showing the theorem was sharp came later that spring. Moreover, I think the idea was his, although I didn't give him due credit then. So Andy was right to care about the quality of the work and to ask for the extra year. The thesis was better and better written and ready for publication soon after the degree was awarded—and my year-old daughter got to go to my commencement. (He and Jean sent her a Raggedy Andy when she was born.)

Eighteen years later Andy employed her as a painter. That's how I learned how he applied logic outside mathematics. She saw him eating breakfast hurriedly one day—peanut butter spread on bread right out of the freezer. He said the nutritional value was the same.

I was telling Andy once about a bijection I'd found for counting permutations with particular cycle structures. He was interested and had some further ideas and references. When he suggested a joint paper [BG] I jumped at the chance to earn a Gleason number of 1. When I wanted to say something numerical about the asymptotics which called for $\Gamma(1/3)$, I looked up nearby values in a table and interpolated. In response to a draft I sent Andy he wrote back:

> There is one not terribly important thing where I can't check you. You obtain
>
> $$\frac{3^{1/6}e^{\pi\sqrt{3}/18}}{\Gamma(1/3)} \approx 0.6057624.$$
>
> With my hand calculator I found $\Gamma(1/3) \approx 2.678938543$ (of which at least 8 figures ought to be right) and hence the above number comes out 0.6065193. Hand calculators make substantial errors in exponentials, so I really don't know which is right.

Andy's "With my hand calculator I found ..." is a little disingenuous. There's no Γ key on the calculator—he programmed the computation. Today Mathematica quickly finds $\Gamma(1/3) \approx 2.67893853471$ with twelve significant figures, so Andy's intuition about eight was right.

Over the years I had lunch with Andy often, sampling Chinese, Vietnamese, and Indian food in Cambridge and nearby towns. Over lunch once, thinking about geometry, he told me he'd give a lot for "one good look at the fourth dimension." Any mathematical topic, at any level of sophistication, was fair game. I'd tell him why I thought the convention for writing fractions was upside down; he'd tell me he was thinking about the foundations of geometry or the Riemann hypothesis. Often in the past year I've wanted to ask him about something that came up in my teaching or while editing these essays and was stunned anew by the realization that I couldn't ever do that again.

Solving Cubics by Trisecting Angles

Andy was a problem solver more than a theory builder. He liked hard problems, like Hilbert's Fifth, about which you can read more below. Others less deep interested him no less. I think he even enjoyed the problems in spherical trigonometry and navigation on the exams he took to maintain his naval commission while in the reserves.

Once he set out to discover which regular polygons you could construct if you add the ability to trisect angles to the tasks available with Euclidean straightedge and compass. His answer, in "Angle trisection, the heptagon, and the triskaidecagon" [G1]: just the n-gons for which the prime factorization of n is of the form $2^r 3^s p_1 p_2 \cdots p_k$, where the p_i are distinct primes greater than 3, each of the form $2^t 3^u + 1$. His proof depends on the observation that these are precisely the primes for which the cyclotomic field has degree $2^t 3^u$ and so can be constructed by a sequence of adjunctions of roots of quadratics and of cubics, all of whose roots are real.

You solve such a cubic by trisecting an angle, because when the cubic has three real roots (the *casus irreducibilis*), finding them with Cardano's formula requires extracting the cube root of a complex number. To do that you trisect its polar angle and find the cube root of the modulus. For the particular cubics that come up in the construction of these regular polygons, the modulus is the $3/2$ power of a known quantity, so a square root computes the cube root.

Andy's solution to that problem allowed him to indulge several of his passions. The paper is full of historical references, including the corollary that the ability to trisect angles doesn't help you duplicate the cube. That requires solving the *other* kind of cubic. He cites (among others) Plemelj, Fermat, Euler, and Tropfke and concludes with a quote from Gauss's *Disquisitiones Arithmeticae.*[1]

The "triskaidecagon" in the title, where most of us would be satisfied with "13-gon", exemplifies Andy's love of language. He had lots of ideas he never got around to publishing. I wonder if he wrote this paper in part just so he could use that word.

Andy loved to compute too. About his construction of the triskaidecagon he writes:

> After considerable computation we obtain
>
> $$12\cos\frac{2\pi}{13} = \sqrt{13} - 1 + \sqrt{104 - 8\sqrt{13}}\cos\frac{1}{3}\arctan\frac{\sqrt{3}(\sqrt{13}+1)}{7-\sqrt{13}}.$$

Mathematica confirms this numerically to one hundred decimal places. I don't think there's software yet that would find the result in this form.

I first explicitly encountered Andy's passion for precision of expression when in graduate school he told me that the proper way to read "101" aloud is "one hundred one" without the "and". That passion stayed with him to the end: when he was admitted to the hospital and asked to rate his pain on a scale of 1 to 10, he's reputed to have said first, "That's a terrible scale to use…"

Andy told me once that he knew he wanted to be a mathematician just as soon as he outgrew wanting to be a fireman.[2] He succeeded.

Stories

In the essays that follow you'll find more about Andy's mathematics and more stories. I'll close here by quoting some that aren't included there.

Persi Diaconis writes about Andy's legendary speed:

> Andy was an (unofficial) thesis advisor. This was illuminating and depressing. My thesis was in analytic number theory, and I would meet with Andy once a week. A lot of the work was technical, improving a power of a logarithm. I remember several times coming in with my current best estimates after weeks of work. Andy glanced at these and said, "I see how you got this, but the right answer is probably . . . " I was shocked, and it turns out he was right.

Jill Mesirov describes a similar experience:

> I remember quite clearly the first time that I met Andy Gleason. I was working at IDA in Princeton at the time, and Andy was a member of the Focus Advisory Committee. The committee met twice a year to review the work being done, and I had been asked to give a

[1] *Andy seems to have missed Viète's construction [V]. My thanks to Robin Hartshorne for this reference and for some clarifying comments on this section.*

[2] *Perhaps I'm misremembering. His wife, Jean Berko Gleason, said, "He loved looking at the stars. He knew every star in the sky and could tell you their names. Early on, he was planning on becoming an astronomer, but then he learned how cold it was to sit outside and watch."*

presentation of some work on speech I had done jointly with Melvin Sweet. I worked hard on the presentation, and designed it to give some idea of how we were led step by step to the answer. The groundwork was laid for revealing each insight we had gained, but in such a way that it should come as a surprise to the audience and thus make them appreciate the sense of discovery we had enjoyed as we did the research and solved the puzzle ourselves. Needless to say, I hadn't counted on Andy's "infamous" speed!

> Twice I carefully led the audience through some twisted trail to end with the question, "So, what do you think we tried next?" Twice, before the words had begun to leave my mouth, Andy was saying, "Oh, I see, then you want to do this, this, and this, after which you'll observe that …" While I appreciated his quick grasp of the issues, I was beginning to see my carefully laid plans falling by the wayside. Therefore, as I was reaching the next crescendo, and I saw Andy leaning forward in his seat, I turned around, pointed my finger at him and shouted, "You, be quiet!" He smiled, and left me to lead the rest of the crowd through the revelations.

Finally, Victor Manjarrez, a graduate school contemporary of mine, offers this summary:

> In the late fifties and early sixties I took graduate algebra and a reading course from Andrew Gleason. Whenever we spoke at meetings in later years I was struck by how unfailingly polite he always was. The English word "polite" (marked by consideration, tact, or courtesy) evokes the French "politesse" (good breeding, civility), and the Greek "polites" (citizen—of the mathematics community and the world), all of which Andrew Gleason exemplified to the fullest. This, of course, in addition to his amazing erudition.

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John Burroughs, David Lieberman, Jim Reeds

The Secret Life of Andy Gleason

Andrew Gleason was a senior at Yale on December 7, 1941, when the Japanese bombed Pearl Harbor. He applied for a commission in the navy; upon his graduation the following June he reported to their crypanalytic service: the Office of Chief of Naval Operations (OPNAV), 20th Division of the Office of Naval Communications, G Section, Communications Security (OP-20-G). There he joined a group of eight to ten mathematicians working to crack enemy codes. The group included Robert E. Greenwood and Marshall Hall Jr., one of Andy's Yale professors. The National Archives contains declassified documents describing much of the wartime work of OP-20-G. We found there a set called *Enigma Studies* [ES], which describes the group's contributions to the attack on the German Enigma machine. These documents showcase that part of Gleason's work which we will describe.

The Enigma ciphers presented diverse and rapidly mutating challenges. The Germans used several different models of the Enigma machine. Each day they changed the keys on each of perhaps a hundred or so different communications networks. Three of those networks were "Shark", used by the Atlantic U-boat fleet; "Sunfish", by blockade runners and the German U-boats in the Pacific; and "Seahorse", for traffic between German navy HQ and their attaché in Tokyo. Breaking one system or one day's traffic provided only clues towards breaking the others, clues which were sometimes misleading. Several times during the war the Germans made significant modifications to the Enigma.

OP-20-G worked on Enigma in collaboration with the British cryptanalysts at the Government Code and Cypher School at Bletchley Park, in particular, with "Hut 8", whose most famous member

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We owe special thanks to Colin Burke; to Ellen J. L. Knight, Certified NSA Archivist; and to Rene Stein, librarian, National Cryptologic Museum, for guiding us and helping us locate archival records of Gleason's contributions.

We are also grateful to R. Erskine and F. Weierud for searching through the wartime diaries of OP-20-G and the history of Coral, which they had copied at the National Archives. They located information about Gleason's activities and forwarded many interesting items to us.

was Alan Turing. Shortly before the U.S. entered the war the British code breakers began teaching their American counterparts about the Enigma problem: the general theory and notation (largely due to Turing), a host of particular solution methods, and the design of a special-purpose electromechanical computing machine, the "Bombe", which carried out one of the steps of the arduous constrained trial-and-error solution process. Some of these lessons the British had learned from the Poles just before the war; some they had developed during the first two years of the war. At about the time the U.S. entered the war the German navy began using a four-wheel model of the Enigma machine, against which the existing Bombes (designed for attacking three-wheel Enigmas) were comparatively ineffective. This ended the Allies' ability to read Shark in a timely manner during 1942 and early 1943, with devastating consequences to Allied shipping.

Andy Gleason in uniform—left, active duty (1940s) and right, Naval Reserve (1960s).

In November 1942 Turing visited the U.S. to assist the Americans in mastering Bletchley's methods and to consult on the construction of the American Bombes designed to attack the four-wheel Enigma. Andrew Hodges's biography of Turing discusses Turing's report back to Bletchley, in which he expresses some dismay that the Americans really had not grasped the British work-saving algorithmic ideas, relying instead on technological overkill. Nevertheless, he was impressed with the mathematicians being hired at OP-20-G, in particular "the brilliant young Yale graduate mathematician, Andrew Gleason" [H, p. 243]. Hodges relates an anecdote from this visit:

Gleason and Joe Eachus "looked after Alan during his period in Washington. Once Gleason took Alan to a crowded restaurant on 18th Street. They were sitting at a table for two, just a few inches from the next one, and talking of statistical problems, such as that of how to best estimate the total number of taxicabs in a town, having seen a random selection of their license numbers. The man at the next table was very upset by hearing this technical discussion, which he took to be a breach of 'security'. … Alan said, 'Shall we continue our conversation in German?'"

At first OP-20-G was the junior partner to Hut 8, but later it took the lead in attacking Seahorse. A recent paper [EM] describes the Seahorse story in considerable detail. We draw on that account. The Hut 8 team had failed to solve Seahorse because traffic externals convinced them that encryption was being done not by a standard naval Enigma machine but by a simpler version of Enigma. In March 1943 the problem was turned over to OP-20-G. Their analysis revealed new structure in the traffic that allowed them to reject the hypothesized simpler version of Enigma to correctly diagnose an underlying naval Enigma and to specify a menu (i.e., a program) for the naval Bombes so they could efficiently read the traffic.

Reading the first-hand accounts of this work in the *Enigma Studies* E-2 and E-4, one can share the excitement, the frustrations, and finally the elation when success was achieved. Greenwood's "History of Kriegsmarine attack" (paper 6 in E-2) describes how the group first discovered the working of Seahorse's "indicators", which told the message recipient how to set up his receiving Enigma machine. These were appended to the message, encrypted in a "throw-on" cipher. The standard method of attack required interception of a large number of messages from the same day. A successful attack revealed which set of four wheels was being used in the machine and the setting used to encipher all the indicators. One could then decipher the indicators and in turn use them to decipher all the day's messages.

Marshall Hall noticed an interesting feature of the throw-on indicators. On a given day the set of first letters of encrypted indicators for Berlin-to-Tokyo messages was disjoint from the set of first letters for Tokyo to Berlin, but the sets changed from day to day. Gleason came up with and statistically tested a simple hypothesis explaining this, namely, that the wheel settings—the unencrypted form of the indicators—started with letters A–M for messages from Tokyo to Berlin and letters N–Z for the opposite direction.

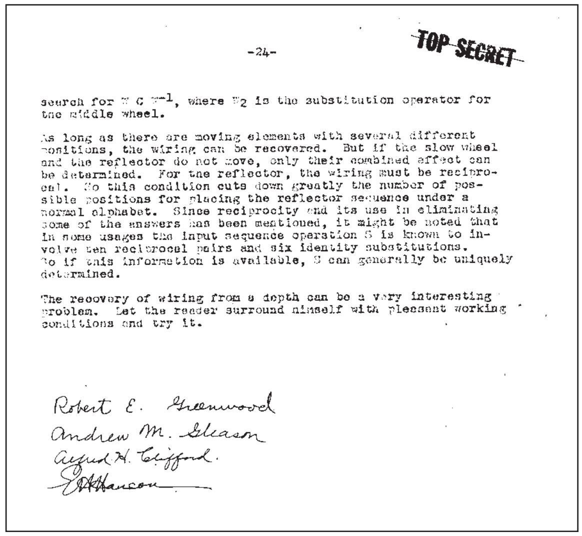
In "Kriegsmarine indicators" (paper 5 in E-2) Gleason, Greenwood, and Hall show how this structure allowed one to derive extra equations, which led to much more efficient Bombe runs. The practical implication was that far fewer messages needed to be intercepted in any one day to be able to work out that day's key. In August 1943 a Bombe run at Bletchley using these ideas broke the first Seahorse messages. This confirmed the model for the underlying Enigma and its indicator system and verified the correctness of their attack programs. This concluded the research phase. The problem was then turned over to a development team. Using the newly available four-wheel naval Bombes and the special tricks discovered for Seahorse, they were able to read Seahorse sporadically in 1943 and almost continuously in 1944 and 1945, resulting in the decryption of thousands of messages.

An excellent discussion of the application of group theoretic ideas to the solution of Enigma problems is given in Greenwood, Gleason, Clifford, and Hanson's "Enigma wiring recovery from the reading of a depth" (paper 7 in E-4, dated 19 April 1945).[1] Simplifying slightly, they reduce the problem of finding the four permutations performed by the Enigma wheels to one of solving a system of simultaneous equations in permutations. The right side of the t-th equation is the permutation effected by Enigma to encipher the t-th plain text character. These are assumed "known" (at least in part) by "depth reading". The left side of the t-th equation expresses the known way the Enigma machine composes the unknown rotor wirings at time t. The paper shows how this problem can be broken into a series of subproblems of the form "given several permutation pairs (π_i, σ_i), find a single permutation x for which $\pi_i = x\sigma_i x^{-1}$ for all i." Interestingly, one of these subproblems is solved by exhibiting an isomorphism of a pair of labeled graphs. The explanation, unlike most technical Enigma exposition of the era, such as found in [T], is couched in standard mathematical terminology.[2] According to one modern commentator, [W], the method in this paper "is a lot more powerful than the 'Rodding' and 'Buttoning-up' methods described by Alan Turing, mainly because it allows recovery of the wiring even when the Stecker is unknown." The exposition is both compelling and charming. One can imagine one is listening to the young Andy Gleason in some of the informal asides:

> The reader may wonder why so much is left to the reader. A book on swimming strokes may be nice to read, but one must practice the strokes while actually in the water before one can claim to be a swimmer. So if the reader desires to actually possess the knowledge for recovering wiring from a depth, let the reader get his paper and pencils, using perhaps four colors to avoid confusion in the connecting links, and go to work.… Note: the writing of $C^{-1}C^2$ instead of C^1 is a whim of the writer. Please humor him to this extent.…

[1] *There is a copy of this paper on the Net in Frode Weierud's Enigma Archive website,* `http://cryptocellar.org/Enigma/EnigmaWiringRecovery.pdf`.

[2] *This use of group theory had to be modified in a novel and clever way to exploit the extra structure available in the Seahorse indicator problem. This is described in "Kriegsmarine indicators" (paper 4 in E-4) by Gleason and Greenwood.*



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TOP SECRET

search for W C W^{-1}, where W_2 is the substitution operator for the middle wheel.

As long as there are moving elements with several different positions, the wiring can be recovered. But if the slow wheel and the reflector do not move, only their combined effect can be determined. For the reflector, the wiring must be reciprocal. So this condition cuts down greatly the number of possible positions for placing the reflector sequence under a normal alphabet. Since reciprocity and its use in eliminating some of the answers has been mentioned, it might be noted that in some usages the input sequence operation S is known to involve ten reciprocal pairs and six identity substitutions. So if this information is available, S can generally be uniquely determined.

The recovery of wiring from a depth can be a very interesting problem. Let the reader surround himself with pleasant working conditions and try it.

Robert E. Greenwood
Andrew M. Gleason
Alfred H. Clifford

The final page of the typescript (shown above) concludes:

> The recovery of wiring from a depth can be a very interesting problem. Let the reader surround himself with pleasant working conditions and try it.

—as if this were a problem in pure mathematics, not an urgent wartime endeavor.

The mass production of four-wheel Bombes led to dramatic successes against Seahorse and the other naval Enigma problems. Research then focused on Japanese machine ciphers. A major achievement of this effort was the diagnosis of the naval cipher Coral and the subsequent decryption of Coral traffic throughout 1944–45. This required, as in Enigma, a painstaking examination of the traffic to find and explain statistical structure and the design and programming of new special purpose machines. Gleason's mathematical contributions to this work included the eponymous "Gleason crutch", a method for estimating extreme tail probabilities for sums of random variables. It can be regarded as a version of Chernoff's theorem in large deviations theory, and like it, it is based on the idea of exponential tilting.

As the war came to an end, Gleason participated in efforts to systematically document the techniques developed by OP-20-G and to set up a postwar curriculum for training cryptanalysts. He also participated in courses and seminars on both applied methods and mathematical foundations, including (prophetically) one based on Pontrjagin's new book on topological groups.[3]

Gleason's codebreaking work exhibits some of his characteristic traits. One is his extraordinary quickness in grasping the heart of a problem and

[3] *Our comments on the post-Enigma work are based on extracts from the wartime diaries of OP-20-G and the voluminous Coral history, which were culled out for us by R. Erskine and F. Weierud.*

rethinking how to solve it from first principles. He says of himself, "I have always felt that it's more crucial for me to come to grips on my terms with the most elementary aspects of a subject. I haven't worried much about the advanced aspects" [AAR, p. 88]. He was particularly effective as a cryptanalyst, because (in his own words) he "learned to do something that a lot of pure mathematicians don't know how to do…how to do quick and dirty mathematics. It's an interesting knack to be able to make a quick appraisal as to whether there is sufficient statistical strength in a situation so that hopefully you will be able to get an answer out of it" [AAR, p. 87].

Gleason's insight into the mathematics underlying cryptography was greater than that of most of his colleagues. Even during the war he prepared lectures and notes for them to help develop their understanding and working knowledge of the mathematical fundamentals. His OP-20-G lecture notes and exercises on probability and statistics were later gathered up and edited into a short textbook used for years in introductory courses at NSA and subsequently reprinted commercially [G]. We were amused to find that one of the exercises in the book is to estimate the number of taxicabs in a town, having seen a random selection of their license numbers.

Legend has it that, in general, the cryptanalysts in World War II did not think much of the mathematicians down the hall, who were always telling them what was wrong with their counts and suggesting "proper" statistics, which in the end didn't produce plain text. But Gleason was different. He was approachable. He listened carefully to their problems and ideas, and his advice was always useful.

After the war Gleason began his academic career at Harvard. He was reactivated in 1950, at the start of the Korean War, and served at the naval facility on Nebraska Avenue. Cryptographic systems had increased in complexity, incorporating digital technology that posed new challenges and dramatically increased the need for trained mathematicians. Many of Gleason's colleagues at Nebraska Avenue went on to significant careers at the newly formed NSA and in emerging academic areas of mathematics and computer science. These included Marshall Hall, Joe Eachus, Dick Leibler, Oscar Rothaus, Howie Campaigne, Bill Blankinship, and Ned Neuburg. In the spring of 1951, Lt. Cmdr. Gleason, Lt. Cmdr. Hall, and Cmdr. Miller[4] were sent to visit mathematics departments around the country to recruit mathematicians with advanced degrees. They found sixty to eighty. One of them, R. Highbarger, told us, "After a few weeks at training school we located in a basement room next to the kitchen grease pit at Arlington Hall Station.… There, we took various CA [cryptanalysis] courses and a bunch of math courses, the best of which were taught by Andy Gleason." Some twenty of these "junior mathematicians" were to become the professional leaders of the nation's cryptanalytic effort in the 1960s and 1970s.

Most of Gleason's applied work during this period remains classified. In his spare time he worked on Hilbert's Fifth Problem. He later said, "there wasn't a single day that I didn't think about it some of the time.… I made a real breakthrough on the problem around February of 1952" [AAR, p. 91]. R. A. Leibler drove Gleason to Princeton to present a talk on his new result at the Institute for Advanced Study. It was snowing hard. Going up Alexander Road they were nearly hit when their car slid through a red light. Leibler told us that Gleason came in dressed in his navy uniform. This caused some initial surprise, which soon turned to excitement and enthusiasm. Gleason lectured all day.

After the Korean War, Gleason returned to the Harvard faculty but continued as an advisor to the nation's intelligence and security programs for fifty years. He served on the NSA Scientific Advisory Board from the mid-1950s through the mid-1960s, where he helped shape the NSA's response to the evolving challenges of the cold war. He continued as an active recuiter for the NSA and for the Communications Research Division (CRD) of the Institute for Defense Analyses, often writing or calling the director to recommend a mathematician who might be particularly well suited for an appointment to the program. He participated in NSA summer research projects (SCAMP) and in the formative technical programs of the CRD. He was a member of the first CRD advisory committee in 1959, then served from 1976 to 1979, from 1986 to 1988, and again from 2004 to 2006.

L. P. Neuwirth, writing in 1992, recalled Gleason's participation in the CRD programs:

> He invariably had something useful to contribute, and the work of others benefited enormously, either directly or indirectly (sometimes with attribution, sometimes without) from his ideas. His contributions have in many cases been lasting, and were made in sufficient generality and depth that they still find application 45 years later. His name is associated with some of these notions… the Gleason semigroup, Gleason weights, and the Gleason crutch.…[his] 22 papers in cryptologic mathematics span the time period from 1945 to 1980. Their content range is wide, and includes algebra, combinatorics, analysis, statistics and computer science.

Gleason did pioneering work in computational algebra in response to the emerging need for good

[4] *We believe this was D. D. Miller, the semigroup theorist, who was also an alumnus of OP-20-G.*

pseudorandom number generators and efficient error correcting codes. In 1955 the Gleason-Marsh Theorem [GM][5] provided a method for generating irreducible polynomials of huge degree over GF(q). (For any d, one could generate irreducibles of degree $q^d - 1$.) In 1961 in a 10-page typescript [G61] Gleason described algorithms he devised for factoring and irreducibility testing of univariate polynomials over GF(q). Programs implementing these ideas had many years of utility. We do not undertake to compare Gleason's unpublished approach to other methods soon to follow: Berlekamp (1967), Zassenhaus (1969), Cantor-Zassenhaus (1981). For a recent historical survey of the field, see, for example, [VGG].

Neuwirth concluded:

> This unfortunately restricted list of some of the ideas he had and some of the areas to which he contributed perhaps sheds a little light on his many contributions to a very much hidden science, and gives some understanding of the unusually high regard in which he is held by the intelligence community …[GLIM, pp. 65–66].

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Richard Palais

Gleason's Contribution to the Solution of Hilbert's Fifth Problem

What *Is* Hilbert's Fifth Problem?

Andy Gleason is probably best known for his work contributing to the solution of Hilbert's Fifth Problem. We shall discuss this work below, but first we need to know just what the "Fifth Problem" is. In its original form it asked, roughly speaking, whether a continuous group action is analytic in suitable coordinates. But as we shall see, the meaning has changed over time.

As Hilbert stated it in his lecture delivered before the International Congress of Mathematicians in Paris in 1900 [Hi], the Fifth Problem is linked to Sophus Lie's theory of transformation groups [L], i.e., Lie groups acting as groups of transformations on manifolds. The "groups" that Lie dealt with were really just neighborhoods of the identity in what we now call a Lie group, and his group actions were defined only locally, but we will ignore such local versus global considerations in what follows. However, it was crucial to the techniques that Lie used that his manifolds should be analytic and that both the group law and the functions defining the action of the group on the manifold should be analytic, that is, given by convergent power series. For Lie, who applied his theory to such things as studying the symmetries of differential equations, the analyticity assumptions were natural enough. But Hilbert wanted to use Lie's theory as part of his logical foundations of geometry, and for this purpose Hilbert felt that analyticity was unnatural and perhaps superfluous. So Hilbert asked if analyticity could be dropped in favor of mere continuity. More precisely, if one only assumed a priori that the group G was a locally Euclidean topological group,

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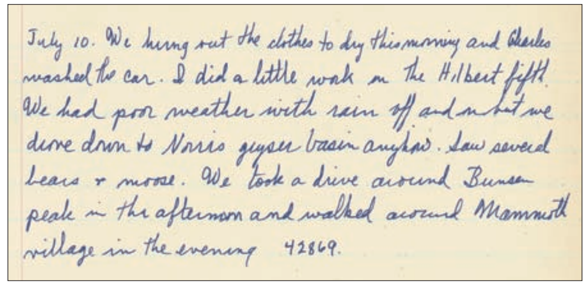
that the manifold M was a topological manifold, and that the action of G on M was continuous, could one nevertheless always choose local coordinates in G and M so that both the group operations and the action became analytic when expressed in these coordinates? We shall speak of the problem in this generality as the *unrestricted* Hilbert Fifth Problem. The *restricted* problem is the important special case in which $G = M$ and the action is left translation. Asking whether we can always find analytic coordinates in the restricted problem is clearly the same as asking whether a locally Euclidean group is necessarily a Lie group.


July 10. We hung out the clothes to dry this morning and Charles washed the car. I did a little work on the Hilbert fifth. We had poor weather with rain off and on but we drove down to Norris geyser basin anyhow. Saw several bears & moose. We took a drive around Bunsen peak in the afternoon and walked around Mammoth village in the evening 42869.

Excerpt from Gleason's vacation journal, July 1947, in which he mentions working on the "Hilbert fifth".

Counterexamples

It turned out that there are many—and in fact many different kinds of—counterexamples to the unrestricted Hilbert Fifth Problem. Perhaps the first published counterexample, due to R. H. Bing [Bi], is an action of $\mathbf{Z}_2$ on $\mathbf{S}^3$ whose fixed-point set is the Alexander Horned Sphere Σ. Now Σ is not "tamely embedded" in $\mathbf{S}^3$, meaning that there are points where it is impossible to choose coordinates so that locally Σ looks like the usual embedding of $\mathbf{R}^2$ in $\mathbf{R}^3$. If the action were even differentiable in some suitable coordinates, then it is easy to see that the fixed-point set would in fact be tamely embedded. (For an even more bizarre type of counterexample, recall that in 1960 M. Kervaire [Kerv] constructed a topological manifold that did not admit any differentiable structure, providing what can be considered a counterexample even for the case when G is the trivial group.)

One could make a case that these examples are "monsters" that could have been ruled out if Hilbert had phrased his statement of the Fifth Problem more carefully. But there is a more serious kind of counterexample that is so elementary that it makes one wonder how much thought Hilbert had given to the Fifth Problem before proposing it. Here is a particularly elementary example, due to Montgomery and Zippin [MZ3], with $G = \mathbf{R}$, the additive group of the real numbers, and $M = \mathbf{C}$, the complex plane. Let f be a continuous real-valued function defined on the positive real axis, and define the action $\phi : \mathbf{R} \times \mathbf{C} \to \mathbf{C}$ by $\phi(t, re^{i\theta}) := re^{i(\theta + f(r)t)}$. (In words, ϕ is a one-parameter group of homeomorphisms of the plane that rotates each circle centered at the origin into itself, the circle of radius r being rotated with angular velocity $f(r)$.) If we choose $f(r)$ to equal 1 for $r \leq 1$ and 0 for $r \geq 2$, the action is the standard one-parameter group of rotations of $\mathbf{C}$ inside the unit disk and is trivial outside the disk of radius 2, so by the Principle of Analytic Continuation, this action cannot be made analytic in any coordinate system. What is worse, we can choose f to have these properties and also be smooth (meaning C^∞), so we see that even if we assume a priori that the action of a Lie Group on a manifold is smooth, it does not follow that it can be made analytic!

After these counterexamples to the unrestricted Hilbert Fifth Problem became known, a tacit understanding grew up to interpret "the Fifth Problem" as referring to the restricted version: Is every locally Euclidean group a Lie group? and we shall follow this convention below.

Early History of the Fifth Problem

It was fairly easy to settle the one-dimensional case. The only (paracompact) connected manifolds of dimension one are the real line, $\mathbf{R}$, and the circle, $\mathbf{S}^1$, and both of course are Lie groups. In 1909 L. E. J. Brouwer [Br] showed that a topological group that is homeomorphic to either of these is in fact isomorphic to it as a topological group. Using results from Brouwer's paper, B. Kerékjártó [Kere] settled the two-dimensional case in 1931. There seems to have been little if any published work on the Fifth Problem between the papers of Brouwer and Kerékjártó, but that is not too surprising considering that much of the modern mathematical infrastructure required for a rigorous discussion of topological groups and the Fifth Problem became available only after a 1926 paper by O. Schreier [Sch]. The three-dimensional and four-dimensional cases of the Fifth Problem were settled much later, by Montgomery [M1] in 1948 and by Montgomery and Zippin [MZ1] in 1952.

The first major breakthrough in the general theory came in 1933, when J. von Neumann [VN], using the recently discovered Haar [Ha] measure, extended the Peter-Weyl Theorem [PW] to general compact groups and used it to settle the Fifth Problem in the affirmative for compact groups. We will sketch a proof of von Neumann's theorem below. Several years later, building on von Neumann's work, Pontryagin [Po] settled the abelian case, and Chevalley [Ch1] the solvable case.

The No Small Subgroups (NSS) Condition

The first time I encountered the phrase "group without small subgroups" I wondered what kind of subgroup a "small" one could possibly be. Of course, what the phrase means is a topological group without *arbitrarily* small subgroups, i.e., one having a neighborhood of the identity that includes no subgroup except the trivial group. We shall follow Kaplansky [Ka] and call this the NSS Condition and a group satisfying it an NSS group. Since NSS may seem a little contrived, here is a brief discussion of the "why and how" of its use in solving the Fifth Problem.

It turns out to be difficult to draw useful conclusions about a topological group from the assumption that it is locally Euclidean. So the strategy used for settling the Fifth Problem was to look for a more group-oriented "bridge condition" and use it in a two-pronged attack: on the one hand show that a topological group that satisfies this condition is a Lie group, and on the other show that a locally Euclidean group satisfies the condition. If these two propositions can be proved, then the positive solution of the Fifth Problem follows—and even a little more.

As you may have guessed, NSS turned out to be ideally suited to play the role of the bridge. In retrospect this is not entirely surprising. A powerful but relatively elementary property of Lie groups is the existence of so-called canonical coordinates, or equivalently the fact that the exponential map is a diffeomorphism of a neighborhood of zero in the Lie algebra onto a neighborhood U of the identity in the group (see below). Since a line through the origin in the Lie algebra maps to a one-parameter subgroup of the group, it follows that such a U contains no nontrivial subgroup and hence that Lie groups satisfy NSS.

Starting in the late 1940s Gleason [G1],[1] Montgomery [M2], and Iwasawa [I] made several solid advances related to the Fifth Problem. This led in 1952 to a satisfying denouement to the story of the Fifth Problem, with Gleason and Montgomery-Zippin carrying out the above two-pronged attack. First Gleason [G3] proved that a locally compact group satisfying NSS is a Lie group, and then immediately afterwards Montgomery and Zippin [MZ1] used Gleason's result to prove inductively that locally Euclidean groups of any dimension satisfy NSS. Their two papers appeared together in the same issue of the *Annals of Mathematics*, and at that point one knew that for locally compact topological groups:

$$\text{Locally Euclidean} \iff \text{NSS} \iff \text{Lie}.$$

(Actually, the above is not quite the full story; Gleason assumed a weak form of finite dimensionality in his original argument that NSS implies Lie, but shortly thereafter Yamabe [Y2] showed that finite dimensionality was not needed in the proof.)

[1] *As far as I can tell, this 1949 paper was the first journal article to define the NSS condition. But there is clear evidence (see journal entry, above) that Gleason was already preoccupied with the Fifth Problem in mid-1947.*

Cartan's Theorem

Starting with von Neumann, all proofs of cases of the Fifth Problem, including Gleason's, were ultimately based on the following classic result that goes back to É. Cartan. (For a modern proof, see Chevalley [Ch2], page 130.)

Theorem (Cartan). *If a locally compact group has a continuous, injective homomorphism into a Lie group and, in particular, if it has a faithful finite-dimensional representation, then it is a Lie group.*

Here is a quick sketch of how the proof of the Fifth Problem for a compact NSS group G follows. Let $\mathcal{H}$ denote the Hilbert space $L^2(G)$ of square-integrable functions on G with respect to Haar measure. Left translation induces an orthogonal representation of G on $\mathcal{H}$, the so-called regular representation, and, according to the Peter-Weyl Theorem, $\mathcal{H}$ is the orthogonal direct sum of finite-dimensional subrepresentations, $\mathcal{H}_i$, i.e., $\mathcal{H} = \bigoplus_{i=1}^{\infty} \mathcal{H}_i$. Define $W_N := \bigoplus_{i=1}^{N} \mathcal{H}_i$. We will show that for N sufficiently large, the finite-dimensional representation of G on W_N is faithful or, equivalently, that for some N the kernel K_N of the regular representation restricted to W_N is the trivial group $\{e\}$. Since the regular representation itself is clearly faithful, K_N is a decreasing sequence of compact subgroups of G whose intersection is $\{e\}$. Thus if U is an open neighborhood of e that contains no nontrivial subgroup, $K_N \setminus U$ is a decreasing sequence of compact sets with empty intersection and, by the definition of compactness in terms of closed sets, some $K_N \setminus U$ must be empty. Hence $K_N \subseteq U$, and since K_N is a subgroup of G, $K_N = \{e\}$.

Following in Gleason's Footsteps

Andy Gleason put lots of remarks and clues in his papers about his motivations and trains of thought, and it is an enjoyable exercise to read these chronologically and use them to guess how he developed his strategy for attacking the Fifth Problem.

Let's start with a Lie group G, and let $\mathfrak{g}$ denote its Lie algebra. There are (at least !) three equivalent ways to think of an element of the vector space $\mathfrak{g}$. First as a vector v in TG_e, the tangent space to G at e; second as the left-invariant vector field X on G obtained by left translating v over the group; and third as the one-parameter subgroup ϕ of G obtained as the integral curve of X starting at the identity. The exponential map $\exp : \mathfrak{g} \to G$ is defined by $\exp(v) = \phi(1)$. It follows immediately from this definition that $\exp(0) = e$ and that the differential of exp at 0 is the identity map of TG_e, so by the inverse function theorem, exp maps a neighborhood of 0 in $\mathfrak{g}$ diffeomorphically onto a neighborhood of e in G. Such a chart for G is called a canonical coordinate system (of the first kind).

Now, suppose we somehow "lost" the differentiable structure of G but retained our knowledge of G as a topological group. Is there some way we could use the latter knowledge to recover the differentiable structure? That is, can we reconstruct $\mathfrak{g}$ and the exponential map? If so, then we are clearly close to a solution of the Fifth Problem. Let's listen in as Andy ponders this question.

"Well, if I think of $\mathfrak{g}$ as being the one-parameter groups, that's a group theoretic concept. Let's see—is there some way I can invert exp? That is, given g in G close to e, can I find the one-parameter group ϕ such that $\phi(1) = \exp(\phi) = g$? Now I know square roots are unique near e and in fact $\phi(1/2)$ is the square root of g. By induction, I can find $\phi(1/2^n)$ by starting with g and taking the square root n times. And once I have $\phi(1/2^n)$, by simply taking its m-th power I can find $\phi(m/2^n)$ for all m. So, if I know how to take square roots near e, then I can compute ϕ at all the dyadic rationals $m/2^n$, and since they are dense in $\mathbf{R}$, I can extend ϕ by continuity to find it on all of $\mathbf{R}$!"

Photograph courtesy of Richard Palais.

Andy with George Mackey (2000). Although Andy never earned a Ph.D., he thought of George as his mentor and advisor and lists himself as George's student on the Mathematics Genealogy Project website.

This was the stated motivation for Gleason's paper "Square roots in locally Euclidean groups" [G1], and in it he goes on to take the first step and show that in any NSS locally Euclidean group G, there are neighborhoods U and V of the identity such that every element in U has a unique square root in V. Almost immediately after this article appeared, in a paper called "On a theorem of Gleason", Chevalley [Ch3] went on to complete the program Andy outlined. That is, Chevalley used Gleason's existence of unique square roots to construct a neighborhood U of the identity in G and a continuous mapping $(g,t) \mapsto \phi^g(t)$ of $U \times \mathbf{R}$ into G such that each ϕ^g is a one-parameter subgroup of G, $\phi^g(t) \in U$ for $|t| \leq 1$, and $\phi^g(1) = g$.

In his key 1952 *Annals* paper "Groups without small subgroups" [G3], Gleason decided not to follow up this approach to the solution of the Fifth Problem and instead used a variant of von Neumann's method. His approach was based on the construction of one-parameter subgroups, but these were used as a tool to find a certain finite-dimensional invariant linear subspace Z of the regular representation of G on which G acted faithfully and appealed to Cartan's Theorem to complete the proof. The construction of Z is a technical tour de force, but it is too complicated to outline here, and we refer instead to the original paper [G2] or the review by Iwasawa.

Andy Gleason as Mentor

Looking back at how it happened, it seems almost accidental that I became Andy Gleason's first Ph.D. student—and David Hilbert was partly responsible.

As an undergraduate at Harvard I had developed a very close mentoring relationship with George Mackey, then a resident tutor in my dorm, Kirkland House. We had meals together several times each week, and I took many of his courses. So, when I returned in 1953 as a graduate student, it was natural for me to ask Mackey to be my thesis advisor. When he inquired what I would like to work on for my thesis research, my first suggestion turned out to be something he had thought about himself, and he was able to convince me quickly that it was unsuitably difficult for a thesis topic. A few days later I came back and told him I would like to work on reformulating the classical Lie theory of germs of Lie groups acting locally on manifolds as a rigorous modern theory of full Lie groups acting globally. Fine, he said, but then explained that the local expert on such matters was a brilliant young former Junior Fellow named Andy Gleason who had just joined the Harvard math department. Only a year before he had played a major role in solving Hilbert's Fifth Problem, which was closely related to what I wanted to work on, so he would be an ideal person to direct my research.

I felt a little unhappy at being cast off like that by Mackey, but of course I knew perfectly well who Gleason was and I had to admit that George had a point. Andy was already famous for being able to think complicated problems through to a solution incredibly fast. "Johnny" von Neumann had a similar reputation, and since this was the year that *High Noon* came out, I recall jokes about having a mathematical shootout—Andy vs. Johnny solving math problems with blazing speed at the OK Corral. In any case, it was with considerable trepidation that I went to see Andy for the first time.

Totally unnecessary! In our sessions together I never felt put down. It is true that occasionally when I was telling him about some progress I had made since our previous discussion, partway through my explanation Andy would see the crux of what I had done and say something like, "Oh! I see. Very nice! and then…," and in a matter of minutes he would reconstruct (often with improvements) what had taken me hours to figure out. But it never felt like he was acting superior. On the contrary, he always made me feel that we were colleagues, collaborating to discover the way forward. It was just that when he saw his way to a solution of one problem, he liked to work quickly through it and then go on to the next problem. Working together with such a mathematical powerhouse put pressure on me to perform at top level—and it was sure a good way to learn humility!

My apprenticeship wasn't over when my thesis was done. I remember that shortly after I had finished, Andy said to me, "You know, some of the ideas in your thesis are related to some ideas I had a few years back. Let me tell you about them, and perhaps we can write a joint paper." The ideas in that paper were in large part his, but on the other hand, I did most of the writing, and in the process of correcting my attempts he taught me a lot about how to write a good journal article.

But it was only years later that I fully appreciated just how much I had taken away from those years working under Andy. I was very fortunate to have many excellent students do their graduate research with me over the years, and often as I worked together with them I could see myself behaving in some way that I had learned to admire from my own experience working together with Andy.

Let me finish with one more anecdote. It concerns my favorite of all Andy's theorems, his elegant classification of the measures on the lattice of subspaces of a Hilbert space. Andy was writing up his results during the 1955–56 academic year, as I was writing up my thesis, and he gave me a draft copy of his paper to read. I found the result fascinating, and even contributed a minor improvement to the proof, as Andy was kind enough to footnote in the published article. When I arrived at the University of Chicago for my first position the next year, Andy's paper was not yet published, but word of it had gotten around, and there was a lot of interest in hearing the details. So when I let on that I was familiar with the proof, Kaplansky asked me to give a talk on it in his analysis seminar. I'll never forget walking into the room where I was to lecture and seeing Ed Spanier, Marshall Stone, Saunders Mac Lane, André Weil, Kaplansky, and Chern all looking up at me. It was pretty intimidating, and I was suitably nervous! But the paper was so elegant and clear that it was an absolute breeze to lecture on it, so all went well, and this "inaugural lecture" helped me get off to a good start in my academic career.

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John Wermer

Gleason's Work on Banach Algebras

Introduction

I first came to know Andy Gleason in the early 1950s. I found him friendly, natural, and interesting. Of course, I knew that his work had recently led to the solution of Hilbert's Fifth Problem. One thing that impressed me strongly about Andy was that he understood, in detail, every colloquium we attended independently of the subject matter.

A link between the Gleason and Wermer families at that time was Philip, Jean and Andy's Siamese cat. I was a visitor at Harvard in 1959–60, and Andy was going abroad for that year. We rented their apartment. They asked us to take care of Philip for the year, which my two boys and my wife, Christine, and I were happy to do. When spring 1960 came and we knew we should soon have to surrender Philip, it turned out that the Gleasons would not be able to keep him and asked us whether we would take him along to Providence. We accepted with a whoop and a holler. We called him Philip Gleason, and he became a much-valued member of our household. Philip often disappeared for days, but always returned, thinner and wiser, and definitely had more than nine lives.

A mathematical link between Andy and me came out of the former Soviet Union. Gelfand and Silov had recently started a study of commutative Banach algebras and their maximal ideal spaces, and this theory was intimately related to the theory of holomorphic functions. This area aroused the strong interest of a group of young American mathematicians. Andy Gleason was a prominent member of this group and made fundamental contributions to this field of study.

Let $\mathcal{A}$ be a commutative semisimple Banach algebra with unit, and let $\mathcal{M}$ be the space of all maximal ideals of $\mathcal{A}$. Gelfand [1] showed that $\mathcal{M}$ can be endowed with a topology which makes it a compact Hausdorff space such that there is an isomorphism : $f \to \hat{f}$ which maps $\mathcal{A}$ to a subalgebra of the algebra of all continuous functions on $\mathcal{M}$. Silov [2] then showed that there exists a minimal closed subset $\check{S}$ of $\mathcal{M}$ such that to every f in $\mathcal{A}$ and each point m in $\mathcal{M}$ we have the inequality

$$(1) \qquad |\hat{f}(m)| \le \max_{s\in\check{S}} |\hat{f}(s)|.$$

$\check{S}$ is called the Silov boundary of $\mathcal{M}$.

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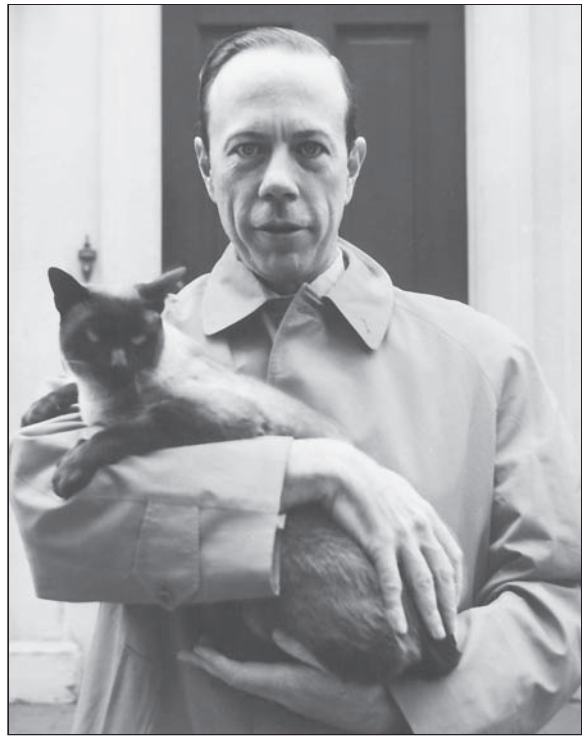

Gleason and Fred, Philip's successor in the Gleason household.

The star example of all this is given by the "disk algebra" A, consisting of all continuous functions on the unit circle Γ which admit analytic continuation to the open unit disk. We take $||f|| = max|f|$ taken over Γ for f in A. Here $\mathcal{M}$ can be identified with the closed unit disk Δ, and $\check{S}$ becomes the topological boundary of Δ. For f in A, $\hat{f}$ is the analytic continuation of f to the interior of Δ.

Another key example is provided by the bidisk algebra A_2 which consists of all functions continuous on the closed bidisk Δ_2 in $\mathbb{C}^2$ which are holomorphic on the interior of Δ_2. The maximal ideal space of $\mathcal{M}$ can be identified with Δ_2; the Silov boundary is not the topological boundary of Δ_2, but instead the torus $T^2 : |z| = 1, |w| = 1$.

Classical function theory gives us, in the case of the disk algebra, not only the maximum principle (1) but also the local maximum principle:
For every f in A, if z_0 lies in the open unit disk and U is a compact neighborhood of z_0 contained in intΔ then

$$(2) \qquad |f(z_0)| \le \max_{z\in\partial U} |f(z)|.$$

It is a fundamental fact, proved by Rossi in [3], that the analogue of (2) holds in general. We have

Theorem 1. (Local Maximum Modulus Principle) Fix a point m in $\mathcal{M}\backslash\check{S}$ and fix a compact neighborhood U of m in $\mathcal{M}\backslash\check{S}$. Then we have for each f in $\mathcal{A}$

$$(3) \qquad |\check{f}(m)| \le \max_{u\in\partial U} |\check{f}(u)|.$$

This result suggests that for an arbitrary $\mathcal{A}$, where $\mathcal{M}\backslash\check{S}$ is nonempty, we should look for some kind of analytic structure in $\mathcal{M}\backslash\check{S}$. In the 1950s Gleason set out to find such analytic structure. He focused on a class of Banach algebras he called "function algebras".

Let X be a compact Hausdorff space. The algebra $C(X)$ of all continuous complex-valued functions on X, with $||f|| = max|f|$ over X, is a Banach algebra. A closed subalgebra $\mathcal{A}$ of $C(X)$ which separates the points of X and contains the unit is called a "function algebra" on X. It inherits its norm from $C(X)$.

Let $\mathcal{M}$ be the maximal ideal space of $\mathcal{A}$. Then X is embedded in the compact space $\mathcal{M}$ as a closed subset, and each f in $\mathcal{A}$ has $\hat{f}$ as a continuous extension to $\mathcal{M}$.

Parts

Let $\mathcal{A}$ be a function algebra on the space X, with maximal ideal space $\mathcal{M}$. Fix a point m in $\mathcal{M}$. The map: $f\to \hat{f}(m)$ is a bounded linear functional on $\mathcal{A}$. We use this map to embed $\mathcal{M}$ into $\mathcal{A}^\star$, the dual space of $\mathcal{A}$. $\mathcal{M}$ then lies in the unit ball of $\mathcal{A}^\star$.

Hence, if m and m' are two points in $\mathcal{M}$, $||m - m'|| \leq 2$. Gleason [4] defined a relation on the points of $\mathcal{M}$ by writing : $m \bullet m'$ if $||m - m'|| < 2$. He proved:

Proposition. The relation "bullet" is an equivalence relation on $\mathcal{M}$.

Note: At first sight, this proposition is counterintuitive, since $m \bullet m'$ and $m' \bullet m''$ are equivalent to $||m - m'|| < 2$ and $||m' - m''|| < 2$. The triangle inequality for the norm yields $||m - m''|| < 4$, whereas we need $||m - m''|| < 2$.

For each $\mathcal{A}$ the space $\mathcal{M}$ splits into equivalence classes under $\bullet$. Gleason called these equivalence classes the "parts" of $\mathcal{M}$.

Observe what these parts look like when $\mathcal{A}$ is the bidisk algebra A_2. Here $\mathcal{M}$ is the closed unit bidisk $\Delta_2 : |z| \leq 1, |w| \leq 1$. Some calculation gives the following: the interior of Δ_2, $|z| < 1, |w| < 1$, is a single part. Each of the disks $(e^{it}, w)|0 \leq t \leq 2\pi, |w| < 1$, $(z, e^{is}), |z| < 1, 0 \leq s \leq 2\pi$ is a part of $\mathcal{M}$. Finally, each point (exp(it), exp(is)), s,t real, is a one-point part lying on the torus $|z| = 1, |w| = 1$. Thus $\mathcal{M}$ splits into the pieces: one analytic piece of complex dimension 2, two families of analytic pieces of complex dimension 1, and uncountably many one-point parts on the Silov boundary of the algebra.

In complete generality, Andy's hopes that for each function algebra the parts of $\mathcal{M}$ would provide analytic structure of the complement of the Silov boundary were not fully realized. Stolzenberg, in [6], gave an example of a function algebra $\mathcal{A}$ such that the complement of the Silov boundary of $\mathcal{A}$ in $\mathcal{M}$ is nonempty but contains no analytic structure. However, an important class of Banach algebras, the so-called "Dirichlet algebras", and their generalizations behaved as Andy had hoped. We turn to these algebras in the next section.

Dirichlet Algebras

Let X be a compact Hausdorff space and let $\mathcal{A}$ be a function algebra on X. In [4], Gleason made the following definition: $\mathcal{A}$ is a *Dirichlet* algebra on X if $Re(\mathcal{A})$, the space of real parts of the functions in $\mathcal{A}$, is uniformly dense in the space $C_R(X)$ of all real continuous functions on X.

The name "Dirichlet" was chosen by Gleason because in the case when $\mathcal{A}$ is the disk algebra A, this density condition is satisfied and has as a consequence the solvability of the Dirichlet problem for harmonic functions on the unit disk.

He stated, "It appears that this class of algebras is of considerable importance and is amenable to analysis." This opinion was born out by developments.

A typical Dirichlet algebra is the disk algebra A on the circle Γ. By looking at A we are led to the basic properties of arbitrary Dirichlet algebras. A has the following properties:

(i) For each point z in Δ, there exists a unique probability measure μ_z on Γ such that for all f in A

$f(z) = \int_{-\pi}^{\pi} f(exp(it))d\mu_z$,

(ii) $\mu_z = \frac{1}{2\pi}p_z dt$,

where p_z is the Poisson kernel at z unless $|z| = 1$, and then μ_z is the point mass at z.

He proved in [4]:

Theorem 2. *Let $\mathcal{A}$ be a Dirichlet algebra on the space X, and let $\mathcal{M}$ be its maximal ideal space.*

(i') Fix m in $\mathcal{M}$. There exists a unique probability measure μ_m on X such that

$$\hat{f}(m) = \int_X f d\mu_m \text{ , for all } f \text{ in } \mathcal{A}.$$

(ii') Fix points m and m' in $\mathcal{M}$. Then m and m' lie in the same part of $\mathcal{M}$ if and only if the measures μ_m and $\mu_{m'}$ are mutually absolutely continuous. In this case, the corresponding Radon-Nikodym derivative is bounded above and below on X.

Note: For m in $\mathcal{M}$, μ_m is called "the representing measure for m".

It turned out that when $\mathcal{A}$ is a Dirichlet algebra with maximal ideal space $\mathcal{M}$, then each part of $\mathcal{M}$ is either a single point or an analytic disk. Explicitly, it is proved in Wermer [7]:

Theorem 3. *Let $\mathcal{A}$ be a Dirichlet algebra with maximal ideal space $\mathcal{M}$. Let Π be a part of $\mathcal{M}$. Then either Π consists of a single point or there exists a continuous one-one map τ of the open unit disk onto Π such that for each f in $\mathcal{A}$ the composition $\hat{f} \circ \tau$ is holomorphic on the unit disk.*

Examples

The following are three examples of Dirichlet algebras.

Example 1: Let K be a compact set in the complex plane C with connected complement, and let X be the boundary of K. The uniform closure $P(X)$ of polynomials on X is a Dirichlet algebra on X.

Example 2: Fix $\alpha > 0$. A_α denotes the space of all continuous functions f on the torus T^2 consisting of all points $(e^{i\theta}, e^{i\phi})$ in C^2 such that f has the Fourier expansion on T^2:

$$\sum_{n+m\alpha\geq 0} c_{nm}e^{in\theta}e^{im\phi}$$

These algebras are studied by Helson and Lowdenslager in [9] and by Arens and Singer in [10]. Each A_α is a Dirichlet algebra on T^2.

Example 3: Let γ be an arc on the Riemann sphere S. Let $B(\gamma)$ denote the algebra of all continuous functions on γ which have a continuous extension to the full sphere S which is holomorphic on S outside of γ. For a certain class of arcs, studied by Browder and Wermer in [8], $B(\gamma)$ is a Dirichlet algebra on γ.

It turned out that substantial portions of the theory of Hardy spaces H^p on the unit disk have natural generalizations when the disk algebra is replaced by an arbitrary Dirichlet algebra.This was pointed out by Bochner in [11] in a slightly different context. It was carried out in [9] for Example 2, and in an abstract context by various authors. (See Gamelin [15].)

Further, Hoffman in [12] introduced a generalization of Dirichlet algebras, called "logmodular algebras", to which the theory of Dirichlet algebras has a natural extension. In particular, parts of the maximal ideal space of such an algebra are either points or disks.

Let H^∞ denote the algebra of all bounded analytic functions on the unit disk, with $||f|| = sup|f|$, taken over the unit disk. Then H^∞ is a Banach algebra. Let X denote the Silov boundary of this algebra. The restriction of H^∞ to X is a function algebra on X. This restriction is not a Dirichlet algebra on X, but it is a log-modular algebra on X. By what was said above, the parts of the maximal ideal space of $H^\infty$are points or analytic disks.

Let M be the maximal ideal space of H^∞, taken with the Gelfand topology. M is compact and contains the open unit disk D as a subset. Lennart Carleson proved in 1962 the so-called Corona Theorem, which implies that D is dense in M. The question had arisen earlier as to the (possible) analytic structure in the complement $M\backslash D$.

Partial results on this question were obtained in 1957 by a group of people talking at a conference, and this result was published under the pseudonym "I. J. Schark"[1] in the paper [16]. Hoffman and Gleason were prominent participants in this enterprise.

[1] *I. Kaplansky, J. Wermer, S. Kakutani, C. Buck, H. Royden, A. Gleason, R. Arens, K. Hoffman.*

Gleason's Problem

Let $\mathcal{A}$ be a function algebra and $\mathcal{M}$ be its maximal ideal space. Fix a point m_0 in $\mathcal{M}$. As a subset of $\mathcal{A}$, m_0 is the set of f such that $\hat{f}(m_0) = 0$. We ask: when does m_0 have a neighborhood in $\mathcal{M}$ which carries structure of a complex-analytic variety? By this we mean the following: there exists a polydisk Δ^n in $\mathbb{C}^n$ and an analytic variety V in Δ^n, and there exists a homeomorphism τ of a neighborhood $\mathcal{N}$ of m_0 on V such that for all f in $\mathcal{A}$ the composition of $\hat{f}$ with the inverse of τ has an analytic extension from V to Δ^n.

Gleason proved the following in [5]:

Theorem 4. *Let $\mathcal{A}$, $\mathcal{M}$, m_0 be as above. Assume that m_0, as an ideal in $\mathcal{A}$, is finitely generated (in the sense of algebra). Then there exists a neighborhood $\mathcal{N}$ of m_0 which has the structure of a complex-analytic variety.*

This result leads naturally to the following question, raised by Gleason:

Let D be a bounded domain in $\mathbb{C}^n$ and denote by $A(D)$ the algebra of continuous functions on the closure of D which are analytic on D. Fix a point $a = (a_1, \ldots, a_n)$ in D. Given f in $A(D)$ with $f(a) = 0$, do there exist functions $g_1, \ldots, g_n$ in $A(D)$ such that $f(z) = \sum_{j=1}^{n}(z_j - a_j)g_j(z)$ for every z in D?

It is now known that the answer is yes if D is a strictly pseudo-convex domain in $\mathbb{C}^n$. A history of the problem is given by Range in [14], Chapter VII, paragraph 4.

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Joel Spencer

Andrew Gleason's Discrete Mathematics

Ramsey Theory

> Six points are in general position in space (no three in a line, no four in a plane). The fifteen line segments joining them in pairs are drawn, and then painted, some segments red, some blue. Prove that some triangle has all its sides the same color.
>
> *—William Lowell Putnam Competition, 1953 ([3], page 38)*

Andrew Gleason's fascination with combinatorial puzzles, his computational skills, and his algebraic insights often led to interesting deep results in discrete mathematics. We sample some of them here.

The Putnam problem quoted above introduces *Ramsey theory*, where Gleason made one of his first contributions. Ramsey theory starts with the fact that for any $k_1, \ldots, k_r$ there is a least $n = R(k_1, \ldots, k_r)$ such that when each of the $\binom{n}{2}$ line segments joining n points in pairs is painted with one of r colors, then for some $1 \le i \le r$ there are k_i points with all segments between them given color i. R is generally called the Ramsey function and the $n = R(k_1, \ldots, k_r)$ are called Ramsey numbers. Solving the Putnam problem above proves $R(3,3) \le 6$. The arguments for the existence of $R(k,l)$ had been given by Ramsey and, independently, by Erdős and Szekeres in the early 1930s (see [4] for general reference). Ramsey theory fascinated Gleason.

In 1955 Gleason and coauthor R. E. Greenwood [1] calculated some small Ramsey numbers. They found $R(3,3) = 6$, $R(3,4) = 9$, $R(3,5) = 14$, $R(4,4) = 18$, and $R(3,3,3) = 17$. The lower bounds sometimes called for ingenious algebraic constructions to provide counterexamples. For instance, to show $R(3,3,3) > 16$ they consider the 16 points

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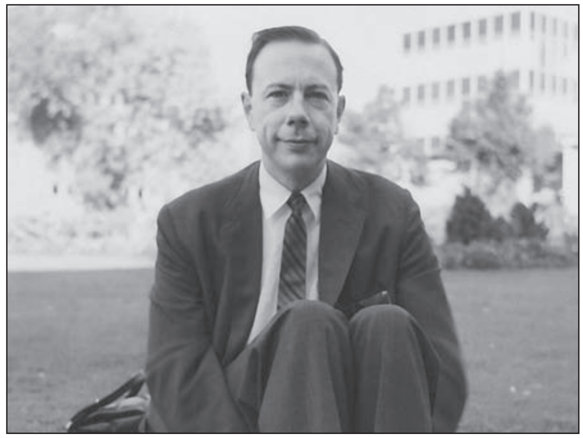

Gleason in Berlin, 1959.

as $GF(16)$. Let $H \subset GF(16)^*$ consist of the nonzero cubes. Then they color the edge between $\alpha, \beta \in GF(16)$ by the coset of $GF(16)^*/H$ containing $\alpha - \beta$. Despite great efforts and high speed computers, only a few other values are known today. Even the value of $R(5,5)$ seems out of reach.

As a graduate student at Harvard in the late 1960s I chose to write a thesis partially on Ramsey numbers. Gleason told me he had spent a great deal of time looking for other exact values. Since I knew of his legendary calculating powers, I took this as sage advice to restrict my attention to their asymptotics.

Coding Theory

Gleason's research in discrete mathematics began not with Ramsey theory but with his cryptographic work during World War II [5]. That's when he first collaborated with Greenwood. After the war he participated in the burgeoning development of coding theory. Although he published little, he had a significant influence on others.

Vera Pless (her [6] is a good general reference for coding theory) recalls "Gleason meetings" in the 1950s on error-correcting codes.

> These monthly meetings were what I lived for. No matter what questions we asked him on any area of mathematics, Andy knew the answer. The numerical calculations he did in his head were amazing.

A *binary code* is a subset of $\{0,1\}^n$. The elements are called codewords. The *weight* of a codeword is the number of coordinates with value one. Gleason studied codes with an algebraic representation.

To define a *quadratic residue code*, begin by identifying $\{0,1\}^n$ with $Z_2[x]/(x^n - 1)$. Suppose n is a prime congruent to ± 1 mod 8. Let Q be the quadratic residues of Z_n^* and set $e(x) = \sum_{i \in Q} x^i$. Then let $C = (1 + e(x))$, the ideal generated by $1 + e(x)$ in $Z_2[x]/(x^n - 1)$. Then C is a code of dimension $(n+1)/2$. These codes have proven particularly useful, in part because of their symmetries.

Let $\overline{C}$ be the code of dimension $n+1$ given by adding a parity bit. (That is, the first n bits are in C, and the last is such that the weight is even.) A symmetry of $\overline{C}$ is a permutation $\sigma \in S_{n+1}$ of the coordinates for which $\sigma(\overline{C}) = \overline{C}$. The *Gleason-Prange Theorem* [6] asserts that

Theorem 1. *The Projective Simple Linear Group $PSL_2(n)$ is a subgroup of the group of symmetries of $\overline{C}$.*

A *linear code* is a $C \subseteq \{0,1\}^n$ which is a subspace of $\{0,1\}^n$. For such C, $C^\perp$ is the usual (over Z_2) orthogonal subspace. When C has A_i vectors of weight i, its weight enumerator is defined by

$$W_C(x,y) = \sum_{i=0}^{n} A_i x^{n-i} y^i.$$

The *Gleason polynomials* are finite sets of polynomials that generate all weight enumerators of a certain type.

Gleason found a particularly striking example for self-dual codes, those for which $C = C^\perp$.

Theorem 2. *If C is self-dual, then W_C is generated by $g_1(x,y) = x^2 + y^2$ and $g_2(x,y) = x^8 + 14x^2y^2 + y^8$.*

There are deep connections to invariant theory here.

The weight enumerator of C determines that of $C^\perp$. The exact relationship was given by Jessie MacWilliams (1917–1990), one of Gleason's most accomplished students, in her thesis.

Theorem 3. *The MacWilliams Identity:*

$$W_{C^\perp}(x,y) = \frac{1}{|C|} W_C(x+y, x-y).$$

Gleason proved much more along these lines in [2]. Neil Sloane starts his paper on *Gleason's Theorem on Self-Dual Codes and Its Generalizations* [8] with "One of the most remarkable theorems in coding theory is Gleason's 1970 theorem about the weight enumerators of self-dual codes."

The Putnam Exam

Gleason was the first three-time winner of the Putnam competition, finishing in the top five while at Yale in 1940, 1941, and 1942. He was disappointed in his first attempt, because he solved only thirteen of the fifteen problems.

For many years he selected one of the five finishers for the Putnam Fellowship at Harvard, a fellowship he was awarded and declined in 1940 in order to remain at Yale. He wrote (with R. E. Greenwood and L. M. Kelly) a beautiful book [3] on the Putnam competition for the years 1938–64. For many problems his solutions (and there are often several) are splendid lectures in the varied subjects. Elwyn Berlekamp (also a Putnam winner) recalls discussions with him:

> [Gleason] would usually offer two or three different solutions to the problem he wanted to talk about, whereas I rarely ever had more than one. He believed that Putnam problems encouraged very strong mastery of what he considered to be the fundamentals of mathematics.

Gleason was always eager to share his passion for mathematics in general and problems in particular. Bjorn Poonen (a multiple Putnam winner and the coauthor of a follow-up book on the Putnam competition 1985–2000 [7]) recalls his undergraduate days:

> Andy struck me as someone genuinely interested in helping younger mathematicians develop. When I was an undergrad at Harvard, he volunteered an hour or two of his time each week for an informal meeting in his office with a group consisting of me and one or two other math undergrads to discuss whatever mathematics was on our minds.

Amen. As a graduate student I had the good fortune to be Andy Gleason's teaching assistant. We would meet in the small preparation room before the classes. Andy would discuss the mathematics of the lecture he was about to give. He was at ease and spoke of the importance and the interrelationships of the various theorems and proofs. My contributions were minimal, but I listened with rapt attention. It was in those moments that I learned what being a mathematician was all about.

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Paul R. Chernoff

Andy Gleason and Quantum Mechanics

About Andy

I met Andy at the beginning of my second year at Harvard when I signed up for his graduate analysis course. Andy briefly interviewed prospective students to see if they had enough background to benefit from this rather sophisticated course. I told Andy that I owned a number of advanced books which I hadn't read.

The course was both a challenge and a pleasure. I can only echo what others have said about Andy's luminous clarity and massive abstract power. But I must admit that the lectures, always exciting, weren't *absolutely* perfect; in the course of a year Andy made one genuine blunder. As to his famous speed, John Schwarz, the well-known string theorist, once said after class that Andy had "the metabolism of a hummingbird".

I was extremely lucky that Andy was affiliated with Lowell House, my undergraduate residence. Every week Andy came for lunch, where we sat around a large circular table. That's how Andy and I became friends. Of course we discussed a lot of mathematics around that table, but lots of other things, including Andy's "war stories". I am not surprised that someone kept a great treasure: all of Andy's napkin manuscripts.

Almost any mathematical problem could intrigue Andy. At one of the annual math department picnics, he had fun figuring out how to do cube roots on an abacus. But most important was his unpretentiousness, openness, and great interest in students. I suppose that all teachers are impatient at times; no doubt Andy was sorely tried on occasion. But he rarely, if ever, showed it. The students in one of his classes gave him a framed copy of Picasso's early painting *Mother and Child*. Perhaps they chose this gift to symbolize Andy's nurturing of them. It's regrettable that there are some teachers for whom *Guernica* would be more appropriate.

Quantum Mechanics

In this section we set the stage for a discussion of Andy's unique contribution to physics: his remarkable paper "Measures on the closed subspaces of a Hilbert space" [G57]. It's interesting in several ways: its history; its influence in mathematics; and especially its unexpected importance to the analysis of "hidden variable" theories of quantum mechanics by the physicist John Bell.

Gleason with koala, Cleland Wildlife Park, Adelaide, Australia, 1988.

In classical mechanics, the *state* of a particle of mass m is given by its position and momentum. The motion or dynamics of a set of particles with associated forces is determined by Newton's second law of motion, a system of ordinary differential equations. This yields a picture of the macroscopic world which matches our intuition. The ultramicroscopic world requires a quite different description. The state of a particle of mass m in $\mathbb{R}^3$ is a complex valued function ψ on $\mathbb{R}^3$. Its momentum is similarly described by the function ϕ, the *Fourier transform* of ψ, normalized by the presence in the exponent of the ratio $\frac{h}{m}$, where h is Planck's constant. (Using standard properties of the Fourier transform, one can deduce Heisenberg's uncertainty principle.) For n particles, ψ is defined on $\mathbb{R}^{3n}$. This is a brilliant extrapolation of the initial ideas of DeBroglie. The Schrödinger equation determines the dynamics. If both ψ and ϕ are largely concentrated around n points in position *and* momentum space respectively, then the quantum state resembles a blurry picture of the classical state. The more massive the particles, the less the blurriness (protons versus baseballs).

The fundamental interpretation of the "wave function" ψ is the work of Max Born.[1] His paper analyzing collisions of particles ends with the conclusion that $|\psi|^2$ should be interpreted as the probability distribution for the positions of the particles. Therefore the wave function must be a unit vector in L^2. Thus did Hilbert space enter quantum mechanics.

Prior to Schrödinger's wave mechanics, Heisenberg had begun to develop a theory in which observable quantities are represented by Hermitian-symmetric infinite square arrays. He devised a "peculiar" law for multiplying two arrays by an ingenious use of the physical meaning of their entries. Born had learned matrix theory when he was a student and realized (after a week of "agony") that Heisenberg's recipe was just matrix multiplication. Hence the Heisenberg theory is called matrix mechanics. (Schrödinger showed that

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[1] *For more historical information, including translations of important original papers, see van der Waerden's excellent survey of the development of quantum mechanics [VW]. Jammer's book [J66] is a superb account of the development of quantum mechanics.*

matrix mechanics and wave mechanics are mathematically equivalent.) As in classical mechanics, the dynamics of a quantum system is determined from its energy H. Periodic orbits correspond to the eigenvalues of H, i.e., the discrete energy levels. The calculation of the eigenvalues is very difficult, save for a few simple systems. The energy levels for the hydrogen atom were ingeniously calculated by Wolfgang Pauli; his results agreed with Bohr's calculations done at the very beginning of the "old" quantum theory.

Born was quite familiar with Hilbert's theory of integral equations in L^2. Accordingly, he was able to interpret Heisenberg's matrices as Hermitian symmetric kernels with respect to some orthonormal basis, which might just as well be regarded as the corresponding integral operators on L^2. Formally, every Hermitian matrix could be regarded as an integral operator, usually with a very singular kernel. (The most familiar example is the identity, with kernel the Dirac delta function.) In this way, Born initiated the standard picture of observables as Hermitian operators A on L^2. But at that time, the physicists did not grasp the important distinction between unbounded Hermitian operators and unbounded self-adjoint operators. That was greatly clarified by John von Neumann, major developer of the theory of unbounded self-adjoint operators.

Having interpreted $|\psi|^2$ as the probability distribution for the positions of particles, Born went on to devise what immediately became the standard interpretation of measurements in quantum mechanics: the probability that a measurement of a quantum system will yield a particular result.

Born's line of thought was this. A state of a quantum system corresponds to a unit vector $\psi \in L^2$. What are the possible values of a measurement of the observable represented by the operator A, and what is the probability that a specific value is observed? Born dealt only with operators with a discrete spectrum, namely, the set of all its eigenvalues. For simplicity, assume that there are no multiple eigenvalues. Let ϕ_n be the unit eigenvector with eigenvalue λ_n. These form an orthonormal basis of L^2. Expand ψ as a series $\sum_k c_k \phi_k$. Since $||\psi||^2 = 1$, we get $\sum_k |c_k|^2 = 1$. Born's insight was that any measurement must yield one of the eigenvalues λ_n of A, and $|c_n|^2$ is the probability that the result of the measurement is λ_n . This is known as *Born's rule*. It follows that the expected value of a measurement of A is $\sum_k |c_k|^2 \lambda_k$. Note that this sum equals the inner product $(A\psi, \psi)$. This is the same as $\mathrm{trace}(PA)$, where P is the projection onto the one-dimensional subspace spanned by ψ. (To jump ahead, George Mackey wondered if Born's rule might involve some arbitrary choices. Gleason ruled this out.)

John von Neumann was the creator of the abstract theory of quantum mechanics. In his theory, a *pure state* is a unit vector in a Hilbert space $\mathcal{H}$. Observables are self-adjoint operators, unbounded in general, whose spectrum may be any Borel subset of $\mathbb{R}$. Von Neumann also developed the important concept of a *mixed state*. A mixed state $\mathbf{D}$ describes a situation in which there is not enough information to determine the pure state ψ of the system. Usually physicists write $\mathbf{D}$ as a convex combination of orthogonal pure states, $\sum_k w_k \psi_k$. This notation is confusing; $\mathbf{D}$ is *not* a vector in $\mathcal{H}$! It may be interpreted as a list of probabilities w_k that the corresponding pure state is ψ_k. Associated with the state $\mathbf{D}$ there is a positive operator D with trace 1, given by the formula

$$D = \textstyle\sum_k w_k P_k$$

where P_n is the projection on the eigenspace of D corresponding to the eigenvalue w_n. The expected value of an observable A is quite clearly

$$E(A) = \textstyle\sum_k w_k (A\psi_k, \psi_k) = \mathrm{trace}(DA).$$

This is von Neumann's general Born rule.

The eigenvalues of a projection operator are 1 and 0; those are the only values a measurement of the corresponding observable can yield. That is why Mackey calls a projection a *question*; the answer is always either 1 or 0: "yes" or "no". The fundamental example is the following. Given a self-adjoint operator A, we will apply the spectral theorem. Let S be any Borel subset of $\mathbb{R}$ and let P_S be the corresponding "spectral projection" of A. (If the set S contains only some eigenvalues of A, then P_S is simply projection onto the subspace spanned by the corresponding eigenvectors.) Now suppose the state of the system is the mixed state $\mathbf{D}$. From the general Born rule, the probability that a measurement of A lies in S is the expected value of P_S, namely, $\mathrm{trace}(DP_S)$. That is the obvious generalization of Born's formula for the probability that a measurement of A is a particular eigenvalue of A or a set of isolated eigenvalues.

Quite generally, consider a positive operator D with $\mathrm{trace}(D) = 1$. The nonnegative real-valued function $\mu(P) = \mathrm{trace}(DP)$ is a countably additive probability measure on the lattice of projections on $\mathcal{H}$. This means that if $\{P_n\}$ is a countable family of mutually orthogonal projections,

$$\mu(\sum_n P_n) = \sum_n \mu(P_n).$$

Also $\mu(I) = 1$. Mackey asked whether *every* such measure on the projections is of this form, i.e., corresponds to a state D. We already mentioned Mackey's interest in Born's rule. A positive answer to Mackey's question would show that the Born rule follows from his rather simple axioms for quantum mechanics [M57], [M63], and thus, given these weak postulates, Born's rule is not ad hoc but inevitable.

Gleason's Theorem

Mackey didn't try very hard to solve his problem for the excellent reason that he had no idea how to attack it. But he discussed it with a number of experts, including Irving Segal, who mentioned Mackey's problem in a graduate class at Chicago around 1949 or 1950. Among the students was Dick Kadison, who realized that there are counterexamples when $\mathcal{H}$ is two-dimensional. The higher-dimensional case remained open.

There matters stood for some years. Then Gleason entered the story. In 1956 he sat in on Mackey's graduate course on quantum mechanics at Harvard. To Mackey's surprise, Andy was seized by the problem "with intense ferocity". Moreover, Kadison was visiting MIT at the time, and his interest in Mackey's problem was rekindled. He quickly perceived that there were many "forced inter-relations" entailed by the intertwining of the great circles on the sphere and in principle a lot could be deduced from an analysis of these relations, though the problem still looked quite tough. He mentioned his observation to Andy, who found it a useful hint. (But Kadison informed me that his observation did not involve anything like Andy's key "frame function" idea.)

Theorem 1 *(Gleason's theorem). Let $\mathcal{H}$ be a separable Hilbert space of dimension greater than 2. Let μ be a countably additive probability measure on the projections of $\mathcal{H}$. Then there is a unique nonnegative self-adjoint operator D, with trace(D) = 1, such that, for every projection P,*

$$\mu(P) = \mathrm{trace}(DP).$$

The proof has three parts. First, using countable additivity and induction, it is easy to reduce the case of any separable real Hilbert space of dimension greater than 2 to the 3-dimensional case. (The complex case follows from the real case.)

Next, consider a vector x on the unit sphere. Let P_x be the one-dimensional subspace containing x, and define $f(x) = \mu(P_x)$. This function is called a *frame function*. The additivity of the measure μ implies that for any three mutually orthogonal unit vectors,

$$f(x) + f(y) + f(z) = 1.$$

The proof comes down to showing that the frame function f is quadratic and therefore is of the form $f(x) = \mathrm{trace}(DP_x)$, where D is as in the statement of the theorem. Gleason begins his analysis by showing that a *continuous* frame function is quadratic via a nice piece of harmonic analysis on the sphere. The centerpiece of the paper is the proof that f is continuous. Andy told me that this took him most of the summer. It demonstrates his powerful geometric insight. However, despite Andy's talent for exposition, much effort is needed to really understand his argument.

Quite a few people have worked on simplifying the proof. The paper by Cooke, Keane, and Moran [CKM] is interesting, well written, and leads the reader up a gentle slope to Gleason's theorem. The authors use an important idea of Piron [Pi]. (The CKM argument is "elementary" because it does not use harmonic analysis.)

Generalizations of Gleason's Theorem

In his paper Andy asked if there were analogues of his theorem for countably additive probability measures on the projections of von Neumann algebras other than the algebra of bounded operators on separable Hilbert spaces.

A von Neumann algebra, or W^* algebra, is an algebra $\mathcal{A}$ of bounded operators on a Hilbert space $\mathcal{H}$, closed with respect to the adjoint operation. Most importantly, $\mathcal{A}$ is closed in the *weak operator topology*. The latter is defined as follows: a net of bounded operators $\{a_i\}$ converges *weakly* to b provided that, for all vectors $x, y \in \mathcal{H}$,

$$\lim_{n\to\infty}(a_n x, y) = (bx, y).$$

A *state* of a von Neumann algebra $\mathcal{A}$ is a positive linear functional $\phi : \mathcal{A} \to \mathbb{C}$ with $\phi(I) = 1$. This means that $\phi(x) \geq 0$ if $x \geq 0$ and also $||\phi|| = 1$. The state ϕ is *normal* provided that if a_i is an increasing net of operators that converges weakly to a, then $\phi(a_i)$ converges to $\phi(a)$. The normal states on $B(\mathcal{H})$ are precisely those of the form $\mathrm{trace}(Dx)$, where D is a positive operator with trace 1.

Let $P(\mathcal{A})$ be the lattice of orthogonal projections in $\mathcal{A}$. Then the formula

$$\mu(P) = \phi(P)$$

defines a finitely additive probability measure on $P(\mathcal{A})$. If ϕ is normal, the measure μ is countably additive.

The converse for countably additive measures is due to A. Paszkiewicz [P]. See E. Christensen [C] and F. J. Yeadon [Y1], [Y2] for finitely additive measures. Maeda has a careful, thorough presentation of the latter in [M].

It is not surprising that the arguments use the finite-dimensional case of Gleason's theorem. A truly easy consequence of Gleason's theorem is that μ is a uniformly continuous function on the lattice of projections P, equipped with the operator norm.

A great deal of work has been done on Gleason measures which are unbounded or complex valued. A good reference is [D]. Bunce and Wright [BW] have studied Gleason measures defined on the lattice of projections of a von Neumann algebra with values in a Banach space. They prove the analogue of the results above. A simple example is Paszkiewicz's theorem for complex-valued measures, which had been established only for positive real-valued measures.

Nonseparable Hilbert Spaces

Gleason's theorem is true only for separable Hilbert spaces. Robert Solovay has completely analyzed the nonseparable case. (Unpublished. However, [SO] is an extended abstract.) I consider Solovay's work to be the most original extension of Gleason's theorem.

Definitions. *A* Gleason measure *on a Hilbert space $\mathcal{H}$ is a countably additive probability measure on the lattice of projections of $\mathcal{H}$. We say that a Gleason measure μ is standard provided there is a positive trace-class operator D with trace 1 such that μ(P) =trace(DP). Otherwise, μ is* exotic.

Definition. *A set X is gigantic if there is a continuous probability measure ρ defined on **all** the subsets of X. Continuity means that every point has measure 0.*

A countable set is not gigantic. Indeed, gigantic sets are very, very large. Also, in standard set theoretic terminology, a gigantic cardinal is called a measurable cardinal.

Gleason's theorem states that every Gleason measure on a separable Hilbert space is standard. But suppose $\mathcal{H}$ is a nonseparable Hilbert space with a gigantic orthonormal basis $\{e_i : i \in I\}$. Let ρ be the associated measure on I. Then the formula

$$\mu(P) = \int_I (Pe_i, e_i)\, d\rho(i)$$

defines an exotic Gleason measure, because $\mu(Q) = 0$ for every projection Q with finite-dimensional range.

On the other hand, it can be shown that if $\mathcal{H}$ is any Hilbert space of nongigantic dimension greater than 2, then every Gleason measure on $\mathcal{H}$ is standard. Solovay presents a proof. (A consequence is that an exotic Gleason measure exists if and only if a measurable cardinal exists.)

If I is any set, gigantic or not, and ρ is any probability measure, continuous or not, defined on all the subsets of I, then the formula above defines a Gleason measure. Solovay's main theorem says that every Gleason measure is of this form.

Theorem 2 (Solovay). *Let $\mathcal{H}$ be a nonseparable Hilbert space, and let μ be a Gleason measure on $\mathcal{H}$. Then there is an orthonormal basis $\{e_i : i \in I\}$ of $\mathcal{H}$ and a probability measure ρ on the subsets of I such that μ is given by the formula above.*

Observe that Gleason's theorem is analogous; ρ is a discrete probability measure on the integers; the numbers $\rho(n)$ are the eigenvalues, repeated according to multiplicity, of the operator D.

Solovay also proves a beautiful formula giving a canonical representation of a Gleason measure μ as an integral over the set $\mathcal{T}$ of positive trace-class operators A of trace 1: there is a measure ν defined on all subsets of $\mathcal{T}$ such that, for all P,

$$\mu(P) = \int_{\mathcal{T}} \text{trace } (AP)\, d\nu(A)$$

Moreover, there is a *unique* "pure, separated" measure ν such that the formula above holds. These two technical terms mean that ν is similar to the sort of measure that occurs in spectral multiplicity theory for self-adjoint operators. The reader may enjoy proving this formula when $\mathcal{H}$ is finite-dimensional; this simple case sheds some light on the general case.

Hidden Variables and the Work of John Bell

The major scientific impact of Gleason's theorem is not in mathematics but in physics, where it has played an important role in the analysis of the basis of quantum mechanics. A major question is whether probabilistic quantum mechanics can be understood as a phenomenological theory obtained by averaging over variables from a deeper nonprobabilistic theory. The theory of heat exemplifies what is wanted. Heat is now understood as due to the collisions of atoms and molecules. In this way one can understand thermodynamics as a phenomenological theory derived by averages over "hidden variables" associated with the deeper particle theory; hence the term "statistical mechanics". Einstein sought an analogous relation between quantum mechanics and—what? He is supposed to have said that he had given one hundred times more thought to quantum theory than to relativity.

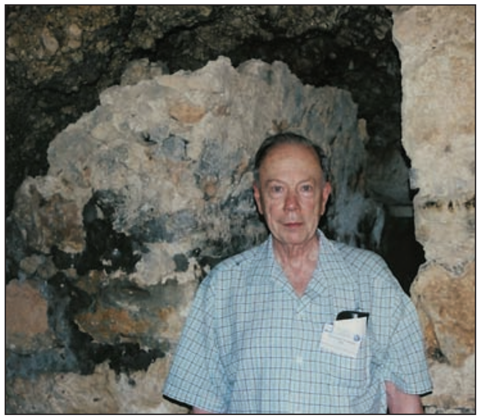
The fourth chapter of John von Neumann's great book [VN] is devoted to his famous analysis of the hidden variable question. His conclusion was that no such theory could exist. He writes, "The present system of quantum mechanics would have to be objectively false, in order that another description of the elementary processes than the statistical one may be possible." That seemed to settle the question. Most physicists weren't much interested in the first place when exciting new discoveries were almost showering down.

But in 1952 there was a surprise. Contrary to von Neumann, David Bohm exhibited a hidden variable theory by constructing a system of equations with both waves and particles which exactly reproduced quantum mechanics. But Einstein rejected this theory as "too easy", because it lacked the insight Einstein was seeking. Worse yet, it had the feature Einstein most disliked. Einstein had no problem understanding that there can easily be correlations between the behavior of two distant systems, A and B. If there is a correlation due to interaction when the systems are close, it can certainly be maintained when they fly apart. His objection to standard quantum mechanics was that in some cases a measurement of system A *instantly* determines the result of a related measurement of system B. Einstein dubbed this "weird action at a distance." Bohm's model has this objectionable property.

In fact, soon after its publication, von Neumann's argument was demolished by Grete Hermann [J74], a young student of Emmy Noether. Her point was that in quantum mechanics the expectation of the sum of two observables A and B is the sum of the expectations: $E(A+B) = E(A) + E(B)$, even if A and B don't commute. This is a "miracle" because the eigenvalues of $A+B$ have no relation to those of A and B unless A and B commute. It is true only because of the special formula for expectations in quantum mechanics. It is not a "law of thought". Yet von Neumann postulated that additivity of expected values must hold for all underlying hidden variable theories. That is the fatal mistake in von Neumann's argument. However, although Heisenberg immediately understood Hermann's argument when she spoke with him, her work was published in an obscure journal and was forgotten for decades.

The outstanding Irish physicist John Bell was extremely interested in the hidden variable problem. Early on he discovered a simple example of a hidden variable theory for a two-dimensional quantum system; it's in chapter 1 of [B], which is a reprint of [B66]. This is another counterexample for von Neumann's "impossibility" theorem. (Bell did a great deal of important "respectable" physics. He said that he studied the philosophy of physics only on Saturdays. An interesting essay on Bell is in Bernstein's book [BE].)

When Bell learned of Gleason's theorem he perceived that in Hilbert spaces of dimension greater than 2, it "apparently" establishes von Neumann's "no hidden variables" result *without* the objectionable assumptions about noncommuting operators. Bell is reported to have said that he must either find an "intelligible" proof of Gleason's theorem or else quit the field. Fortunately Bell did devise a straightforward proof of a very special case: nonexistence of frame functions taking only the values 0 and 1. Such frame functions correspond to projections. This case sufficed for Bell's purposes [B66]. See the first chapter of [B].[2]



At the International Conference on the Teaching of Mathematics, Samos (home of Pythagoras), 1998.

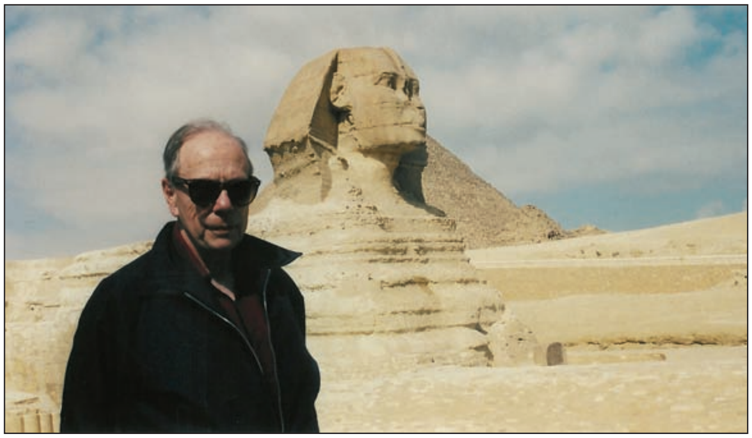
The gist of von Neumann's proof is an argument that dispersion-free states do not exist. Here a state **D** is *dispersion-free* provided $E(A^2) = E(A)^2$ for any observable A. In other words, every observation of A has the value $E(A)$, its mean value. Quantum mechanics is supposedly obtained by averaging over such states. The frame functions considered by Bell correspond precisely to dispersion-free states. But these frame functions are not continuous. Gleason's theorem implies that no such frame functions exist. Therefore there are no dispersion-free states. But Gleason's theorem uses Mackey's postulate of additivity of expectations for *commuting* projections. Bell's argument based on Gleason's theorem avoids the unjustified assumption of additivity of expectation values for noncommuting operators.

Bell writes: "That so much follows from such apparently innocent assumptions leads one to question their innocence." He points out that if P, Q, and R are projections with P and Q orthogonal to R but not to each other, we might be able to measure R and P, or R and Q, but not necessarily both, because P and Q do not commute. Concretely, the two sets of measurements may well require different experimental arrangements. (This point was often made by Niels Bohr.) Bell expresses this fundamental fact emphatically: "The danger in fact was not in the explicit but in the implicit assumptions. It was tacitly assumed that measurement of an observable must yield the same value independently of what other measurements are made simultaneously." In other words, the measurement may depend on its context. This amounts to saying that Gleason's frame functions may not be well defined from the point of view of actual experiments. Accordingly, one should examine Mackey's apparently plausible derivation that projection-valued measures truly provide part of a valid axiomatization of quantum mechanics.

Finally, a few words about the famous "Bell's Inequality".

The second chapter of Bell's book is a reprint of [B64] (actually written after [B66]). In this very important paper, Bell derives a specific inequality satisfied by certain "local" hidden variable theory for *nonrelativistic* quantum mechanics. ("Locality" excludes "weird" correlations of measurements of widely separated systems.) There are many similar but more general inequalities. Moreover, the study of the "entanglement" of separated quantum

[2] *Kochen and Specker [KS] proved a deeper theorem. But Si Kochen informed me that they didn't know of Gleason's theorem until they had almost completed their work.*



Gleason in Egypt in 2001.

systems has opened a new field of mathematical research.

Starting in 1969, difficult experimental work began, using variants of Bell's inequality, to test if very delicate predictions of quantum mechanics are correct. Of course, quantum mechanics has given superb explanations of all sorts of phenomena, but these experiments waterboard quantum mechanics. Many experiments have been done; so far there is no convincing evidence that quantum mechanics is incorrect. In addition, experiments have been done which suggest that influence from one system to the other propagates enormously faster than light. These experiments point toward instantaneous transfer of information.

Bell's papers on quantum philosophy have been collected in his book *Speakable and Unspeakable in Quantum Mechanics* [B]. The first paper [B66] discusses Gleason's theorem and the second "Bell's inequality". The entire book is a pleasure to read.[3]

Anagrams

Among his many talents, Andy was a master of anagrams. His fragmentary 1947 diary records a family visit during Harvard's spring break:

> March 30. …We played anagrams after supper and I won largely through the charity of the opposition.
>
> April 1. …Played a game of anagrams with Mother and won.
>
> April 2. …Mother beat me tonight at anagrams.

So we know a little about where he honed that talent.

Many years ago Andy and I had a little anagram "contest" by mail. (Dick Kadison said then, "You're having an anagram competition with Andy Gleason? That's like arm wrestling with Gargantua.") Anyhow, I figured out ROAST MULES, and I was proud to come up with I AM A WONDER AT TANGLES, which is an anagram of ANDREW MATTAI GLEASON. Unfortunately, it should be MATTEI. But I didn't have the chutzpah to ask Andy to change the spelling of his middle name.

I am grateful for very interesting correspondence and conversations with the late Andy Gleason and George Mackey, together with Dick Kadison, Si Kochen, and Bob Solovay.

[3]The Amer. Math. Monthly *published a nice elementary mathematical exposition of Bell's inequality [McA].*

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Lida Barrett

Andy Gleason and the Mathematics Profession

I knew and respected Andy Gleason as a mathematician for most of my career and most of his. His contributions to mathematics are well known and worthy of respect, but his overall contribution to the mathematics profession goes far beyond the mathematics he did, the courses he taught, the students he influenced, his role on the Harvard campus, and his extensive commitment to mathematics education. For many years Andy was the consummate person to call upon to represent the profession in a variety of settings. His credentials were impeccable: a Yale graduate, a Harvard professor with a chair in mathematicks (with a "ck") and natural philosophy. What better person to send to Washington to testify before a congressional committee or to add to the Mathematical Science Education Board of the National Academy of Sciences or to have as a spokesperson at the Council of Scientific Society Presidents? Not only did he have the credentials, but when he spoke, he had something to say: thoughtful, well conceived, suitable to the audience, comprehensive, to the point, and, most likely, brief. His manner was gracious and his demeanor modest. Raoul Bott said it well at Andy's retirement party:

> The straightness Andy brings to his mathematics he extends to all that have dealings with him. In these many years together I have never heard a word that seemed false in what he had to say. Nor have I seen him hesitate to take on any task, however onerous, for the welfare of the Department or the University. Needless to say, the rest of us are masters of this art. For, of course, the best way to avoid a chore is to be out of earshot when it is assigned. Hungarians imbibe this principle with their mother's milk, but Andy, for all his brilliance, never seems to have learned it [GLIM].

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Within the profession Andy served in many ways. He was president of the American Mathematical Society in 1981 and 1982. At the Mathematical Association of America he served on the committee on the Putnam Prize Competition (he placed in the top five three years in a row during his years as an undergraduate) and the Science Policy Committee. In 1996 the MAA honored him with its Yueh-Gin Gung and Dr. Charles Y. Hu Award for Distinguished Service [Gung].

Andy chaired the committee in charge of the 1986 International Congress of Mathematicians in Berkeley, California. Hope Daly, the staff person from the AMS who handled the operation, says of him, "He was wonderful, a great leader. He quickly understood problems when they arose and had immediate answers. And he was really wonderful to work with, humble, pleasant." She offers as an example of the many ways in which he could help his action on the morning of the meeting when he saw the staff making direction signs for the somewhat confusing Berkeley campus to replace those the students had taken down the night before. Asking what needed to be done, he was told the signs had to be tacked up. So he took a stack and a hammer and went out and did just that. After the successful congress he edited the proceedings; see [ICM].

He was a master of exposition for audiences at any level. His 1962 Earle Raymond Hedrick Lectures for the MAA on "The Coordinate Problem" addressed the need for good names. The abstract[1] reads:

> In the study of mathematical structures, especially when computations are to be made, it is important to have a system for naming all of the elements. Moreover, it is essential that the names be so chosen that the structural relations between the various elements can be expressed by relations between their names. When the structure has cardinal $\aleph_0$ it is natural to take integers or finite sequences of integers as names. When the cardinal is c, it is appropriate to take real numbers or sequences of real numbers as names. Most mathematical systems are described initially in terms of purely synthetic ideas with no reference to the real number system. Theorems concerning the existence of analytic representations for different types of structures [are] discussed.

He also wrote for the general reader. In *Science* in 1964 he explained the relationship between

[1] *We have been unable to locate a copy of the text of the lectures.*

topology and differential equations [DE]. His first paragraph sets the tone for that hard task:

> It is notoriously difficult to convey the proper impression of the frontiers of mathematics to nonspecialists. Ultimately the difficulty stems from the fact that mathematics is an easier subject than the other sciences. Consequently, many of the important primary problems of the subject—that is, problems which can be understood by an intelligent outsider—have either been solved or carried to a point where an indirect approach is clearly required. The great bulk of pure mathematical research is concerned with secondary, tertiary, or higher-order problems, the very statement of which can hardly be understood until one has mastered a great deal of technical mathematics.

In spite of these formidable difficulties, he concludes his introduction:

> I should like to give you a brief look at one of the most famous problems of mathematics, the *n*-body problem, to sketch how some important problems of topology are related to it, and finally to tell you about two important recent discoveries in topology whose significance is only beginning to be appreciated.

Needless to say, he succeeds.

The other essays in this collection detail the depth and significance of his work in mathematics and mathematics education. Here I have sought to acknowledge how he has contributed both to our profession and far beyond it, to the understanding of the role of mathematics in today's world.

On a personal note, I found Andy the source of extraordinarily useful nonmathematical information. I have capitalized personally on his knowledge of interesting books, speeches, and other activities nationwide, and the latest scoop on restaurants and auto mechanics in the Cambridge area. It was fun, rewarding, and challenging to work with him. I will miss his presence in the mathematics community.

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Deborah Hughes Hallett (with T. Christine Stevens, Jeff Tecosky-Feldman, and Thomas Tucker)

Andy Gleason: Teacher

Andy Gleason was a teacher in the widest possible sense of the word: he taught us mathematics, he taught us how to think, and he taught us how to treat others.

From Andy I learned the importance of a teacher seeing mathematics through both a mathematician's and a student's eyes. Andy's mathematical breadth is legendary; his curiosity and empathy about the views of students, be they first-graders or graduate students, were equally remarkable. I vividly remember his concern in the early years of the AIDS epidemic that an example about the prevalence of HIV infections would upset students. Equally vivid in my memory is Andy's delight when his approach to the definite integral and his insight into student understanding came together to produce a much better way to teach integration. This was one of dozens of occasions when Andy made those around him rethink familiar topics from a fresh viewpoint. New ideas about teaching bubbled out of Andy's mind continuously; he was equally quick to recognize them in others. When one of his former Ph.D. students, Peter Taylor, sent Andy some calculus problems, Andy gleefully suggested that we try them. He regarded teaching mathematics—like doing mathematics—as both important and also genuinely fun.

In the Classroom and as an Advisor

At Harvard Andy regularly taught at every level. He never shied away from large, multisection courses with their associated administrative burden. He was always ready to step forward into the uncharted territory of a new course in real analysis,

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calculus, quantitative reasoning, or the history of mathematics.

Christine Stevens, one of Andy's doctoral students, writes:

> I first encountered Andy in the fall of 1971, when I enrolled in his course on The Structure of Locally Compact Topological Groups (Math 232). It goes without saying that the course was a model of lucid exposition, but I also remember Andy's enthusiastic and often witty responses to students' questions. Indeed, some of them are recorded in the margins of my notebook, alongside some rather deep mathematics. I also recall the cheerful energy with which he lectured one cold winter day when the heating system in Sever Hall had given out.
>
> I eventually wrote my dissertation on an issue that Andy had mentioned in that course. We mapped out an approach in which the first step involved proving something that he deemed "almost certainly true." When he commenced one of our subsequent appointments by asking me how things were going, I replied, "not too well." I explained that I had proved that the statement that was "almost certainly true" was equivalent to something that we had agreed was probably false. To be honest, I was kind of down in the dumps about the situation. Andy's response was immediate and encouraging. Without missing a beat, he replied, "Well, that's not a problem. Just change the hypotheses!"

Courses, Books, and Classroom Notes

In 1964 Andy instituted a new course at Harvard, Math 112, to provide math majors a transition from the three-year calculus sequence to Math 212, the graduate course in real analysis. It functioned as an introduction to the spirit of abstract mathematics: first-order logic, the development of the real numbers from Peano's axioms, countability and cardinality. This was the first of the "bridge" courses now ubiquitous for math majors, only twenty years before its time. Tom Tucker recalls:

> I was a student in that first Math 112, and it was my first experience with Andy. He chided me that the course might be too elementary for me, since most students from Math 55 went straight on to Math 212. But I had taken Math 55 as my first course at Harvard and was still in shock. I needed some encouragement, something I really could understand, and that is exactly what Andy gave me. He helped salvage my mathematical career.

Andy's work in Math 112 led to his only solo text in mathematics, *Fundamentals of Abstract Analysis*.[1] In his review of the book, Dieudonné captures the essence of Andy's pedagogy:[2]

> Every working mathematician of course knows the difference between a lifeless chain of formalized propositions and the "feeling" one has (or tries to get) of a mathematical theory, and will probably agree that helping the student to reach that "inside" view is the ultimate goal of mathematical education; but he will usually give up any attempt at successfully doing this except through oral teaching. The originality of the author is that he has tried to attain that goal in a textbook, and in the reviewer's opinion, he has succeeded remarkably well in this all but impossible task.

Over the course of his teaching career, Andy wrote hundreds of pages of lecture notes for his students, reworking them afresh each year. Some were handwritten on spirit duplicator sheets; some were typeset using macros he developed under an early version of Unix. More than lecture notes, these were complete with hand-drawn figures and exercises. His efforts in course development in the early 1970s included two complete unpublished texts. The first was for a new full-year integrated linear algebra/multivariable calculus course (Math 21) , the second for the history-based general education course Natural Sciences 1a: Introduction to Calculus.

Andy combined his interest in education, mathematics, and history in his design for Natural Sciences 1a. Nothing like a standard treatment of the material, this course took a historical approach to the development of the basic ideas of calculus, beginning with an explication of Archimedes' *The Sand Reckoner* and culminating with a derivation of Kepler's laws of planetary motion from Newton's physical laws.

Natural Sciences 1a was intended for the nonspecialist student with an interest in the history of ideas. Andy wanted the students to grapple with issues like irrationality and continuity. Many of his assignments asked students for nontechnical essays in which they explored the mathematics through personal contemplation. Students signing up for this course seeking an easy way to satisfy

[1] *Gleason, A. M.,* Fundamentals of Abstract Analysis, *published first by Addison Wesley, then by A K Peters (1991).*

[2] *Math Reviews: MR0202509 (34 #2378).*

Andy's Students (Thesis titles and year of degree)

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Functions resembling quotients of measures (1965).

Bredon, Glen Eugene
Some theorems on transformation groups (1958).

Brown, Julia May Nowlin
Homologies and elations of finite projective planes (1970).

Cohen, Daniel Isaac Aryeh
Small rings in critical maps (1975).

Cohn, Donald L
Topics in liftings and stochastic processes (1975).

Getchell, Charles Lawrence
Construction of rings in modular-lattices (1973).

Grabiner, Sandy
Radical Banach algebras and formal power series (1967).

Hales, Raleigh Stanton, Jr.
Numerical invariants and gamma products of graphs (1970).

Kennison, John Frederick
Natural functors in topology and generalizations (1963).

Krause, Ralph Mack
Minimal metric spaces (1959).

Kronstadt, Eric Paul
Interpolating sequences in polydisks (1973).

MacWilliams, Florence Jessie
Combinatorial problems of elementary abelian groups (1962).

Marcus, Daniel Alan
Direct decompositions of commutative monoids (1972).

Monash, Curt Alfred
Stochastic games: the minmax theorem (1979).

Oberg, Robert Joseph
Functional differential equations with general perturbation of argument (1969).

Palais, Richard Sheldon
A global formulation of the Lie theory of transformation groups (1956).

Phelps, Mason Miller
The closed subalgebras of a commutative algebra over the real numbers (1958).

Puckette, Miller Smith
Shannon entropy and the central limit theorem (1986).

Ragozin, David Lawrence
Approximation theory on compact manifolds and Lie groups, with applications to harmonic analysis (1967).

Rochberg, Richard Howard
Properties of isometries and almost isometries of some function algebras (1970).

Sidney, Stuart Jay
Powers of maximal ideals in function algebras (1966).

Spencer, Joel Harold
Probabilistic methods in combinatorial theory (1970).

Stevens, Terrie Christine
Weakened topologies for Lie groups (1979).

Stromquist, Walter Rees
Some aspects of the four-color problem (1975).

Taylor, Peter Drummond
The structure space of a Choquet simplex (1969).

Turyn, Richard Joseph
Character sums and difference sets (1964).

Wang, Helen Pi
Function-algebra extensions and analytic structures (1973).

Yale, Paul Blodgett
A characterization of congruence groups in geometries of the Euclidean type (1959).

a requirement got a lot more than they bargained for.

Educational Philosophy

Andy was always interested in how people learn. He really wanted to know what goes on in students' brains when they think about mathematics: the semantics, the grammar, the denotations and connotations, the cognition. His concern extended from teaching analysis to Harvard undergraduates to teaching arithmetic to grade school students. It was all important to him.

His educational philosophy combined the pragmatic and the radical. He could be a stickler about precision, insisting always on "the function f", rather than "the function $f(x)$", but the reasons were always cognitive—students often confuse the function with its formula. On the other hand, he did not insist on formality. He had no problem describing the continuity of the function f at $x = a$ as "you can make $f(x)$ as close as you want to $f(a)$ by making x close enough to a." The physicist Richard Feynman once criticized mathematicians for "preferring precision to clarity." Andy always preferred clarity.

Andy's inquiries about learning mathematics sometimes led to radical positions. In his article[3] "Delay the teaching of arithmetic" he suggested that the usual algorithms of arithmetic not be taught until grade 6. He cited work[4] of Benezet on just such an experiment in the Manchester, NH, schools in the 1930s. The students not taught the algorithms learned them perfectly well in seventh grade, but their problem-solving ability, their willingness to "take responsibility for their answers," was dramatically better than the control group's. In his paper Andy recalls his own childhood math classes requiring four calculations for each day: a sum of seven 6-digit numbers, a subtraction of two 7-digit numbers, a product of a 6-digit number by a 3-digit number, and a long division of a 6-digit number by a 3-digit number; answers were graded right or wrong and 75% was passing. Andy estimates the number of individual operations for each problem and concludes that a student getting each operation correct with 99.5% probability would still average only 73, failing. As Andy remarked once on long division, getting even one problem correct out of ten indicates sufficient understanding of the algorithm.

Andy was acutely aware of the importance of students' attitudes toward mathematics, as evidenced by his remarks[5] in the 1980s to the National Academy of Sciences:

[3] `http://www.inference.phy.cam.ac.uk/sanjoy/benezet/gleason.pdf`.

[4] *Benezet Centre*, `http://www.inference.phy.cam.ac.uk/sanjoy/benezet/`.

[5] *From unpublished notes in Gleason's files.*

> Right now there is debate apparently existing as to how mathematics should react to the existence of calculators and computers in the public schools. What should be the effect on the curriculum?…and so on. Now the unfortunate point of that is that there is even a very serious debate as to whether there should be an impact on the curriculum. That is what I regard as absolutely ridiculous. Let me just point out that… in this country there are probably 100,000 fifth grade children right now learning to do long division problems. In that 100,000 you will find very few who are not thoroughly aware that for a very small sum of money (like $10) they can buy a calculator which can do the problems better than they can ever hope to do them. It's not just a question of doing them just a little better. They do them faster, better, more accurately than any human being can ever expect to do them and this is not lost on those fifth graders. It is an insult to their intelligence to tell them that they should be spending their time doing this. We are demonstrating that we do not respect them when we ask them to do this. We can only expect that they will not respect us when we do that.

About ten years ago Andy gave a talk at the Joint Mathematics Meetings in which he described how he had, some years previously, spent a summer teaching arithmetic to young children. His goal had been to find out how much they could figure out for themselves, given appropriate activities and the right guidance. At the end of his talk, someone asked Andy whether he had ever worried that teaching math to little kids wasn't how faculty at research institutions should be spending their time. Christine Stevens remembers Andy's quick and decisive response: "No, I didn't think about that at all. I had a ball!"

Education at a National Level

Andy led in promoting the involvement of research mathematicians in issues of teaching and learning.

He was deeply involved with the reform of the U.S. mathematics K–12 curriculum in the post-Sputnik era. He chaired the first advisory committee for the School Mathematics Study Group (SMSG), the group responsible for "the new math". He was a codirector with Ted Martin of the 1963 Cambridge Conference on School Mathematics. The report of that conference proposed an ambitious curriculum for college-bound students that culminated in a full-blown course in multivariable calculus in n-dimensions including the Inverse Function Theorem, differential forms, and Stokes' Theorem. Although the proposed curriculum would appear to be far too sophisticated by today's standards, the space race loomed large in the public mind and the need for highly trained scientists, mathematicians, and engineers became a national crusade. The SMSG program begun in 1959 was aimed at all students and was roundly criticized at the time as being inappropriate for average students and teachers. The Cambridge Conference appeared to be an attempt to woo research mathematicians to school reform through consideration of an "honors" track for the most able students. In that context, some critics complained the proposed curriculum was "timid"!

In 1985–89, Andy helped establish the Mathematical Sciences Education Board to coordinate educational activities for all the mathematical professional organizations; his citation for the MAA Distinguished Service Award recognized the importance of this contribution. From the 1980s until his death, Andy was influential in calculus reform and the subsequent rethinking of other introductory college courses.

That a mathematician of Andy's stature would take the time to think deeply about the school curriculum made such work legitimate.

Quantitative Reasoning (QR)

In the late 1970s Harvard College undertook a sweeping reorganization of the General Education requirements. The new core curriculum replaced existing departmental offerings with specially designed courses in a broad variety of areas of discourse. It was hard to see how mathematics fit in the new core. Given his extensive contact with curricular projects and his interest in education, Andy was a natural choice to lead an investigation into what a mathematics requirement might be and how it was to be implemented.

Rather than drawing up a checklist of what kinds of mathematics a Harvard graduate should know, Andy instead started with the idea that at the very least, the core requirement in mathematics should prepare students for the kinds of mathematical, statistical, and quantitative ideas they'd be confronting in their other core courses. Working with faculty who were developing those courses, Andy quickly realized that the skills students required had more to do with the presentation, analysis, and interpretation of data than with any particular body of mathematics, such as calculus. Thus, the core Quantitative Reasoning Requirement, or QRR, was born.

So, long before quantitative literacy became a well-defined area of study with its own curriculum and textbooks, Andy and Professor Fred Mosteller of the Harvard statistics department developed a small set of objectives for the QRR. These included understanding discrete data and simple statistics, distributions and histograms, and simple hypothesis testing. There was no reliance on high school algebra or other mathematics that students had seen before, since high schools had not yet begun offering an Advanced Placement Statistics course. So the requirement leveled the playing field—both math majors and history majors would have to learn something new to satisfy the QRR.

Andy also thought about implementing the QRR—how to help 1,600 first-year students meet the requirement without mounting an effort as large, and costly, as freshman writing. He decided that the ideas students were being asked to master, while novel, were not very hard and that most students could learn them on their own, given the appropriate materials. For the small number of students who couldn't learn from self-study materials, there would be a semester-long course.

So, in the summer of 1979, Andy gathered a team of about a dozen undergraduates ("the Core corps") who wrote self-study materials and gathered newspaper articles for practice problems. These were published as manuals and supplied to all entering students. Andy invited the student authors to his home in Maine that summer, which was typical of his friendliness and openness. Jeff Tecosky-Feldman, then the student leader of the Core corps, helped organize the trip to Maine. He recalls:

> The other students were buzzing with the rumor that Andy had been involved in cracking the Japanese code in World War II, but were too timid to ask him about it themselves, so they put me up to it. When I asked Andy, his response was typical: "It would not be entirely incorrect to say so", and he left it at that.

Calculus

In January 1986 Andy participated in the Tulane Conference that proposed the "Lean and Lively" calculus curriculum. October 1987 saw Andy on the program at the "Calculus for a New Century" conference; in January 1988 the idea for the Calculus Consortium based at Harvard took shape.

Andy's role in the Calculus Consortium was without fanfare and without equal. He started by gently turning down my request that he be the PI on our first NSF proposal and, after a thirty-second silence that seemed to me interminable, suggested we be co-PIs. He then helped build one of the country's first multi-institution collaborative groups. Now commonplace, such arrangements were at the time viewed with some skepticism at the NSF, whose program officers wondered whether such a large group could get anything done.

Throughout his time with the consortium, Andy's words, in a voice that was never raised, were the keel that kept us on course. His view of the importance (or lack of it) of various topics in the calculus curriculum shaped many of our discussions, and his vision inspired many of our innovations. Andy hated to write—he saw the limitations of any exposition—so we quickly learned that the best way to get his ideas on paper was for one of us to write a first draft. This drew him in immediately as he reshaped, rephrased, and in essence rewrote the piece. That Andy could do this for twenty years without denting an ego is a testament to his skill as a teacher. Who else could say, as I responded to a flood of red ink by asking whether I'd made a mistake, "Oh no, much worse than that" and have it come across as a warm invitation to discussion? We all remember Andy remarking, "That's an interesting question!" and knowing that we were about to see in an utterly new light something we'd always thought we understood.

The 1988 NSF proposal led to a planning grant in 1989. The founding members of the consortium met for the first time in Andy's office. Faculty from very different schools discovered to their surprise that students' difficulties were similar in the Ivy League and in community colleges. A multiyear proposal followed, with features now commonplace in federally funded proposals but then unusual. Andy was skeptical about some of these and suggested we remove the section on dissemination—after all, he pointed out, we didn't know whether what we'd write would be any good. When the proposal went to the NSF for feedback before the final submission, I got a call from the program director, Louise Raphael, asking about the missing section on dissemination. When I explained, Louise, who knew how things worked in DC, responded by saying I should tell Andy "not to be a mathematician." We then understood our mandate from the NSF to disseminate the discussion of the teaching of calculus to as many departments and faculty as possible. Over the next decade we gave more than one hundred workshops for college faculty and high school teachers, in which Andy played a full part—presenting, answering questions, and listening to concerns.

The debate about calculus benefitted enormously from Andy's participation. He became a father figure for calculus reform in general and the NSF-supported project at Harvard in particular. His goal was never reform per se; it was to discuss openly and seriously all aspects of mathematics learning and teaching. In 1997 Hyman Bass wrote[6] "It is the creation of this substantial community of professional mathematician-educators that is the most significant (and perhaps least anticipated) product of the calculus reform movement. This is an achievement of which our community can be justly proud and which deserves to be nurtured and enhanced."

[6] *Bass, H., Mathematicians as Educators,* Notices of the AMS, *January 1997.*

Andy—reasoned, calm, soft-spoken, a gentleman in every sense of the word—was dedicated to this community throughout his life.

Outside the Classroom

Andy had an extraordinary range of knowledge. He talked about baseball scores, horsemanship,[7] Chinese food in San Francisco, and the architecture of New York with the same insight he talked about mathematics. He was fascinated by every detail of the world around him. He persuaded a cameraman to show him the inside of the video camera when we were supposed to be videotaping. When we were "bumped" to first-class on a plane, Andy was much less interested in the preflight drink service than in listening to the pilots' radio chatter so that he could calculate the amount of fuel being loaded onto the plane. To the end of his life, Andy investigated the world with a newcomer's unjaded curiosity.

Andy inspired rather than taught many of us. His transparent honesty and humility were so striking that they were impossible to ignore. For example, before publishing my first textbook, I asked him how authors got started, since publishers wanted established names. Andy replied matter-of-factly, "Most people never do," returning to me the responsibility to achieve this.

Andy's moral influence was enormous. Always above the fray and without a mean bone in his body, Andy commanded respect without raising his voice. His moral standards were high—very high—making those around him aspire to his tolerance, understanding, and civility. Andy's presence alone forged cooperation.

In his commentary on the first book of Euclid's *Elements*, Proclus described Plato as having "… aroused a sense of wonder for mathematics amongst students." These same words characterize Andy. Through the courses he taught and the lectures that he gave for teachers, Andy inspired thousands of students with his sense of the wonder and excitement of mathematics. Through him, many learned to see the world through a mathematical lens.

Gleason on a horse farm, with the inevitable clipboard under his arm.

Leslie Dunton-Downer

Andrew Gleason—a Remembrance. Remarks Delivered at the Memorial Service, Memorial Church, Harvard University, November 14, 2008

I was a Junior Fellow in Comparative Literature at the Harvard Society of Fellows during the final years that Professor Andrew Gleason served as its chair, from 1993 to 1996. The society gathers researchers from all fields: from astrophysics, classics, economics, and others, clear through to zoology. Fellows at the society spend three years free from any requirement or examination, pursuing, and I now quote from the vows that all new Fellows take: "a fragment of the truth, which from the separate approaches every true scholar is striving to descry." On Monday nights in academic term-time, Junior Fellows converse with a dozen or so Senior Fellows, professors who not only elect Junior Fellows but also engage them in mind-opening conversations over suppers in a dining hall furnished to nourish these exchanges. Professor Gleason, who had himself been a Junior Fellow, officiated when I took my vows at the society, and as chair he presided over Monday night dinners during my three years in his fellowship. This is how I knew him, and my fondness for him grew exponentially with each passing season at the society.

The first time I beheld Professor Gleason, here was the situation: It was a Monday morning at the so-called Yellow House, at 78 Mount Auburn Street here in Cambridge, the society's administrative base camp. I was surely extremely nervous, because I was to be interviewed that very afternoon by the full assemblage of Senior Fellows, a terrifying prospect—each Senior Fellow was an academic star in his respective field, and many were reputed to be intimidating. A Junior Fellow had been assigned the task of showing me about the building. At one point, noisily chattering, we made our way down a corridor, where an office door was opened widely. We paused there to look through the doorway. Inside the room, there was a man leaning back on his chair before an empty desk. His head was

[7] *Andy's daughters are accomplished equestrians.*

Leslie Dunton-Downer is a writer. She thanks Jean Berko Gleason, Diana Morse, Martha Eddison, and Melissa Franklin for their help in preparing this remembrance.

tilted skyward, and his eyes focused on a point that appeared to be on the ceiling, but may have been further off. We stood there for an awkward few beats. I believe that we were together unsure if the man was about to greet us or if we ought to take the initiative to greet him. But he remained still, absorbed in his own world. The Junior Fellow and I shrugged at each other and continued on our way until we reached a common room out of earshot. I turned to her, made a quizzical face, and asked, "What was that man doing?" "Math," she said.

I had never before seen a real mathematician in the act of doing math. I was mystified by the absence of any tools in his office. Wouldn't he require a calculator or a slide rule or something to inspire himself to be mathematical—maybe a chessboard or a Rubik's Cube? At the very least, what about a pencil and paper? She shook her head: "That mathematician is Andrew Gleason. He works in his head."

Professor Gleason was, I think by disposition, a decipherer. He had deciphered codes and mathematical problems and as a hobby took delight in deciphering the movements of celestial bodies. On Monday nights Professor Gleason sat at the head of a horseshoe-shaped table in the society's dining room. Like all chairs at the society, he would guide his flocks of Junior Fellows in his own way, leaving his own signature on the institution. He was not a garrulous chair—"Oscar Wildean" is not the first adjectival phrase that comes leaping to mind to describe his conversational style—but he could become animated suddenly, and with deep sincerity, when conversation turned to subjects close to his heart: astronomy, classical music, and, among so many others, of course, math.

Much of the time he would listen or observe with his extraordinary Gleasonian powers of concentration. Many of us wondered what he was thinking on those occasions when he was so sharply present yet enigmatically silent. Perhaps he was deciphering us. He never made a single judgmental remark; his leadership was delicate, trusting, and surefooted. He put out a strong aura of principled tranquility, as if his Junior Fellows' paths, and indeed the paths of all people and objects and ideas in his midst, no matter how rough, were part of a larger pattern that would eventually become clearer to him. I found a poem that captures this Professor Gleason, the one whom I and others came to know in a quiet way and to love with great respect, a man whose presence we now begin to sense expanding through all that he discerned. He seems to be present in these lines by Robinson Jeffers:

I admired the beauty
While I was human, now I am part of the beauty.
I wander in the air,
Being mostly gas and water, and flow in the ocean;
Touch you and Asia
At the same moment; have a hand in the sunrises
And the glow of this grass.

The last time that I saw Andrew Gleason was at the annual dinner held by the society in May of this year. The gathering took place at the Fogg Museum, a few meters to the east of here. On that occasion, many Junior Fellows from Professor Gleason's time as chair gathered to catch up with one another and with him. He had led us through our fellowship years with a light touch, a seemingly invisible touch. He always encouraged each fellow to wrestle with those daunting "fragments of truth" on his or her own terms, come what may. It had only been with hindsight, after leaving the society, that many of us came to appreciate the subtle qualities of his leadership, how he shaped our lives, both inwardly and in action, even as he had often seemed chiefly to be deciphering the world, working things out in his head.

Stephen Hawking published this observation twenty years ago, by chance on the eve of Professor Gleason's becoming chair at the society: "We do not know what is happening at the moment farther away in the universe: the light that we see from distant galaxies left them millions of years ago, and in the case of the most distant object that we have seen, the light left some eight thousand million years ago. Thus, when we look at the universe, we are seeing it as it was in the past."

Perhaps we are only now beginning to see Andrew Gleason. Those of us who had the privilege to know him will cherish the light that he casts out to us, even in his absence—perhaps all the more forcefully because of his absence or, rather, because he has now become a beautiful part of the beauty that he once admired.

References

[1] Robinson Jeffers, "Inscription for a Gravestone", *The Collected Poetry of Robinson Jeffers*, edited by Tim Hunt, Stanford University Press, 2001, p. 372.

[2] Stephen Hawking, *A Brief History of Time*, Bantam Dell, 1988.

Jean Berko Gleason

A Life Well Lived

I would like to begin these remarks by thanking everyone on behalf of our family—myself and our daughters, Katherine, Pam, and Cynthia—for the outpouring of hundreds of messages that we have received about Andy and your friendship with him. A number of themes stood out in these messages: you often talked of his brilliance, his kindness, his sense of humor, his generosity, fairness, and welcoming spirit. Newcomers to the Society of Fellows or to the mathematics department at Harvard were not only made to feel at home, but they had

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Andy and Jean in 1958.

rigorous intellectual discussions with Andy in which they found that their views and opinions were both challenged and respected. An hour's talk left you with weeks of things to think about.

Others will speak about Andrew Gleason's lasting contributions to science and to education. I would like to tell you a little bit about him as a person. I met Andy Gleason by accident over fifty years ago. I was a graduate student at Radcliffe College and he was a young Harvard professor, luckily not in my field, which is psycholinguistics. But I had friends in the Harvard mathematics department who were giving a party. When they told me that the famous Tom Lehrer was going to be at the party and that he might also play the piano and sing, I decided to go. Tom did sing, but I never got across the crowded room to meet him. Instead I met this slim young fellow who invited me out to dinner. So that was the beginning of our relationship, which soon led to a marriage that lasted forty-nine years. Since Andy was not the type of person to talk about himself very much, I'd like to tell you a few things about his origins that you may not know.

You may think of Andy as quintessentially New England, white Anglo-Saxon Protestant—the blue eyes, the pale skin, the disinterest in worldly goods. It is mostly true: his father was a member of the Mayflower Society. Andy was a direct descendent of four people who came on the *Mayflower*, including Mary Chilton, who by tradition was the first woman to come ashore at Plymouth Rock. But perhaps you did not know that Andy was also just a little bit Italian. His middle name, Mattei, came from his grandfather, Andrew Mattei, an Italian-Swiss winemaker who came to Fresno, California, and established vineyards, where he prospered and produced prizewinning wine. Andrew Mattei's daughter, Theodolinda Mattei, went to Mills College in California and on graduation did what all wealthy, well-bred young women of the day did: she embarked on the grand tour, a trip around the world via steamship, with, of course, a chaperone. On board ship Theodolinda met a dashing young botanist on his way to collect exotic plant specimens. This quickly became a classic shipboard romance and led to the marriage in 1915 of Theodolinda Mattei and Henry Allan Gleason, who was to become not only Andrew's father but a famous botanist, chief curator of the New York Botanical Garden, and early taxonomist and ecologist whose work is still cited—he wrote the classic works on the plants of North America. Andy had an older brother, Henry Allan Gleason Jr.; Andy's older sister, Anne, is one of the smartest people I have ever met.

We were married on January 26, 1959. This was actually the day of the final examination in the course Andy was teaching. So he gave out the blue books at 2:15 and came here to the Appleton Chapel of The Memorial Church to get married at 3 p.m. We took a wedding trip to New Orleans, and he did not bring the exams. Over the next forty-nine years we raised our three talented daughters, bought a house in Cambridge and a wonderful house on a lake in Maine, and traveled all over the world, sometimes to see some of Andy's favorite things, which included total eclipses of the sun, most recently in 2006 sailing off the coast of Turkey. We were both teaching, of course, and maintaining our own careers, but we managed to have a lot of fun too. During those forty-nine years Andy maintained the calm spirit he was known for and really never raised his voice in anger. He had a great sense of humor and was extraordinarily generous, giving away surprisingly large sums of money, often to his favorite schools: Harvard and his alma mater, Yale.

Because mathematics was truly his calling, Andy never stopped doing mathematics. He carried a clipboard with him even around the house and filled sheets of paper with ideas and mysterious (to me) numbers. When he was in the hospital during his last weeks, visitors found him thinking deeply about new problems. He was an eminent mathematician. He was also a good man, and he led a good life. We are sorry it did not last a little longer.

Note: Unless otherwise indicated, all photographs and other images in this article are courtesy of Jean Berko Gleason.

We Do Not Choose Mathematics as Our Profession, It Chooses Us: Interview with Yuri Manin

Mikhail Gelfand

This is a translation from the Russian of an interview of Yuri Manin, conducted by Mikhail Gelfand. The interview appeared on September 30, 2008, in the newspaper *Troitsky Variant* (see `http://www.scientific.ru/trv/2008/`), which has granted permission for the translation to be published here.

Yuri Manin holds the Trustee Chair and is professor of mathematics at Northwestern University. He is professor emeritus at the Max-Planck-Institut für Mathematik in Bonn, Germany, and principal researcher at the Steklov Mathematical Institute in Moscow. Manin edited this translation for publication in the *Notices*.

The translator, Mark Saul, is an associate editor of the *Notices*, a senior scholar for the John Templeton Foundation, and retired teacher from the Bronxville Schools.

Gelfand: *Has the style of mathematical research changed in the past fifty years?*

Manin: Individual or societal?

Gelfand: *Either.*

Manin: I think that people engaged in research in mathematics today are doing so the same way it was done 200 years ago. This is partly because we don't choose mathematics as our profession, but rather it chooses us. And it chooses a certain type of person, of which there are no more than several thousand in each generation, worldwide. And they all carry the stamp of those sorts of people mathematics has chosen.

The social style has changed, in the sense that social institutions have changed within which one studies mathematics. This evolution was not unusual. There was the period of Newton, later of Lagrange and so forth, when academies and universities were being formed, when individual mathematical amateurs, who once studied alchemy or astrology in the same way, by exchanging letters, started forming social structures. (I omit the period of antiquity, whose natural development was interrupted in Europe during the first thousand years of Christianity.) Then came the scientific journals. This all was put in place 300 years ago. In the last half of the twentieth century, computers have contributed to this development.

Gelfand: *But between Newton and Lagrange, and the second half of the twentieth century, nothing significant changed?*

Manin: No. This social system was consolidated, academies plus universities plus journals. These developed bit by bit and assumed the form in which we now know them. Take for example the first volume of *Crelle's Journal* (*Journal of Pure and Applied Mathematics*), which came out in 1826—well, it doesn't differ at all from a contemporary journal. Abel's article appeared there, on the unsolvability in radicals of the general equation of degree higher than four. A wonderful article! As a member of the editorial board of *Crelle*, I would accept it even today with great pleasure.

In the last few decades, the interface between society and professional mathematicians has changed. This interface now embraces computer folks and people around them, including various PR people whom we need because of new methods

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of financing our work, related to proposals, grants, and things like that. In mathematics this looks odd—you must first write just what it is you are doing that is so great, then later give an accounting of what you've accomplished.

Gelfand: *A student of Kantorovich*[1] *used to tell how in a midyear report Kantorovich wrote, with a straight face, "The theorem is 50 percent proven."*

Manin: In the Mathematics Institute in Moscow there was a clear-cut system: I would write that I was planning to prove the theorems that in fact were proven in the past year. Then I had a whole year to continue my work.

But these are all trifles. So long as mathematics chooses us, and so long as there are people such as Grigory Perelman and Alexander Grothendieck, we will remember our ideals.

Gelfand: *Yes, grants in mathematics are something very odd. On the other hand, if we don't have grants, what other mechanisms might there be?*

Manin: Well, what do we need? Salaries for people and a budget for the institution. I was lucky, I worked for a salary and on a budget, not just in Moscow, but in Bonn for fifteen years. I don't see anything bad in that.

But the fact that the organizations that provide these salaries and budgets have decided to adopt the marketplace language is another thing entirely. The marketplace debases three areas: health care, education, and culture. Roger Bacon keenly spoke about the "idols of the marketplace" fallacy. Mathematics is a part of culture, in the broad sense of that term, and not part of industry or services or something of that sort.

Gelfand: *But won't market-free methods lead to stagnation, so that there will be no progress?*

Manin: Up to now there has been no stagnation.

Gelfand: *What you talk about is possible for mathematics, because mathematics is an inexpensive science.*

Manin: Exactly. I always say, "Why should we put ourselves on the market? We (a) don't cost anything, and (b) don't use up natural resources and don't spoil the environment." Give us salaries, and leave us in peace. I don't wish to generalize at all: I speak only of mathematics.

Gelfand: *You mentioned computers. What has changed in mathematics since their appearance?*

Manin: What has changed in pure mathematics? The unique possibility of doing large-scale physical experiments in mental reality arose. We can try the most improbable things. More exactly, not the most improbable things, but things that Euler could do even without a computer. Gauss could also do them. But now, what Euler and Gauss could do, any mathematician can do, sitting at his desk. So if he doesn't have the imagination to distinguish some features of this Platonic reality, he can experiment. If some bright idea occurs to him that something is equal to something else, he can sit and sit and compute a value, a second value, a third, a millionth. Not only that. People have now emerged who have mathematical minds, but are computer oriented. More precisely, these sorts of people were around earlier, but, without computers, somehow something was missing. In a sense, Euler was like that, to the extent that he was just a mathematician—he was much more than just a mathematician—but Euler the mathematician would have taken to computers passionately. And also Ramanujan, a person who didn't even really know mathematics. Or, for instance, my colleague here at the institute, Don Zagier. He has a natural and great mathematical mind, which is at the same time ideally suited to work with computers. Computers help him study this Platonic reality, and, I might add, quite effectively.

Photo courtesy of Xenia Semenova.

Yuri Manin, Cinque Terre, Italy, 1994.

I myself am not this sort of person at all, but I understand what this is about and would be glad to have collaborators who might help me in this. So this is what computers have done for pure mathematics.

Gelfand: *What about the relationship between mathematics and theoretical physics? How is that structured?*

Manin: This relationship has changed during my own lifetime.

It is important to note that in the time of Newton, Euler, Lagrange, Gauss, the relationship was so close that the same people did research in both mathematics and theoretical physics. They might have considered themselves more as mathematicians or more as physicists, but they were exactly the same people. This lasted until about the end of the nineteenth century. The twentieth century revealed significant differences. The story of the development of the general theory of relativity is a striking example. Not only did Einstein not know the mathematics he needed, but he didn't even know that such mathematics existed when he started understanding the general theory of relativity in 1907 in his own brilliantly intuitive language. After several years dedicated to the study of quanta, he returned to gravitation and in 1912 wrote to his friend Marcel Grossmann: "You've got to help me, or I will go out of my mind!" Their first article was called "A sketch of a theory of general

[1] *L. V. Kantorovich (1912–1986), Soviet mathematician and economist, Nobel Prize in Economics 1975.*

relativity and a theory of gravity: I. Physics Part by Albert Einstein; II. Mathematics Part by Marcel Grossmann."

This attempt was half successful. They found the right language but had not yet found the right equations. In 1915 the right equations were found by Einstein and David Hilbert. Hilbert derived them by finding the right Lagrangian density—the importance of this problem, it seems, for some time eluded Einstein as well. It was a great collaboration of two great minds that unfortunately prompted historians to start silly fights about priorities. The creators themselves have been grateful and generous in recognizing each other's insights.

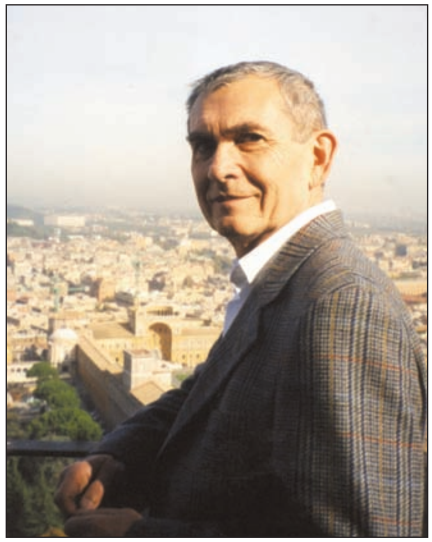

Photo courtesy of Xenia Semenova.

Manin, in front of the panorama of Rome from the gallery of San Pietro, 1998.

For me, this story marks the period in which mathematics and physics parted ways. This divergence continued until about the 1950s. The physicists dreamed up quantum mechanics, in which they found a need for Hilbert space, Schrödinger's equations, the quantum of action, the uncertainty principle, the delta function. This was a completely new type of physics and a completely new type of philosophy. Whatever pieces of mathematics were necessary—they developed them themselves.

Meanwhile, the mathematicians did analysis, geometry, started creating topology and functional analysis. The important thing at the beginning of the century was the pressure by philosophers and logicians, trying to clarify and "purify" the insights of Cantor, Zermelo, Whitehead, et al., about sets and infinity. Somewhat paradoxically, this line of thought generated both what came to be known as the "crisis in foundations" and, somewhat later, computer science. The paradox of a finite language that can give us information about infinite things—is this possible? Formal languages, models and truth, consistency, (in)completeness—very important things were developed, but quite disjoint from physicists' preoccupations of that time.

And Alan Turing appeared, to tell us: "The model of a mathematical deduction is a machine, not a text." A machine! Brilliant. In ten years, we had von Neumann machines and the principle of separation of programs (software) and hardware. Twenty years more—and everything was ready.

During the first third of the century, except for particular minds—von Neumann was undoubtedly both a physicist and a mathematician, and I know of no other person with a mind on that scale in the twentieth century—mathematics and physics developed in parallel and after a while stopped taking notice of each other. In the 1940s Feynman wrote about his wonderful path integral, a new means of quantifying things, and worked on it in a startlingly mathematical way—imagine something like the Eiffel Tower, hanging in the air with no foundation, from a mathematical point of view. So it exists and works just right, but standing on nothing we know of. This situation continues to this very day. Then, in the 1950s the quantum field theory of nuclear forces started to appear, and it turned out that mathematically the respective classical fields are connection forms. The classical equation of stationary action for them was known in differential geometry. The equation of Yang-Mills entered the scene, mathematicians began to look askance at the physicists, and the physicists at the mathematicians. It turned out, paradoxically—and for me pleasantly—that we began to learn more from the physicists than they learned from us. It turned out that with the help of quantum field theory and the apparatus of the Feynman integral they developed cognitive tools that allowed them to discover one mathematical fact after another. These weren't proofs, just discoveries. Later the mathematicians sat themselves down, scratched their heads, and reshaped some of these discoveries in the form of theorems and began trying to prove them in our honest manner. This shows that what the physicists do is indeed mathematically meaningful. And the physicists say, "We always knew that, but of course, thanks for your attention." But in general, as a result, we learned from the physicists what questions to ask, and what answers we might presuppose—as a rule, they turn out to be correct. The renowned physicist and mathematician Freeman Dyson in his Gibbs lectures "Missed opportunities" (1972) has beautifully described many cases when "mathematicians and physicists lost chances of making discoveries by neglecting to talk to each other." Especially striking for me was his revelation that he himself "missed the opportunity of discovering a deeper connection between modular forms and Lie algebras, just because the number theorist Dyson and the physicist Dyson were not speaking to each other."

Then Witten appeared, with his unique gift for the production of glorious mathematics from this very Eiffel Tower that hangs in the air. I looked in Wikipedia: before getting his Ph.D. in physics in 1976, when he was twenty-five, he was planning to engage in political journalism, then economics… until he finally heard the call of mathematics and physics.

He is the master of such astonishing mental equipment, which produces mathematics of unlikely strength and force, but arising from physical insights. And the starting point of his insights is not the physical world, as it is described by experimental physics, but the mental machinery developed for the explanation of this world by Feynman, Dyson, Schwinger, Tomonaga, and many other physicists—machinery that is entirely mathematical but that has very weak mathematical foundation. It is such an earthshaking heuristic principle, not at all some triviality, but, I must say again, an enormous structure without a foundation, at least of the kind we have gotten accustomed to.

Gelfand: *So has everyone grown used to the fact that there is no foundation, and lived with it, or are they trying to build a foundation?*

Manin: None of the attempts that have been made have succeeded in sufficient generality. Mathematicians have developed a few approximations to what we might call the Feynman integral; for example, Wiener integration, which was invented as early as the 1920s. It was used to study Brownian motion, where there is a rigorous mathematical theory. There are also some interesting variants, but the theory is much more narrow than is required to cover all varied applications of the Feynman integral. You see, as a mathematical theory it's small—in strength or power it is not comparable to the machinery that now produces really great mathematics.

I don't know what will happen with the machinery when Witten stops working on it, but I very much hope that it will soon permeate the mathematical world. A small industry has arisen whose goal is to prove the theorems that Witten guessed, in particular, in the so-called Topological Quantum Field Theory (TQFT), and its output is ample and well known.

Actually, homotopical topology and TQFT have grown so close that I have started thinking that they are turning into the language of new foundations.

Such things have already occurred. Cantor's theory of the infinite had no basis in the older mathematics. You can argue about this as you like, but this was a new mathematics, a new way to think about mathematics, a new way to produce mathematics. In the final analysis, despite the arguments, the contradictions, Cantor's universe was accepted by Bourbaki without apology. They created "pragmatic foundations", adopted for many decades by all working mathematicians, as opposed to "normative foundations" that logicists or constructivists tried to impose upon us.

Gelfand: *It seems that mathematicians writing about Bourbaki in Russian have different points of view. There are rather harsh critics of all this set-theoretic foundational work, who criticize Bourbaki's isolation from the physicists and the wonderful possibilities they can open for us.*

Manin: There is nothing special in this. The fact that they curse at Bourbaki shows that they don't know how things are now done. What Bourbaki did was to take a historical step, just as what Cantor himself did. But this step, while it played an enormous role, is very simple—it was not creating the philosophical foundations of mathematics, but rather developing a universal common mathematical language, which could be used for discussion by probabilists, topologists, specialists in graph theory or in functional analysis or in algebraic geometry, and by logicians as well.

You start with a few common elementary words, "set, element, subset…", then you build up definitions of the basic structures that you study, "group, topological space, formal language… ". Their names form the second layer of your own terminology. There might come the third, fourth, or fifth layer, but basic construction rules are common, and getting together, people could talk to each other with complete understanding: "Formal language is a set of letters, plus a subset of well-formed words—terms, plus connectives and quantifiers, plus deduction rules… ." From this perspective, Gödel's incompleteness theorem, for example, loses any sort of mystery. The theorem acquires its mystery when you start examining it philosophically, but actually, it is simply a theorem stating that a certain structure does not have finitely many generators. Oh, my God! Such structures are a penny a pound, but just think, here is one more. The profundity appears when we add to this a particular self-referential semantics. Then it enters the philosophical foundation of mathematics.

So Bourbaki in fact did something completely different from what these guys think. (I omit here any discussion of Bourbaki's influence on mathematics education in France: as with all sociological questions, this may arouse a chorus of controversy in any audience.)

Gelfand: *What is the status of hypotheses in mathematics? For example, Fermat's Last Theorem—in recent years no one has been trying to find a counterexample: everyone understood that it was correct and that one must try to prove it. And there are many such well-known propositions, especially in number theory.*

Manin: Here I take a position that sets me apart from many good colleagues. I've heard many arguments against me on this subject. I must explain to you how I imagine mathematics. I am an emotional Platonist (not a rational one: there are no rational arguments in favor of Platonism). Somehow or other, for me mathematical research is a discovery, not an invention. I imagine for myself a great castle, or something like that, and you gradually start seeing its contours through the deep mist, and begin to investigate something. How you formulate what it is you've seen depends on your type of thinking and on the scale of what you have seen, and on the social circumstances around you, and so on.

What you have seen can be formulated as the presence or absence of something. Look at $x^2 + y^2 = z^2$. It is wonderful that we can write down all the integral solutions in one formula—in a certain sense this was known to Diophantus. When you've done this, it raises a question: Fine, but what about cubes? You search and search, and there are none. Hmm. How strange. And if we ask about fourth powers? Hmm. Again nothing. Well, can it be that there is never anything further? And so you discover a difference between the second power and the third, fourth, and so on. This history of Fermat's Last Theorem, well, it is that sort of history. But when you pose a problem, that this-and-this is equal to that-and-that, or that such-and-such never happens, you never know in advance if you have a good problem or a bad one—not until it is solved or almost solved.

Problems have qualities. In number theory, there are many problems that can be formulated in elementary terms, and we know that Fermat's Last Theorem was a wonderful problem. We know this because, throughout its history, from its statement to its solution, it turned out to be connected to a host of things that were not connected to each other a priori. And for its solution, it was necessary to investigate these fundamental things. The problem turned out to be a detail in an enormous edifice.

But we can take other problems, say those concerning perfect numbers or twin primes. Are there infinitely many perfect numbers, that is, numbers that are equal to the sum of their divisors? Or infinitely many pairs of primes whose difference is 2? To this day, no one has built any interesting theory around these problems, although their statements look no worse than that of Fermat's Last Theorem.

Gelfand: *Are these properties of the problems themselves, or is it just that no one is actively investigating them, for some social reason?*

Manin: As a Platonist, I *know* that this is a property of the problems themselves, but it is a property that one cannot recognize at the moment of formulating the problem. It reveals itself in the process of historical development.

Partly for this reason, I am not partial to problems. Solving a problem requires the skill of finding a detail, but you don't know what it is a detail of. As a Platonist, I am partial to complete programs. A program arises when a great mathematical mind sees something as a whole, or not as a whole, but as something more than a single detail. But it is seen at first only vaguely.

Gelfand: *That is, instead of a single distinct detail, you vaguely see a whole building.*

Manin: Yes. And so you begin to blow away the mists, to find appropriate telescopes, seek analogies with edifices that have been discovered before, create a language for the things that you see so vaguely, and so on. This is what I would call, tentatively, a program.

Cantor's theory of the infinite was such a program. It was a rare event: it was at once a program and a discovery, that there were orders of infinity. And, say, the continuum hypothesis—whether there is something between the countable infinity and the continuum—is a question that has turned out to be less important than many other questions, but very stimulating. If Cantor had asked only about this—it would have been bad. Its significance would have been discovered only in the future. But he did considerably more right away; he started a whole program of investigation.

Weil's hypothesis, about how many solutions there are to an equation modulo p, is such a program, which became well known during my lifetime. He immediately saw a striking analogy: in the areas where he was looking, there was a gap, but in other places there was an entire theory, (co)homology theory, implying the Lefschetz theorem on fixed points of maps. Half of Grothendieck's life, and of several people around him including Pierre Deligne, was devoted to filling this gap. They filled the gap, the analogy became precise, and modern algebraic geometry was born. And much more has happened as a result: set theory as *the* language of contemporary mathematics started to recede, and categories, with all subsequent superstructures, started to replace sets in their old function.

In logic, there was Hilbert's program, except that he formulated it too optimistically. He wanted to prove that everything true was provable. He saw the contours of the edifice inaccurately, but the program developed anyway. Gödel, Turing, Church, von Neumann, computers, and computer science—to a great degree this originated with Hilbert.

The four-color problem is for me an example of a bad problem which didn't lead to a program. It was proved with the aid of computers so that to this day swords are crossed over it. But that's not so important as the fact that until now no one has incorporated it into any sort of sufficiently rich context. So it is simply a means of training the mind.

For these reasons, I generally don't like problems as such. But when a problem arises within a program—that's when it can be a good one, when we know in advance to what edifice this detail belongs. The Riemann Hypothesis, without a doubt, is a problem that Riemann originated within a program, although during the course of a century and a half, the narrow number theorists continued to look at it as a very important isolated challenge. I'm somewhat apprehensive that its first solution might be a proof using blunt analytic methods. It will receive every imaginable prize, the solution will be acclaimed in every newspaper in the world, and all of this will be misleading because the "right" solution should be given in a wider context, which we already know. We even know several approaches to a solution. Nevertheless, it is quite possible that the first solution will be a poor and uninteresting one.

Gelfand: *Are there hypotheses that everyone had grown used to and assumed to be obviously correct, but then counterexamples were found?*

Manin: I don't think I know of any long-standing hypotheses that people believed, but then found counterexamples.

Gefand: *If someone found a counterexample to Fermat's Last Theorem, rather than a proof, would this be a great earthshaking event? Or would it simply mean that the problem was not a good one?*

The problem would still have been a good one, because it stimulated the development of a context. And then someone solves it within this context. The answer could be positive or negative—this second question is less significant. The significance of the question is that it helped to establish an important context.

If a counterexample had been found before the 1960s, everyone would have been scratching their heads. If a counterexample had been found somewhere in the 1970s, it would have been very interesting and somewhat shattering, because by that time it had become clear that Fermat's Last Theorem could be deduced from several other conjectures that are far from simple and that had a more far-reaching character, related to the Langlands program. By then it was known that if these things were true, then so was Fermat's Last Theorem. Of course if a counterexample to Fermat's Last Theorem had been found, then these things would have to be false. And this would have meant the destruction of a much more fundamental and complex system of belief. It would have evoked enormous interest and attempts at understanding what was amiss, we would have to rebuild a lot of the edifice, and so on. All that would have followed from the discovery of a counterexample.

Gelfand: *Have there been such strong counterexamples in history? Perhaps Gödel's Theorem? Before that it was supposed that one could prove everything that is true.*

Manin: Hilbert believed this, and I don't know how many others believed it. But this shows that you must view this program correctly. Its first important outcome was the construction of a mathematical context in which one could formulate questions about truth and provability in mathematics as precise mathematical problems rather than vague philosophical ones. By the nature of this quest, one has to introduce self-referentiality, and the rest becomes the matter of inventiveness, brilliantly demonstrated by Tarski and Gödel.

At the start of the formulation of the program, people made wrong guesses about what it would lead to, and the counterexamples showed that these were in fact errors.

Gelfand: *Were there other interesting wrong perceptions?*

Manin: There were some showing a lack of human imagination. In the history of mathematics, such things are not usually called counterexamples, but paradoxes. Take for instance the theorem of Banach-Tarski. You start with a ball, and it turns out that you can cut it into five pieces, rearrange them, put them back together, and you obtain two balls of the same size as the initial one. This construction tells us a lot. For example, to the critics of the set-theoretic approach in general, it means that if this view leads one to such an assertion, then it is not mathematics, but some sort of wild nonsense. For logicians it is an example of a paradoxical application of the axiom of choice of Zermelo and so an argument against accepting it. And aside from all this, it is very beautiful geometry. Once I was asked to deliver a lecture for the general public in an art museum, and I decided that the Banach-Tarski paradox is a great subject for the presentation "The Abstract Art of Mathematics". The key point was that we must not imagine "pieces" as solid material objects, but rather clouds of points. We must imagine that a ball consists of indivisible points. You are allowed to call a "piece" any subset of these points, you can move it and turn it around, but only as a whole, moving it as a single object, so that the pairwise distances between points remain the same. So you split the sphere not into solid pieces, but into five clouds. And these clouds can mutually penetrate each other; in fact, there's nothing solid about them. They have no volume, no weight, they are wonderful objects of a highly trained imagination.

Why is there no obvious contradiction? Isn't it true that two balls contain more points than each one? No, the infinite number of points is exactly the same, that's easy to prove. I explained this to my grandson, that there are as many points in a sheet of paper as there are on the wall of the room. "Take the sheet of paper, and hold it so that it blocks your view of the wall completely. The paper hides the wall from your sight. Now if a beam of light comes out of every point on the wall and lands in your eye, it must pass through the sheet of paper. Each point on the wall corresponds to a point on the sheet of paper, so there must be the same number of each."

The message here is that if you make a dust of individual points out of your initial ball, there will be enough points to fill two, or three, or even an infinity of balls of arbitrary sizes. The difficulty arises when you try to define clouds of points that you will have to move and turn and rearrange into two balls leaving no gaps. This is mathematical trickery, very beautiful, but if you want to explain it well, you need much more time.

So it's not a counterexample, but a paradox baffling an untrained imagination.

Several such paradoxes were discovered during the time of transition between classical mathematics and set theoretic mathematics. There was the theorem that a curve could fill the square. There were many such things, and they taught us a lot.

Many people thought that this was pure fantasy, but the newly trained imagination allowed one to recognize "paradoxical" behavior of Fourier series, to understand Brownian motion, then to invent wavelets, and it turned out that these were not at all fantasies but almost applied mathematics.

Gelfand: *So what will happen in the next twenty years?*

Manin: I don't foresee any revolutionary changes, because in my view there have been none in the last 300 years. Every time new and powerful intuitions arose, mathematics retained its character, in some strange way. This is also a theme of a lecture, one I've not given. I would like to show the development of the idea of the integers from the most remote times to Kolmogorov complexity, and all this can be done almost without appealing to new mathematics. One and the same idea persists. It changes a bit in one era or another, its verbal casing changes. But all the same it stays completely invariant and so lives on. Nothing is forgotten.

And so I don't foresee anything extraordinary in the next twenty years. Probably, a rebuilding of what I call the "pragmatic foundations of mathematics" will continue. By this I mean simply a codification of efficient new intuitive tools, such as Feynman path integrals, higher categories, the "brave new algebra" of homotopy theorists, as well as emerging new value systems and accepted forms of presenting results that exist in the minds and research papers of working mathematicians here and now, at each particular time.

When "pragmatic foundations" of mathematics are made explicit, usually in several variants, the advocates of different versions may start quarreling, but to the extent that it all exists in the brains of the working generation of mathematicians, there is always something they have in common. So, after Cantor and Bourbaki, no matter what we say, set theoretic mathematics resides in our brains. When I first start talking about something, I explain it in terms of Bourbaki-like structures: topological spaces, linear spaces, the field of real numbers, finite algebraic extensions, fundamental groups. I cannot do otherwise. If I'm thinking of something completely new, I say that it is a set with such-and-such a structure; there was one like this before, called this-and-that; another similar one was called this-and-this; so I apply slightly different axioms, and I will call it such-and-such. When you start talking, you start with this. That is, at first we start with the discrete sets of Cantor, upon which we impose something more in the style of Bourbaki.

But fundamental psychological changes also occur. Nowadays these changes take the form of complicated theories and theorems, through which it turns out that the place of old forms and structures, for example, the natural numbers, is taken by some geometric, right-brain objects.

Instead of sets, clouds of discrete elements, we envisage some sorts of vague spaces, which can be very severely deformed, mapped one to another, and all the while the specific space is not important, but only the space up to deformation. If we really want to return to discrete objects, we see continuous components, the pieces whose form or even dimension does not matter. Earlier, all these spaces were thought of as Cantor sets with topology, their maps were Cantor maps, some of them were homotopies that should have been factored out, and so on.

I am pretty strongly convinced that there is an ongoing reversal in the collective consciousness of mathematicians: the right hemispherical and homotopical picture of the world becomes the basic intuition, and if you want to get a discrete set, then you pass to the set of connected components of a space defined only up to homotopy.

That is, the Cantor points become continuous components, or attractors, and so on—almost from the start. Cantor's problems of the infinite recede to the background: from the very start, our images are so infinite that if you want to make something finite out of them, you must divide them by another infinity.

This is parallel to the way we envisage a Feynman integral. At first it is just a hieroglyph charged with an interpretational challenge. The first two, three, four steps of interpretation are all ad hoc, appealing to various analogies with other cases where the mathematics is clean ("toy models"). At a certain stage you may get a formal series that doesn't just diverge, but consists of terms that are themselves divergent (although finite-dimensional) integrals. Then you artificially regularize each term, making it finite. But the series, in general, still diverges. So you invent an interpretation of the series. And finally, having forced your way through a crowd of infinities, you obtain a finite answer. As a bonus, you get a series of marvelous mathematical theorems. I see in this an analogy with a rebuilding of pragmatic foundations in terms of category theory and homotopic topology.

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For more information, please contact Professor Rob Meyerhoff, Graduate Program Director (robert.meyerhoff@bc.edu).

Book Review

The Princeton Companion to Mathematics

Editor's Note: To review this unusually wide-ranging volume, the *Notices* invited five distinguished mathematicians who are both experts in their fields and broadly knowledgeable about mathematics in general. Their reports are presented in alphabetical order.

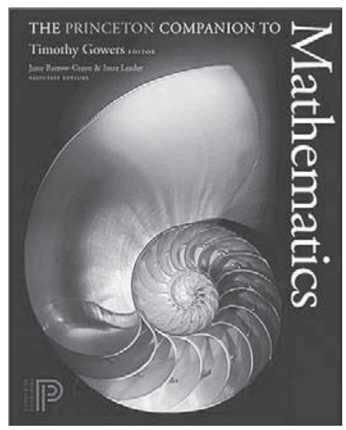
—Andy Magid

The Princeton Companion to Mathematics
Timothy Gowers, editor
June Barrow-Green and Imre Leader, associate editors
Princeton University Press, 2008
US$99.00, xxii+1,034 pages
ISBN-13: 978-0-691-11880-2

Bryan Birch

This is an enormously ambitious book, full of beautiful things; I would wish to keep it on my bedside table, but that could only be possible by relays, since of course it is far too large. Timothy Gowers and his associate editors have aimed to give an account of as much of mathematics as can reasonably be made accessible; in particular, students at school should be helped to understand what mathematics is about, intending graduate students should be helped to decide what topics to research in, and established mathematicians should be helped to understand what their colleagues are doing.

Many of the articles have been written by the editors themselves, but most have been written by an enormous team of collaborators recruited by the editors. In his Introduction, Gowers stresses the importance of accessibility and pays tribute to his authors' willingness to revise their articles: if he didn't understand it, he asked them to change it—he must have been enormously tactful! Almost all of the articles I have sampled have been excellent, not just accessible but enjoyable to read, and varied voices add to the liveliness of the book. The book does not attempt to show the reader the frontiers of knowledge (in the nature of things, few of them are accessible), but there are signposts all



over the place. In my opinion, the book is magnificently successful, but aspiring research students should be warned that this is a companion, not an encyclopaedia, and some important topics for research are not even touched on.

The plan of the book is a classic "arch" form in eight parts. The heart is Part IV, containing accounts of twenty-six "branches" of mathematics in an arbitrary but sensible linear order. This is where one learns what one's colleagues are doing! The first branch ("Algebraic numbers" by Barry Mazur) happened to be the one I know most about. He uses a light touch and stops short of p-adic numbers (in Part III), let alone class field theory (which has an article of its own in Part V). His simple examples convey the essence of the subject beautifully, but I would have liked him to have gone a little deeper; of course I enjoyed the article enormously, it is good to read stuff one knows well, written by as good a writer as Barry. When I went on to the second branch ("Analytic number theory" by Andrew Granville), the writing was still excellent and I continued to enjoy myself; but whereas the part of analytic number theory with which I am familiar is mainly concerned with polynomial equations, Andrew Granville's article is centred on the properties of primes, and there is nothing in it about Waring's problem (which gets mentioned later on, particularly in the biographical Part VI). More seriously, transcendence theory and Diophantine approximation seem to have

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gone missing too; even if one divides mathematics into twenty-six branches and keeps it accessible, the branches remain huge and gaps start opening! "Computational number theory", "Algebraic geometry", "Arithmetic geometry", "Algebraic topology"—a particularly nice chapter—but I was starting to find it tougher. I jumped ahead to IV.25, "Probabilistic models of critical phenomena", of which I know very little but have enjoyed what I know, and Gordon Slade didn't disappoint me.

What about the rest of the book? Part I is the editor's introduction to what mathematics is about and to the language of mathematics. It is addressed to a beginning student, but its simple examples illustrate sophisticated points that we can all learn from. Part II explains where modern mathematics has come from, in particular containing substantial historical articles. Part III at first sight appears something of a ragbag, containing bits and pieces which need to go somewhere because they are important but don't fit conveniently into any of the branches. Arranged in alphabetical order for easy reference, it is surprisingly satisfactory to consult. The bias of the book is toward the questions and results of mathematics, and that is how it has been split into branches in Part IV; but concepts and methods are important too, and don't split the same way. Accordingly, important procedures and techniques have their description in Part III, sometimes in extensive articles. I note that cohomology gets short shrift; it is a valuable and pervasive technique, but may be hard to write about attractively.

In contrast to Part III, Part V ("Theorems and problems") is more by way of a beauty contest. I am gratified to have a share in fourth place (albeit for alphabetical reasons); the B-S-D conjecture has been stated clearly and simply, although only in the weak form; again, this is a companion, not an encyclopaedia! Millennium problems aside, this part contains some lovely plums; for a number theorist like me the sections from V.27 onward are a delight. (Gowers has treated number theory very generously in this companion!) At the very end, Osserman's article on the Weil conjectures gets it exactly right.

The book concludes with a part containing the lives and works of great mathematicians, a part entitled "Influence of mathematics", and finally "Final perspectives". "Influence of mathematics" begins with various applications of mathematics, including particularly authoritative articles by Daubechies on wavelets, by Frank Kelly on traffic, by Sudan on coding, and by Cocks on cryptography; these are followed by articles on music and on art. "Final perspectives" contains five essays which are intended to provoke thought and certainly do so, and at the very end there are letters of advice to a young mathematician from Atiyah, Bollobás, Connes, Dusa Macduff, and Peter Sarnak.

To sum up, the book is really excellent. I know of no book that will give a young student a better idea of what mathematics is about. I am certain that this is the only single book that is likely to tell me what my colleagues are doing. I am less sure that an intending graduate student should take this book as a guide to his choice of research topic, since different fields of similar importance may not be served equally in this volume—some may even be missing; but he or she should certainly read the final part. A final carping comment: the publishers should consider issuing a library edition in at least three volumes; I fear that the spine of the present heavy volume may break from overuse.

Simon Donaldson

Two extracts from the preface convey a good overall picture of what the book is about:

"[The companion] simply aims to present for the reader a large and representative sample of the ideas that mathematicians are grappling with at the beginning of the twenty-first century."

"The companion is not an encyclopaedia: …the book is like a human companion, complete with gaps in its knowledge and views on some topics that may not be universally shared."

The book has eight parts which contain rather different kinds of material aimed at different likely readership. Roughly, the material could be divided into three classes:

(1) material for a general audience, similar to a *Scientific American* article or popular mathematics lecture;

(2) material at an undergraduate mathematics level;

(3) expository articles aimed at professional mathematicians, somewhat in the style of the AMS *Bulletin* articles.

There are contributions from many different authors, but the book is permeated by Gowers' distinct vision and he has written a large amount of the material.

Working outward, the heart of the book is Part IV, which consists of expositions of twenty-six "Branches of mathematics" of about fifteen pages each. For example we have "Algebraic numbers" (Mazur), "Differential topology" (Taubes), "Partial differential equations" (Klainerman), "Extremal and probabilistic combinatorics" (Alon and Krivelevich). These are roughly at the level (2)–(3) above. The most successful of these articles are excellent, giving overview and insight that would

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be hard to find elsewhere. Two of the articles I particularly liked are "Partial differential equations" (tackling such a large subject in such a short space) and "Representation theory" (Gronowski), which moves from the elementary theory up to advanced topics but conveys an overall unity. The first two articles, "Algebraic numbers" and "Analytic number theory" (Granville), are very informative and interesting, at least for this reader, and illustrate a contrast in styles. The first explains many of the basic ideas in the subject (such as ideal class groups and unique factorisation) with outline proofs, while the second concentrates more on stating results and interesting open questions. Both approaches work well and are probably the right ones for the subjects. Each of these articles in Part IV finishes with a short list of further reading.

Part III of the book is made up of shorter articles (one or two pages) about ninety-nine "Mathematical concepts". The level and style varies greatly. A sample of three alphabetically adjacent articles conveys the contrasting approaches:

> "The Euler and Navier-Stokes equations" (Fefferman). A statement of the equations and a discussion of the long-time existence problem, the distinction between weak and strong solutions, and some modern results. Culminates in the insight, "We need to understand why a tiny viscosity dissipates a lot of energy."
>
> "Expanders" (Wigderson). The definition (a graph with n-vertices is a c expander if for every $m \leq n/2$ and every set S of m vertices there are least cn edges between S and its complement). Description of constructions and why expanders are important, including surprising (and recent) applications to estimating averages over large sets.
>
> "The exponential and logarithm functions" (Gowers). This is pitched at a much more elementary level: the problem of defining 2^a when a is integral, rational or irrational. The exponential function defined by power series or the limit of $(1 + x/n)^n$, with outline proofs. Logarithms and extension to complex variables.

Again, these are all excellent in their different ways. The first two will be concise, insightful references at the level (2)–(3) above, and the third nicely summarises standard material around about the beginning undergraduate/senior high school level in a way that might be more digestible than when buried in a textbook. There are comprehensive cross-references between the different articles. In Part III there are few references to other sources, and more would be useful (for example the original research articles on "Expanders" discussed above, and sources where the reader might find more about the Ricci flow).

So much for Parts III and IV. The "Introduction", Part I (76 pages, written by Gowers), could stand alone as a general description of modern mathematics. The discussion includes, among much else, "What is mathematics about?"; "Some fundamental mathematical definitions"; different modes of thought characterising algebra, geometry and analysis; formal and informal language used in proofs; "What do you find in a mathematical paper?". This could be extremely valuable for an undergraduate contemplating a career in mathematical research. Part II consists of seven substantial historical articles. Part V is made up of short articles, somewhat like Part III but focused on particular results and problems (again with a wide range, from "The fundamental theorem of arithmetic" to "The Poincaré conjecture"). Part VI is historical again, brief biographies of ninety-six mathematicians, and Part VIII ("Final perspectives") consists of a variety of essays on general, sometimes more philosophical, topics.

Part VII ("The influence of mathematics") deserves special mention. As explained in the preface, the central focus of the book is on *pure mathematics* but with a sympathy to applications. Part VII addresses applications in more detail, and, while the coverage has to be very selective, the articles are particularly interesting; perhaps the most informative for the professional pure mathematician. Here "applications" should be interpreted broadly: the articles include "Wavelets", "Medical statistics", "Mathematics and music".

It is easy to complain about what is not covered in the book, although such criticism is largely deflected by the not-an-encyclopaedia quote above. There is very little on differential geometry. I was hoping to find a broad discussion of the influence of cohomology in various guises (surely one of the main developments of the twentieth century), but was disappointed. It would have been interesting and topical to see more on quantum field theory, as a notable idea "that mathematicians are grappling with at the beginning of the twenty-first century" (although there is some coverage of this under the headings "Mirror symmetry" and "Vertex operator algebras"). In general I would often have been happier with a little more formality in the definitions, etc., but this would make the book more of an encyclopaedia, more standard and less distinctive.

Overall this book is an enormous achievement for which the authors deserve to be thanked. It contains a wealth of material, much of a kind one would not find elsewhere, and can be enjoyed by readers with many different backgrounds.

Gil Kalai

Praise

This book is an unusually rich description of the many facets of mathematics as a science, as an art, as a powerful tool, and as a human activity.

The human face of mathematics comes to play not only in the general history chapters and the little chapters on individual mathematicians, but often also in chapters devoted to areas of mathematics and to concepts, problems, and results. Take, for example, this nice quotation: "Borcherds was struck by the formal similarity between V^1 and the chirals algebras of CFT's" (the story of the proof of the moonshine conjecture from the chapter on vertex operators, p. 549.) You do not have to fully understand these objects in order to get a good sense of the discovery's first moments, and the joy it produced. Another example of a defining moment in mathematics described with a personal touch: "Gerhard Frey realized that such a curve might be so unusual that it may contradict the Shimura-Tanayama-Weil conjectures" (From the chapter, "Fermat's last theorem", p. 692). Oh yeah!

The different ways different authors chose to present a field, a concept, or a theorem shed light on different personal approaches toward mathematics.

While the self-mandate of the book is limited to pure mathematics, there is also a very strong spirit of applied mathematics. The oldest and strongest connection of mathematics is to physics and through it to other exact sciences and engineering; indeed, physics is strongly felt in most parts of the book. Next, in my view, comes statistics. The reader will get a strong taste of the importance of statistics and probability (and a taste for more). Optimization and algorithms are also amply represented in the book. It is not common to see as strong an emphasis on the philosophy of mathematics and mathematics in philosophy as appears in this book, and this is most welcomed.

The book is so rich and yet it is well done. A rare achievement indeed!

Critique

In a movie describing a human mission to the planet Mars, the proud families of three astronauts who had just landed there were about to talk to the astronauts. They greeted them and were told that because of the speed of light they would have to wait 90 seconds for a response. Once these 90 seconds passed and the movie paid its dues to science, the conversation continued back and forth without any further interruption. This is similar to a common problem (and a common unsuccessful solution) in trying to make mathematical presentation self-contained. In this book, the large introductory chapters to the mathematical endeavor as a whole are superb, but it seems that some chapters describing major areas of mathematics require a few introductory little chapters of a similar kind. The book is not and cannot really be self-contained.

Aside from that, reading a large encyclopedia-type book like *The Princeton Companion to Mathematics* (PCM) can be discouraging, recognizing how little your little corner of the woods in this huge forest is. Something to take comfort from is the fractal nature of science and of mathematics. A little discovery in a small corner, a concept or a theorem, can make a big difference for the large picture. Even more comfort comes from taking notice not just of the value of mathematics but of *mathematics as a value*, an idea that the PCM strongly champions.

The book, at 2.6 kilograms, is much too heavy. I hope contributors will put their chapters on their home pages and that a future edition will be divided into several volumes.

Advice

There are several pieces of advice in the book for young mathematicians, but an advice chapter for middle-aged and older mathematicians is notably missing. Béla Bollobás, in his nice advice, quotes G. H. Hardy who wrote that there is no permanent place in the world for ugly mathematics. When Hardy wrote this phrase the term he felt need to explain was "ugly" (and he elaborated on what beauty in mathematics means) but these days we probably have more trouble explaining the term "permanent". We cannot really accept Hardy's romantic saying as normative advice, nor can we really accept Bollobás's follow-up, that there is no place in the world for nonenthusiastic mathematicians. If you prove good lemmas and theorems or make other progress in exploring mathematics, the amount of enthusiasm for mathematics is up to you. Mathematics and mathematicians come in many kinds, as the book in front of us largely demonstrates, and there is a place in the world for all, though alas, perhaps not permanently.

Just Another Good Lemma

When Paul Erdős received the Wolf prize he said: "If I could get a good lemma—I wouldn't give it for a hundred medals." (Erdős was paraphrasing the Hungarian poet János Arany who wrote "If I could have a good sleep—I wouldn't give it for a hundred medals.") Gosta Mittag-Leffler seemed to have had another approach. Promoting mathematics (as Hardy said about him) more than any other mathematician of his time required him to avoid,

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at times, the temptation of proving lemmas. Contributing to mathematics and to the mathematical community also comes in many ways, and this book is a daring and successful attempt to enrich the infrastructure of mathematics. It offers the readers rich and useful sources on mathematics and mathematicians. The book is an achievement that Tim Gowers, June Barrow-Green, Imre Leader, and the many other contributors can be proud of, and that we all can take pleasure from.

Richard Kenyon

What is this book? It is not immediately easy to say. It is not, what one might suspect at first glance, some sort of printed version of the Wikipedia of mathematics. Nor is it an encyclopedia of mathematics: you won't find tables of formulas or integrals or definitions of mathematical terms. It is not "complete" in this sense. Nor in fact is it necessarily a good resource for learning about a particular subject.

Part of what the book is, rather, is a description of what mathematics is, accessible to the public. I've been tempted to give it to my 15-year-old to read, as a way of explaining what I do. It also contains a history of mathematics: a concise chronological description of major mathematicians, theorems, definitions, and proofs.

Another part of what it is (and this is the part for me as a working mathematician) is a collection of facts/essays/ideas which every mathematician ought to know—at least in an ideal world. It is something to browse when I want to learn a little about those parts of math which…uh…are not part of my culture. Here is a collection of essays about various subjects of mathematics written by experts(!)—and here I mean my mathematical friends and colleagues—in a language which is not only understandable but downright accessible. I greatly enjoyed flipping through the book, browsing its articles, uncovering new gems of ideas. To be honest, the short articles are great but sometimes, well, frustratingly short. I wished some of them went into a little more depth! But maybe this is a sign that the book is serving its purpose: getting the reader interested enough in a subject to go out and get more information elsewhere.

Another delightful aspect of the short articles is that they were commissioned in a free-form way: authors were (apparently) not given strict guidelines about what to say. As a consequence, the article about, say, algebraic numbers, written by Barry Mazur, is not a dry list of definitions interspersed with lemmas and theorems, covering the basic facts in the subject. It is, rather, about what interests Barry Mazur as a mathematician, that is, a tale of tidbits, facts, and yes, definitions, which starts out from basic, motivating high-school algebra questions and leads up to (almost) serious but exciting questions of modern number theory. It is this personalized flavor that makes the whole program enjoyable, entertaining, and interesting.

My advice to you, reader, is to buy the book, open it to a random page, read, enjoy, and be enlightened.

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Angus Macintyre

The Preface begins with a notorious quotation from Bertrand Russell, giving a logicist "definition" of pure mathematics:

> Pure Mathematics is the class of all propositions of the form 'p implies q', where p and q are propositions containing one or more variables, the same in the two propositions, and neither p nor q contains any constants except logical constants. And logical constants are all notions definable in terms of the following: Implication, the relation of a term to a class of which it is a member, the notion of *such that*, the notion of relation, and such further notions as may be involved in the general notion of propositions of the above form. In addition to these, mathematics *uses* a notion which is not a constituent of the propositions it considers, namely the notion of truth.

The *Princeton Companion to Mathematics* very neatly counters this by saying that it is about everything that Russell's definition leaves out. The aim is to present, in an attractive and accessible way, a large and representative sample of those ideas of modern, pure mathematics that most engage the mathematicians of our time. From the *Companion* I learned Eisenstein's "In the end, the best mathematical genius cannot discover alone what has been discovered by the collaboration of many outstanding minds." The *Companion* achieves its aims by such a collaboration, by skillful and unobtrusive editing. It makes possible a wide range of mathematical journeys, from short excursions for the untravelled to explorations that will reward the most experienced and accomplished of mathematicians.

Let us begin with origins and pioneers. While the historical sections do not have the pop drama of Bell's *Men of Mathematics* (a work known to have opened the eyes of many young people), they have their own authority of scholarship, and they enhance the longer articles. There are ninety-six

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short scientific biographies of deceased mathematicians, and one of Bourbaki. The ninety-six begin with Pythagoras, and end with Abraham Robinson. I was a little surprised to see among the ninety-six so many who had worked in logic (I counted eighteen, including of course some whose main claim to fame is elsewhere).

I wandered back and forth in the book. I recommend going early to the illuminating section "Final perspectives". I was particularly taken by the contributions of Tony Gardiner and Michael Harris. What they have in common, for me, is an emphasis on the specifics (or "motley") of mathematics, an evolving human activity unlike any other.

Gardiner's "The art of problem solving" is built around a delightful series of quotations (many familiar, but of enduring strength). He pursues the metaphor of exploration of a largely unexplored mental universe, where the great discoveries are rooted in detailed knowledge of "mathematics in the small". Mathematics is a craft, where serious insight is gained only through constant practice. He has a special interest in getting children started well in the craft, but much of what he says is relevant at all stages of our unending apprenticeship. There is a welcome scepticism about the jargon of theories of problem solving, and condemnation of "reforms" that reduce the emphasis on, and time for, serious elementary mathematics. In the penultimate subsection of "Final perspectives", Atiyah, Bollobás, Connes, McDuff, and Sarnak, each an inspiring master of our craft, have wise, and quite specific, advice for young mathematicians aiming to cross into the modern research world. Atiyah has a memorable phrase: "All the really creative aspects of mathematical research precede the proof stage."

Harris's title is "'Why mathematics?' You might ask", and it is what he says about mathematical ideas that I want to consider. His emphasis is on ideas and the experience of mathematics. Here are some of his phrases:

> "the basic unit of mathematics is the concept, not the theorem";
>
> "the purpose of a proof is to illuminate a concept";
>
> "Even the most ruthless funding agency is not yet so post-human as to require an answer to the question 'Why experience?'."

Note the extreme contrast to the Russell quotation cited earlier. I commend pages 973–975 for a light, convincing account of the objectivity of mathematical ideas (they can be stolen, or counted!) and an affirmation of the public intuition that underlies mathematics. The *Companion* itself amply confirms what Harris writes. There are no proofs, but many wonderful ideas (often linked to physics). That I, and I presume very many others, can go to a randomly chosen article and get the "drift" certainly confirms the public intuition. The deliberately flexible structure of the book (there is little point in reading it from cover to cover) conveys a sense of the deep mystery of the organism of mathematics. Those who regret the absence of proofs may turn to *Proofs from the Book.* Most of us will learn from both.

Parts I and II are the most skippable for professionals, but they are well done and indispensable for beginners.

Part III displays the motley of present-day concepts. That they come in alphabetical order did not affect my appreciation.

Part IV, "Branches of mathematics", leads to the most important and complex ideas. I read all the papers, and I can honestly say I enjoyed them all. Here one sees how new subjects have evolved and how others have been linked in unforeseen ways. Imagine how this book would have looked fifty years ago! There would have been little computational number theory, little cryptography, almost no arithmetic geometry, very little geometric group theory, a lot less dynamics, no fractals, no wavelets, no computational complexity, no mirror symmetry, no classification of finite simple groups, no proof of the Weil Conjectures, no Langlands Program, no vertex operator algebras, a very different and much more fragmented combinatorics, few links from stochastics to the rest of the mathematical world, no forcing in set theory, no modularity of elliptic curves over Q, no Ricci flow in the style of Hamilton and Perlman. Thus we must hope that the *Companion* will go through many revisions and be for later generations the rich resource it is for us.

I shared a couple of concerns with other reviewers. For an idea so pervasive in modern mathematics, cohomology gets rather little coverage, except for three pages in Totaro's beautiful paper. One can hope for much more in a revised edition. A quite different subject, of enormous difficulty, with a long history, and problems readily intelligible to all readers of the *Companion* seems to me neglected—namely transcendence theory.

The papers on PDE's satisfied me greatly. For those of an algebraic or logical bent, it has generally proved very demanding to extend one's understanding of PDE's much beyond the formal level of an undergraduate course. Reading the *Companion,* I now saw a much bigger picture. To quote Klainermann: "One looks in awe at how equations, such as the Laplace, heat, wave, Dirac, KdV, Maxwell, Yang-Mills, and Einstein equations, which were originally introduced in specific physical contexts, turned out to have very deep applications in areas such as geometry, topology, algebra and combinatorics."

Mutatis mutandis, such sentiments are appropriate reactions to most of the ideas in this book.

W H A T   I S . . .

a Legendrian Knot?

Joshua M. Sabloff

Legendrian knots lie at the intersection of knot theory and contact topology. This can be construed to mean that Legendrian knots arise when contact topology imposes extra structure on knot theory or that they mediate the injection of knot-theoretic ideas into the study of contact topology and its applications. We will take the first view to explain what Legendrian knots are and the second to motivate their study.

A (smooth) *knot* is a smooth embedding of the circle into $\mathbb{R}^3$ (or into any 3-manifold, but we will mostly stay in $\mathbb{R}^3$). A *contact structure* is a special type of *plane field*—just as a vector field assigns a vector to each point in space, a plane field assigns an entire plane of directions to each point. Figure 1 presents the *standard contact structure* ξ_0 on $\mathbb{R}^3$, which will be described in more detail below. Though we will not give the general definition of a contact structure here, the idea is that the planes in a contact structure twist so much that there is no surface whose tangent planes are all part of the contact structure. On the other hand, there are curves whose tangent vectors do lie in the contact structure; such curves are called *Legendrian*, and a knot that is also a Legendrian curve is a *Legendrian knot*.

Until the end of the article, we will restrict our attention to Legendrian knots in the standard contact $(\mathbb{R}^3, \xi_0)$. To get a feel for the standard contact structure, consider the track that the wheel of a unicycle makes in a parking lot, with the caveat that the wheel never points north–south. The state of the unicycle may be described by the coordinates (q, p, z) in $\mathbb{R}^3$, where (q, z) is the position of the unicycle in the parking lot and p is the slope of the wheel with respect to the q- and z-axes when viewed from above. At any given time, the unicycle can swivel in place, move forward or backward in the direction its wheel points, or use some linear combination of these motions. Thus, the path $\gamma(t) = (q(t), p(t), z(t))$ that describes the motion of the unicycle must be tangent to the plane field spanned by ∂_p and $\partial_q + p\partial_z$, and hence it must satisfy

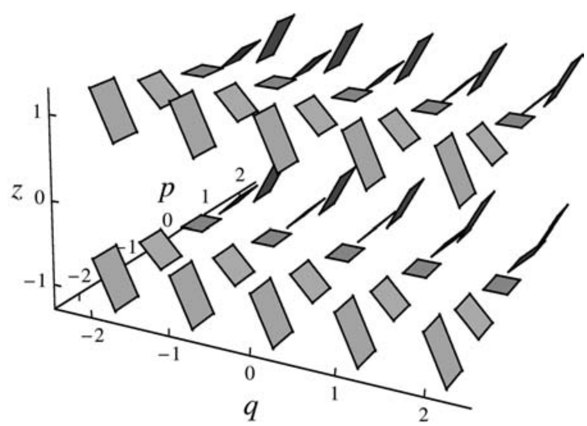

Figure 1. The standard contact structure on $\mathbb{R}^3$ (figure created using Mathematica).

$$z'(t) - q'(t)p(t) = 0. \tag{1}$$

This plane field is the aforementioned standard contact structure, and the curve $\gamma(t)$ is Legendrian.

The constraints imposed on a knot by equation (1) are best visualized using projections to the qz and qp planes, as shown in Figure 2(a). Equation (1) implies that the p coordinate of a Legendrian curve is determined by the slope of its qz or *front* projection. In terms of the unicycle, the

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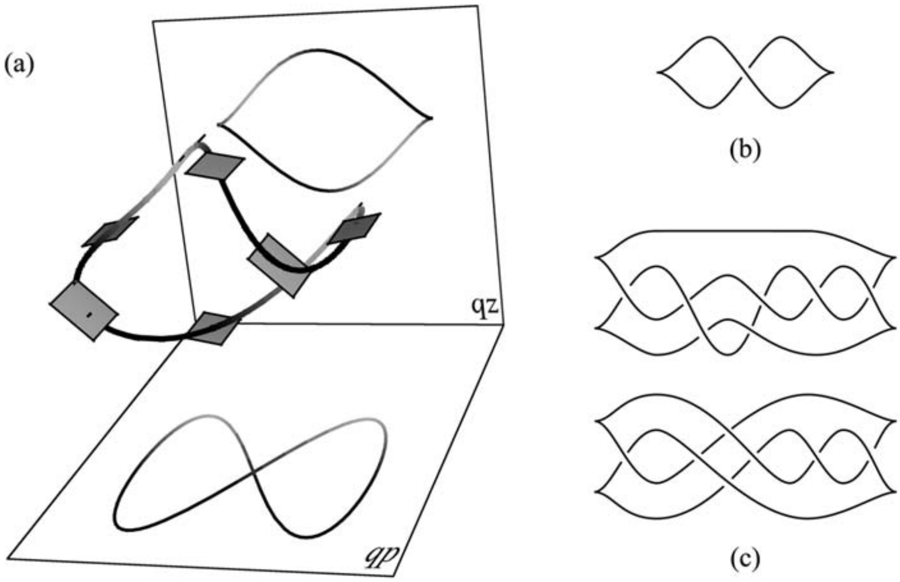

Figure 2. (a) A Legendrian unknot, with its front projection in back and its Lagrangian projection below (figure created using `Mathematica`); (b) Front projections of another Legendrian unknot; (c) The Chekanov-Eliashberg examples.

front projection is the track left on the parking lot. Several front projections of Legendrian knots are shown in Figure 2. Notice that the crossing data is always the same: the strand of more negative slope crosses in front. Any closed curve in the qz plane, immersed except at finitely many cusps and having no vertical tangents, is the front projection of some Legendrian knot.

Equation (1) also implies that the z coordinate of a Legendrian curve can be recovered (up to a constant) by integrating the quantity $q'(t)p(t)$ along its qp, or *Lagrangian*, projection. Since the z coordinate of a knot must return to its starting value as we go around the knot, Green's theorem shows that the Lagrangian projection of a Legendrian knot must bound the zero signed area. In particular, the round circle cannot be the Lagrangian projection of a Legendrian knot.

Two fundamental goals of knot theory are to understand "geography"—how to distinguish or even classify knots—and to investigate the geometry of a knot's position in 3-space. These two goals apply to Legendrian knot theory as well. Here, we declare two smooth knots to be equivalent if one can be smoothly deformed into the other through smooth knots; similarly, two Legendrian knots are equivalent if one can be smoothly deformed into the other through Legendrian knots.

Two equivalent Legendrian knots are equivalent as smooth knots, but the converse is false. To see why, we introduce two "classical" invariants. The *Thurston-Bennequin number* measures the linking between a Legendrian knot and a second copy of the knot pushed off in a direction (such as ∂_z) that is always transverse to ξ_0. The knot in Figure 2(a) has $tb = -1$, while the knot in Figure 2(b) (also an unknot!) has $tb = -2$. The *rotation number* of an oriented Legendrian knot measures the winding number of the tangent vector of the Lagrangian projection of the knot. This can also distinguish the knots in Figure 2(a,b).

The classical invariants refine the "geography" question for Legendrian knots in a fixed smooth knot class: which pairs (tb, r) of classical invariants can be realized by a Legendrian knot, and how many Legendrian knot classes have the same pair? For the unknot, Eliashberg and Fraser proved that any (tb, r) pair whose components have opposite parity and that satisfies the *Bennequin bound* $tb + |r| \leq -1$ is realized by exactly one Legendrian knot class, and only those pairs are realized. In fact, every Legendrian unknot can be constructed by adding a sequence of zig-zags (called *stabilizations*) to the front diagram of the knot in Figure 2(a).

Torus knots, the figure-8 knot, and certain torus links have similar classifications, but in general, the story is more complicated: both Chekanov and Eliashberg discovered that the two Legendrian knots in Figure 2(c) are in the same knot class, have $tb = 1$ and $r = 0$, but are not equivalent. There are several types of "nonclassical" invariants that can distinguish these, and other, knots: Legendrian contact homology, a special case of Eliashberg, Givental, and Hofer's Symplectic Field Theory; Chekanov and Pushkar and Traynor's theory of generating families; and Ozsváth, Szabó, and Thurston's Legendrian invariant in Knot Floer Homology. These recently developed invariants detect subtle contact-topological features of a Legendrian knot and its complement, and a picture of what these features are is just beginning to emerge.

Legendrian knots are not only interesting in their own right, but also provide tools for the investigation of contact topology and knot theory. In contact topology, Legendrian knots are frequently employed as probes of the ambient contact structure. The first example of this was Bennequin's discovery of an "exotic" contact structure ξ' on $\mathbb{R}^3$: he found a Legendrian unknot in $(\mathbb{R}^3, \xi')$ that violated the Bennequin bound. Legendrian knots are also used as surgery loci for the construction of new contact manifolds. Legendrian knots influence smooth knot theory through their close ties to known geometric (slice genus) and quantum (HOMFLY, Kauffman, Khovanov, …) knot invariants and the construction of new invariants like Ng's Knot Contact Homology, which uses higher-dimensional Legendrian knots. Further, surgery on Legendrian knots (and/or its analog for knots transverse to the contact structure) plays a significant role in Kronheimer and Mrowka's proof that every nontrivial knot has Property P. Finally, Legendrian knots have recently been brought back to their historical roots as "wave fronts" in geometric optics with Chekanov and Pushkar's solution of Arnol'd's 4-cusp conjecture. Despite this progress, however, our understanding of the geography, geometry, and applications of Legendrian knots is still in its opening chapters.

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Mathematical Sciences in the FY 2010 Budget

Samuel M. Rankin III

Highlights

• Federal support for the mathematical sciences is slated to grow from an estimated US$509.73 million in FY 2009 to an estimated US$536.69 million in FY 2010, an increase of 5.3 percent.

• The National Science Foundation's (NSF) Division of Mathematical Sciences (DMS) would increase by 8.9 percent to US$246.41 million.

• The aggregate funding for the mathematical sciences in the Department of Defense (DOD) agencies Air Force Office of Scientific Research (AFOSR), Army Research Office (ARO), Defense Advanced Research Project Agency (DARPA), National Security Agency (NSA), and Office of Naval Research (ONR) would decrease by 0.1 percent from FY 2009.

• The aggregate funding for the mathematical sciences in the Department of Energy (DOE) would increase by approximately 6.4 percent.

Introduction

Research in the mathematical sciences is funded primarily through the National Science Foundation, the Department of Defense (including the National Security Agency), the Department of Energy, and the National Institutes of Health (NIH). As in previous years, the majority of federal support for the mathematical sciences in FY 2010 would come from the NSF, contributing approximately 45.9 percent of the federal total. The DOD accounts for around 19.8 percent of the total and the DOE 18.3 percent, with NIH supplying around 16.0 percent.

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This article is a slightly revised version of a chapter about federal funding in the mathematical sciences in AAAS Report XXXIII, Research & Development FY 2010, published by the American Association for the Advancement of Science. The report is available on the Web at `http://www.aaas.org/spp/rd/`.

The NSF currently accounts for over 60 percent of the federal support for academic research in the mathematical sciences and is the only agency that supports mathematics research broadly across all fields. The DOD, DOE, and NIH support research in the mathematical sciences that contributes to the missions of these agencies.

DOD supports mathematical sciences research and related activities in several programs: the Directorate of Mathematics, Information, and Life Sciences and the Directorate of Physics and Electronics, within AFOSR; the Information Sciences Division within ARO; the Mathematics, Computers, and Information Sciences Research division within ONR; the Defense Sciences Program and the Microsystems Technology Office within DARPA; and the Mathematical Sciences Program within NSA.

DOE funds mathematics through its Applied Mathematics and Scientific Discovery through Advanced Computing (SciDAC) programs within the DOE Office of Advanced Scientific Computing Research. The National Institutes of Health funds mathematical sciences research primarily through the National Institute of General Medical Sciences (NIGMS) and through the National Institute of Biomedical Imaging and Bioengineering (NIBIB).

Trends in Federal Support for the Mathematical Sciences

The FY 2010 estimated aggregate spending for mathematical sciences research and related activities would be US$536.69 million, a potential increase of 5.3 percent over FY 2009 estimated spending. The NSF Division of Mathematical Sciences budget would increase by 8.9 percent in FY 2010, while the DOD agencies would decrease by 0.1 percent from FY 2009. ONR increases its spending for the mathematical sciences by 8.1 percent, while AFOSR increases its spending by 5.0 percent, and ARO's mathematics budget decreases by 6.4

percent. The mathematical sciences budget of DARPA decreases by 15.5 percent from FY 2009, and the NSA mathematics budget is flat. The DOE mathematical sciences budget increases by 6.4 percent, while NIH funding grows by 1.2 percent.

The mathematical sciences make major contributions to the country's intellectual capacity and provide the tools, insight, and capability needed for innovation and technological progress. Many disciplines depend on research in the mathematical sciences to open up new frontiers and advance discovery. Mathematical sciences research contributes to advances in areas such as medicine, cyber security, weather prediction, digital data compression and mining, aeronautics, and computing, to name a few. Even so, many mathematical scientists who are performing excellent research and who submit grant proposals deemed of very high quality are consistently either not funded or are underfunded. According to the Science and Engineering Indicators, 2008 Edition, in FY 2006, only 34.6 percent of full-time mathematics faculty having doctoral degrees received federal research support. This is much lower than most other scientific fields.

The American Recovery and Reinvestment Act of 2009 (ARRA) provided the NSF Division of Mathematical Sciences with an additional US$98.00 million over the FY 2009 appropriated amount. This enabled the division to provide support for deserving investigators who, because of lack of funds, were not supported in the past. Many of the researchers supported via Recovery funds are in the early stages of their careers. If the NSF budget, and consequently the DMS budget, fails to grow adequately in the future, the ability to support more high-quality mathematical researchers will severely diminish.

National Science Foundation (NSF)

The Division of Mathematical Sciences (DMS), `http://www.nsf.gov/div/index.jsp?div=DMS`, is housed in the NSF Directorate of the Mathematical and Physical Sciences (MPS). This directorate also contains the Divisions of Astronomical Sciences, Chemistry, Materials Research, Physics, and Multidisciplinary Activities. The DMS supports advances in the intellectual frontiers of the mathematical sciences and enables the advance of knowledge in other scientific and engineering fields.

DMS has essentially two modes of support: (1) research and education grants, and (2) institutes. Grants include individual-investigator awards; awards for groups of researchers, including multidisciplinary; educational and training awards aimed at increasing the number of U.S. students choosing careers in the mathematical sciences. DMS provides core support for five mathematical sciences research institutes, as well as major support for three other institutes. These institutes, funded on a competitive basis, serve to develop new ideas and directions in the mathematical sciences, as well as to promote interaction with other disciplines. Usually 53 percent of the DMS budget is available for new research grants and the remaining 47 percent is used primarily to fund continuing grants made in previous years.

DMS is slated to receive US$246.41 million in FY 2010, an increase of US$20.23 million or 8.9 percent over FY 2009 funding. During FY 2009, the current funding cycle for four of the mathematical sciences research institutes will end. These institutes can recompete as part of an Institute Solicitation that will be announced in FY 2010. The FY 2010 budget request can accommodate an increase in the number and size of institute awards. Four to six awards are expected as the DMS Institute budget climbs to US$26.00 million, an increase of US$6.0 million. Other programs slated to receive increases are Cyber-enabled Discovery and Innovation (CDI), +US$5.20 million to a total budget of US$10.40 million; Science and Engineering Beyond Moore's Law (SEBML), +US$2 million to US$2.75 million; Solar Energy Research (SOLAR), +US$1.70 million to US$2.40 million; and Climate Research (CR) will begin at US$1.85 million.

SEBML continues the algorithmic "Moore's Law", the exponential increase in speed of basic computations due to innovative new algorithms and new mathematical frameworks for computation. SOLAR will support multidisciplinary teams engaged in potentially transformative research on efficient harvesting, conversion, and storage of solar energy. CR will focus on development of mathematical methods and effective computational techniques needed for simulation and analysis of climate models.

Air Force Office of Scientific Research (AFOSR)

Funding for the mathematical sciences at AFOSR is found in the Directorate of Mathematics, Information, and Life Sciences and the Directorate of Physics and Electronics. The AFOSR mathematics program includes specific portfolios in dynamics and control, physical mathematics and applied analysis, computational mathematics, optimization and discrete mathematics, electromagnetics, and sensing, surveillance, and navigation. For additional information on the focus areas within each of these portfolios, refer to the Broad Area Announcement 2009-1 which can be viewed on the AFOSR public website at `http://www.afosr.af.mil`. The AFOSR FY 2010 budget for the mathematical sciences would increase by 5.0 percent over FY 2009.

Army Research Office (ARO)

The Mathematics Program, housed in the Information Sciences Division, `http://www.arl.army.mil/main/main/default.cfm?Action=29&Page=194` manages the following programs:

modeling of complex systems, computational mathematics, discrete mathematics and computer science, probability and statistics and stochastic analysis, and cooperative systems. The Mathematical Sciences Division plays an essential role in the modeling, analysis, and control of complex phenomena and large-scale systems which are of critical interest to the Army. The areas of application include communication networks, image analysis, visualization and synthetic environments, pattern recognition, test and evaluation of new systems, sensor networks, network science, robotics, and autonomous systems. The division also works closely with the Computing Sciences Division and Network Science Division of ARO to develop mathematical theory for systems control, information processing, information assurance, network design, and data fusion. The Mathematics Program budget would decrease by 6.4 percent from FY 2009.

Defense Advanced Research Projects Agency (DARPA)

The Defense Sciences Office (DSO) and the Microsystems Technology Office (MTO) inside DARPA both have mathematics programs cutting across mathematics and its applications. Current program areas include twenty-three mathematical challenges, analog-to-information, cognitively augmented design for quantum technology, discovery and exploitation of structure in algorithms, focus areas in theoretical mathematics, fundamental laws of biology, multiple optical non-redundant aperture generalized sensors, nonlinear mathematics for mixed signal microsystems, sensor topology and minimal planning, space-time adaptive processing, and topological data analysis. Further details can be found at `http://www.darpa.mil/dso/personnel/mann.htm`; `http://www.darpa.mil/dso/personnel/singpurwalla.htm`; and `http://www.darpa.mil/MTO/personnel/healy_d.html`. The aggregate DARPA mathematics budget decreases by 15.5 percent from FY 2009.

Department of Energy (DOE)

Mathematics at DOE is funded through the Office of Advanced Scientific Computing Research (ASCR), `http://www.science.doe.gov/ascr/`, one of six interdisciplinary research offices within DOE's Office of Science. Research supported by ASCR

Table 1: Federal Funding for the Mathematical Sciences (millions of dollars)#

	FY 08 Actual	FY 09 Plan	FY 09 ARRA	FY 10 Request	Change 2009–10 Amount	Change 2009–10 Percent
National Science Foundation						
DMS	211.75	226.18	98.00	246.41	20.23	8.9%
Department of Defense*						
AFOSR	36.60	47.60	00.00	50.00	2.40	5.0
ARO	12.00	12.50	00.00	11.70	-0.80	-6.4
DARPA	18.60	21.78	00.00	18.40	-3.38	-15.5
NSA	4.00	4.00	00.00	4.00	0.0	0.0
ONR	13.60	20.35	00.00	22.00	1.65	8.1
Total DOD	84.80	106.23	00.00	106.10	-0.13	-0.1
Department of Energy						
Applied Mathematics	32.15	40.16	@	44.85	4.69	11.7
SciDAC**	54.05	52.06	@	53.24	1.18	2.3
Total DOE	86.20	92.22		98.09	5.87	6.4
National Institutes of Health						
NIGMS*	45.00	47.00	@	47.00	0.00	0.00
NIBIB*	38.10	38.10	@	39.09	0.99	2.6
Total NIH	83.10	85.10		86.09	0.99	1.2
Total All Agencies	465.85	509.73	98.00	536.69	26.96	5.3

#Budget information is derived from agency documents and conversations with agency program managers and representatives.

**Estimates.*

***Scientific Discovery through Advanced Computing (SciDAC).*

@Unavailable at time of writing.

underpins computational science throughout DOE. ASCR funding for the mathematical sciences is found primarily in the Applied Mathematics program and the Scientific Discovery through Advanced Computing (SciDAC) program. The Applied Mathematics activity supports the research, development, and application of applied mathematical models, methods and algorithms to understand complex physical, chemical, biological, and engineered systems related to the department's mission. For example, the topics of supported research efforts include (1) numerical methods for the solution of systems of partial differential equations, large-scale linear or nonlinear systems, or very large parameter-estimation problems; (2) analytical or numerical techniques for modeling complex physical, biological or engineered phenomena, such as fluid turbulence, microbial populations, or network systems; (3) analytical or numerical methods for bridging a broad range of temporal and spatial scales; (4) optimization, control, and risk analysis of complex systems, such as computer networks and electrical power grids; and (5) mathematical research issues related to analysis of petascale data. The FY 2010 Applied Mathematics program budget will support the long-term cybersecurity and complex network systems challenges of open science that was transferred from Next Generation Networking for Science initiated in FY 2009 and will also support a new fellowship program for graduate students and young investigators in applied mathematics and high-performance computer science. In FY 2010 the Computational Partnerships activity will support a small number of new interdisciplinary teams focused on transforming critical DOE applications for extreme scale computing. These competitively selected teams will evaluate the impact of directions in computer hardware on application capability. They will form a critical interface to existing SciDAC Centers and Institutes on the tool and library implications of these developments and develop the understanding needed to enable these applications to execute effectively on future computer architectures. Aggregate funding for the mathematical sciences would increase by 6.4 percent over FY 2009.

National Institutes of Health (NIH)

NIH funds mathematical sciences research through the National Institute of General Medical Sciences (NIGMS) and the National Institute of Biomedical Imaging and Bioengineering (NIBIB). Mathematical sciences areas of interest are those that support the missions of NIGMS and NIBIB. The NIGMS Center for Bioinformatics and Computational Biology supports research in areas that join biology with the computer sciences, engineering, mathematics, and physics. The Center manages programs in computational biology, such as the generation of mathematical models of biological networks, the development of modeling and simulation tools, the conduct of basic theoretical studies related to network organization and dynamic processes, and the development of methods for the analysis and dissemination of computational models. NIGMS is currently supporting a biomathematics initiative at around US$12 million per year in cooperation with the National Science Foundation. NIBIB supports the mathematical sciences through its Mathematical Modeling, Simulation and Analysis Program Area. The aggregate budget for the mathematical sciences in NIBIB and NIGMS would increase by 1.2 percent over FY 2009.

National Security Agency (NSA)

The Mathematical Sciences Program of the NSA administers a Grants Program that supports fundamental research in the areas of algebra, number theory, discrete mathematics, probability, and statistics. The Grants Program also accepts proposals for conferences and workshops in these research areas. In addition to grants, the Mathematical Sciences Program supports an in-house faculty Sabbatical Program. The program administrators are especially interested in funding initiatives that encourage the participation of underrepresented groups in mathematics (such as women, African-Americans, and other minorities). As the largest employer of mathematicians in the United States, NSA has a vested interest in maintaining a healthy academic mathematics community in the United States. For more information, see the website `http://www.nsa.gov/msp/index.cfm`. The NSA mathematics budget would remain unchanged from FY 2009.

Office of Naval Research (ONR)

The ONR Mathematics, Computers, and Information Research Division's scientific objective is to establish rigorous mathematical foundations and analytical and computational methods that enhance understanding of complex phenomena and enable prediction and control for naval applications in the future. Basic research in the mathematical sciences is focused on analysis and computation for multiphase, multimaterial, multiphysics problems; predictability of models for nonlinear dynamics; electromagnetic and acoustic wave propagation; signal and image analysis and understanding. Also of interest are modeling pathological behaviors of large, dynamic complex networks and exploiting hybrid control to achieve reliability and security; optimization; formal methods for verifiably correct software construction. For more information see the website, `http://www.onr.navy.mil/sci_tech/31/311/default.asp`. The Mathematical, Computer, and Information Sciences Division's budget would increase by 8.1 percent over FY 2009.

Note: Information gathered from agency documents and from agency representatives.

2008 Annual Survey of the Mathematical Sciences in the United States

(Third Report)

Faculty Profile
Enrollment and Degrees Awarded Profile
Graduate Student Profile

Polly Phipps, James W. Maxwell, and Colleen A. Rose

Introduction

The Annual Survey of the Mathematical Sciences collects information each year about departments, faculties, and students in the mathematical sciences at four-year colleges and universities in the United States. The information presented in this report was gathered on a questionnaire called the Departmental Profile which was mailed to all mathematical sciences departments in Groups I, II, III, IV, Va, and M and to a stratified random sample drawn from Group B. The questionnaire gathered information about the number of faculty in various categories, the recruitment of new faculty, undergraduate and graduate course enrollments, number of bachelor's and master's degrees awarded during the preceding year, and the number of graduate students, all as of fall 2008. The 2008 First Report, Part II, presented data collected earlier about faculty salaries (pages 388–94 of the March 2009 issue of *Notices of the AMS)*. Definitions of the various departmental groupings used in the Annual Survey reports can be found on page 1300 of this report.

The careful reader will note that a row or column total may differ slightly from the sum of the individual entries. All the table entries are the rounded values of the individual projections associated with each entry, and the differences are the result of this rounding (as the sum of rounded numbers is not always the same as the rounded sum). Further details on the statistical procedures used with the survey are described on page 1300.

This Third Report of the 2008 Annual Survey gives information about faculty size, departmental enrollments, majors, and graduate students for departments of mathematical sciences in four-year colleges and universities in the United States.

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.

Faculty Size

Table 1A gives the number of faculty for different categories of faculty broken down by survey group, Table 1B gives the same information for females only, and Table 1C gives some percentages based on the information in Tables 1A and 1B. The estimated total number of full-time faculty in the mathematics groups (Groups I, II, III, Va, M, and B combined) is 22,166, with a standard error of 367, up 696 from last year. The doctoral mathematics departments (Groups I, II, III, and Va) full-time

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Highlights

Changes in the numbers of faculty from 2007 to 2008 were modest. The estimated number of full-time faculty in all mathematics departments combined is 22,166, up 3% from 21,470 last year. Almost all of this increase is due to the increase in the 2008 count of full-time faculty in Group B departments. The number of nondoctoral full-time faculty is 3,977, up slightly from 3,839 last year. The number of part-time faculty is 6,700, down 5% from 7,065 last year.

For the doctoral math departments combined, the number of full-time non-tenure-track doctorate-holding faculty continued its slow but steady climb since 2001. This number reached 1,601 for 2008, up 30% over its 2001 figure of 1,233. Faculty holding a postdoctoral position have been tracked separately since 2003 and for the second consecutive year, this category accounted for just over half of the non-tenure-track faculty reported by the doctoral math departments.

For the combined mathematics departments, women comprised 28% of the full-time faculty in fall 2008. For the doctoral mathematics departments combined, women comprised 13% of the doctoral-holding tenured and tenure-track faculty and 25% of the doctoral-holding non-tenure-track faculty in fall 2008. For Group M faculty these same percentages are 26 and 32 respectively, and for Group B faculty they are 25 and 26 respectively. Among the nondoctoral full-time faculty in all math departments combined, women comprise 55%. All percentages are in line with those of the past two years, though definitely up from those of 2001 for all but Group B departments.

For all mathematics departments combined, the number of full-time positions under recruitment during 2007-2008 increased 13% over the 2006-2007 figure, reaching a high of 2,012. This is larger than any such number reported over the past thirteen years, save for the 2000-2001 academic year. The number of tenured/tenure-track positions under recruitment during this period was 1,213, up 7% from the previous year's figure of 1,131. The number of full-time positions filled was 1,816, with 978 of these tenured/tenure-track positions. These figures are up 22% and 21%, respectively, from the figures reported for fall 2007. Again, most of the increase in these estimates comes from Group B departments.

For all mathematics departments combined, the number of new doctoral hires for positions beginning in fall 2008 was up 20% from the previous year's number, to 758. On the other hand, there was a substantial decline in the umber of new doctoral recipients obtaining tenure-track positions for fall 2008 with 284 such hirings reported compared to 331 reported for fall 2007. At the same time, the number of non-tenure-track positions filled by new doctoral recipients increased from 303 in fall 2007 to 474 in fall 2008. All of this increase in hiring is the result of the increases in hiring into non-tenure-track positions by Group M and B departments.

Among the 253 individuals hired into tenure-track positions in the doctoral mathematics departments, 136 held a non-tenure-track position when hired and 34% of these were postdoctoral positions. For the 725 individuals hired into tenure-track positions in Groups M and B combined, 29% (211) held a non-tenure-track position when hired and 6% of these were postdoctoral positions.

The reported number of full-time graduate students at doctoral mathematics departments decreased slightly for the second consecutive year from 10,937 to10,883 for fall 2008. The number and percentage of women among these graduate students also decreased slightly to 3,193 (29%.) The percent of U.S. citizens among the total full-time graduate students remained steady at 56%. The percentage of underrepresented minorities among the U.S. citizen graduate students remains steady 10%, in line with the figures for the prior years.

faculty has remained relatively stable at 8,055, Group M is up 87 faculty members, and Group B is up 608. The total faculty size in the statistics and biostatistics group (Group IV) is up to 1,749 this year from 1,691 last year.

This year the estimated number of part-time faculty in Groups I, II, III, Va, B, and M combined is 6,700, down 5% from last year's 7,065. The number of non-tenure-track doctoral faculty (including postdoctoral positions) is estimated at 2,364 this year, up 9% from 2,170 last year. The number of nondoctoral full-time faculty is estimated at 3,977 in Groups I, II, III, Va, M, and B combined, up from 3,839 last year, a 4% increase. In Group IV the number of part-time faculty decreased from 149 last year to 143 this year, and the number of non-tenure-track doctoral faculty increased from 378 last year to 386 this year due to the increased number of postdoctoral appointments.

Table 1D gives an eight-year history of tenured/tenure-track, and non-tenure-track doctorate-holding faculty, and all part-time faculty for Groups I, II, III, and Va combined, for Group M, and for Group B. Also shown for each number in this table is the percentage of females. Comparing the 2008 values to the 2001 values, we see that for Groups I, II, III, and Va combined the number of tenured/tenure-track faculty is up 2%, the number of non-tenure-track faculty is up 30%, and the number of part-time faculty is down 20%. For Group M, the number of tenured/tenure-track faculty is up 7%, the number of non-tenure-track faculty is up 26%, and the number of part-time faculty is down 21%. Finally in Group B, the number of tenured/tenure-track faculty is up 19%, the number of non-tenure-track faculty is up 6%, and the number of part-time faculty is down 12%.

Table 1E gives a summary of the various types of faculty found in departments of mathematical sciences by gender and group.

Tables 1F and 1G give more information about two types of faculty: full-time faculty without a doctorate and part-time faculty. The Table 1F shows the information for the 3,977 full-time faculty in the mathematics departments who do not have doctoral degrees. The majority of these faculty, 3,211 (81%), are found in Groups M and B

Table 1A: Total Faculty, Fall 2008

	GROUP									
	I Public	I Private	II	III	Va	I, II, III, & Va	M	B	I, II, III, Va, M, & B	IV
Total full-time faculty *(Standard error)*[1]	**1793**	**1045**	**2622**	**2301**	**293**	**8055** *(61)*	**4578** *(69)*	**9533** *(361)*	**22166** *(367)*	**1749** *(35)*
Doctoral full-time faculty	1708	1041	2346	1913	282	7289	3635	7265	18189	1659
Tenured	1060	583	1550	1269	168	4631	2535	4820	11985	856
Untenured, tenure-track	208	81	328	394	47	1058	868	1913	3839	417
Postdoctoral appointments	251	259	243	58	39	851	22	18	891	112
Other non-tenure-track	189	118	224	191	28	750	209	514	1473	274
Nondoctoral full-time faculty *(Standard error)*[1]	85	4	277	389	11	766 *(20)*	943 *(34)*	2268 *(158)*	3977 *(161)*	89 *(6)*
Total part-time faculty *(Standard error)*	**193**	**29**	**403**	**521**	**26**	**1172** *(29)*	**1824** *(75)*	**3703** *(303)*	**6700** *(309)*	**143** *(13)*

[1] See 'Remarks on Statistical Procedures' page 1300.

departments. Table 1G shows the part-time faculty broken down by gender and whether they have a doctoral degree. Comparing Table 1G to last year's table, we see an overall decrease in part-time faculty with the largest decrease (13%) in Group M and B part-time male faculty from 3,467 last year to 3,078 this year; a reflection of the decline in Group B (from 2,319 to 1,692).

Female Faculty

Table 1B gives a complete breakdown of all categories of female faculty by group. For 2008–2009 the estimated total number of full-time faculty in Groups I, II, III, Va, M, and B combined is 22,166 of which 6,118 are females. Females comprise 28% of the full-time faculty up from 27% (5,891) in 2007–2008. In Group B the estimated number of doctoral female faculty decreased from 1,863 last year to 1,825 this year, tenured female faculty increased from 1,123 to 1,137, untenured but tenure-track female faculty decreased from 620 to 552, and non-tenure-track doctoral female faculty (including postdoctoral appointments) increased from 119 to 136. In Group M the doctoral full-time female faculty increased from 925 last year to 961 this year.

Table 1C compares the number of full-time and female full-time faculty that fall into each reporting group for fall 2008. The percentage who are female in each group is given in the bottom row of Table 1C. These percentages vary considerably among the groups, from a low of 14% for Groups I Public and I Private to a high of 32% for Groups M and B.

Table 1D contains information about the percentage of female faculty among the tenured/tenure-track and non-tenure-track doctoral full-time faculty and among the part-time faculty for the years 2001 to 2008.

Table 1E gives the male/female breakdown by count and percentage for Groups I, II, III, and Va combined, Groups M and B combined, and Group IV for various categories of faculty. It shows that the percentage of women is generally higher in statistics (Group IV) than in the doctoral mathematics groups (Groups I, II, III, and Va combined) and that the percentage of tenured faculty who are women is highest in Groups M and B combined.

Table 1F shows that of the 3,977 nondoctoral full-time faculty in Groups I, II, III, Va, M, and B combined, 2,186 (55%) are females. From Table 1G we see that in these same groups there are 6,700 part-time faculty, of which 2,889 (43%) are females.

Faculty Recruitment

Table 2A contains detailed information on the number of full-time doctoral faculty positions under recruitment during 2007–2008 for employment beginning in the academic year 2008–2009. Among mathematics departments (Groups I, II, III, Va, M, and B), 2,012 positions were under recruitment, up 13% compared to those under recruitment during 2006-2007. Of those 2,012 positions, 1,776 (88%) were available to new doctoral recipients, and of those 1,776 positions, 1,081 (61%) were tenured/tenure-track positions. The 1,081 tenured/tenure-track positions open to new doctoral recipients is up 16% from the 935 such positions under recruitment in 2006–2007 primarily reflecting increases in Groups I and II. The total number of tenured/tenure-track full-time doctoral positions under recruitment in Groups I, II, III, Va, M, and B combined is 1,213, up from last year's 1,131 (an increase of 7%). In Groups I, II, III, and Va combined, the total number of posted doctoral positions open at the associate/full level decreased from 126 last year to 96 this year.

Table 2B condenses the information in Table 2A. It also reorganizes the doctoral hires into one

Table 1B: Female Faculty, Fall 2008

	GROUP									
	I Public	I Private	II	III	Va	I, II, III, & Va	M	B	I, II, III, Va, M, & B	IV
Female full-time faculty	**253**	**142**	**565**	**586**	**50**	**1596**	**1455**	**3067**	**6118**	**525**
(Standard error)						*(22)*	*(28)*	*(179)*	*(181)*	*(14)*
Doctoral full-time faculty	202	140	388	373	43	1146	961	1825	3932	480
Tenured	72	43	154	183	16	468	577	1137	2182	170
Untenured, tenure-track	55	18	81	110	8	272	311	552	1135	153
Postdoctoral appointments	34	44	51	15	11	154	9	9	172	38
Other non-tenure-track	41	36	102	65	8	251	64	127	442	119
Nondoctoral full-time faculty	51	2	178	213	7	450	494	1242	2186	45
Female part-time faculty	64	4	154	209	7	439	759	1692	2889	54

Table 1C: Full-Time Faculty, Fall 2008

	GROUP								
	I Public	I Private	II	III	Va	M	B	IV	TOTAL
Full-time faculty	**1793**	**1045**	**2622**	**2301**	**293**	**4578**	**9533**	**1749**	**23914**
Percentage of total full-time faculty	*8%*	*4%*	*11%*	*10%*	*1%*	*19%*	*40%*	*7%*	*100%*
Female full-time faculty	253	142	565	586	50	1455	3067	525	6643
Percentage of total female full-time faculty	*4%*	*2%*	*9%*	*9%*	*1%*	*22%*	*46%*	*8%*	*100%*
Percentage of total female faculty within group	*14%*	*14%*	*22%*	*25%*	*17%*	*32%*	*32%*	*30%*	*28%*

Table 1D: Mathematics Faculty Counts and Percentage Female, Fall 2001-2008

	2001	2002	2003	2004	2005	2006	2007	2008
Groups I, II, III, & Va								
Doctoral full-time faculty								
Tenured/tenure-track	**5598**	**5616**	**5559**	**5604**	**5686**	**5668**	**5709**	**5688**
Percentage female	*10%*	*10%*	*10%*	*11%*	*11%*	*12%*	*12%*	*13%*
Non-tenure-track	**1233**	**1274**	**1343**	**1314**	**1401**	**1461**	**1576**	**1601**
Percentage female	*21%*	*23%*	*25%*	*25%*	*24%*	*25%*	*25%*	*25%*
Part-time faculty	**1467**	**1504**	**1389**	**1355**	**1054**	**1128**	**1143**	**1172**
Percentage female	*38%*	*35%*	*35%*	*37%*	*37%*	*40%*	*37%*	*37%*
Group M								
Doctoral full-time faculty								
Tenured/tenure-track	**3191**	**3188**	**3005**	**3113**	**3351**	**3400**	**3325**	**3403**
Percentage female	*23%*	*22%*	*22%*	*23%*	*24%*	*25%*	*25%*	*26%*
Non-tenure-track	**183**	**276**	**230**	**277**	**263**	**283**	**232**	**231**
Percentage female	*24%*	*39%*	*33%*	*48%*	*36%*	*28%*	*38%*	*32%*
Part-time faculty	**2323**	**2393**	**1952**	**1888**	**1842**	**1493**	**1868**	**1824**
Percentage female	*36%*	*37%*	*37%*	*37%*	*37%*	*41%*	*39%*	*42%*
Group B								
Doctoral full-time faculty								
Tenured/tenure-track	**5665**	**5569**	**6172**	**5770**	**6875**	**6623**	**6427**	**6733**
Percentage female	*24%*	*23%*	*26%*	*25%*	*25%*	*27%*	*27%*	*25%*
Non-tenure-track	**504**	**507**	**460**	**472**	**516**	**545**	**363**	**532**
Percentage female	*29%*	*36%*	*20%*	*29%*	*32%*	*25%*	*33%*	*26%*
Part-time faculty	**4197**	**4117**	**3997**	**4846**	**3630**	**3922**	**4053**	**3703**
Percentage female	*43%*	*45%*	*42%*	*44%*	*41%*	*40%*	*43%*	*46%*

section for new doctoral hires and another for other doctoral hires (so excludes posted doctoral positions that were temporarily filled with a person without a doctorate). Table 2C is derived from Table 2B, with the percentage of the filled positions that were tenured/tenure-track included in the table.

This year the estimated total number of new doctoral hires in mathematics departments is up 20% (to 758 from 634) from last year; it is down 6% (to 280 from 298) in Groups I, II, III, and Va combined, and up 43% (to 478 from 335) in Groups M and B combined. The number of new doctoral tenure-track hires in the math groups combined is down 14% as a result of a decrease in Groups M & B combined (down to 226 from 283). Among the new doctoral hires in Groups I, II, III, and Va combined, 19% of all males and 27% of all females took tenure-track positions. In contrast, for new doctoral hires in Groups M and B combined, 24% of all males and 89% of all females took tenure-track positions. From Table 2C we see that in Groups I, II, III, and Va 21% of the hires of new doctoral recipients are in tenured/tenure-track positions (up from 16% last year), while in Groups M and B 47% of the new doctoral hires are in tenured/tenure-track positions (down from 84% last year).

Table 1E: Summary of Full-Time and Part-Time Faculty, Fall 2008

	GROUP					
	I, II, III, & Va		M & B		IV	
	Male	Female	Male	Female	Male	Female
Full-time faculty	**6459**	**1596**	**9589**	**4522**	**1224**	**525**
Percentage	*80%*	*20%*	*68%*	*32%*	*70%*	*30%*
Doctoral full-time faculty	6143	1146	8113	2786	1179	480
Percentage	*84%*	*16%*	*74%*	*26%*	*71%*	*29%*
Tenured	4162	468	5641	1714	686	170
Percentage	*90%*	*10%*	*77%*	*23%*	*80%*	*20%*
Untenured, tenure-track	786	272	1918	863	264	153
Percentage	*74%*	*26%*	*69%*	*31%*	*63%*	*37%*
Postdoctoral appointments	697	154	22	18	74	38
Percentage	*82%*	*18%*	*54%*	*46%*	*66%*	*34%*
Other non-tenure-track	498	251	533	191	155	119
Percentage	*66%*	*34%*	*74%*	*26%*	*57%*	*43%*
Nondoctoral full-time faculty	315	450	1475	1736	45	45
Percentage	*41%*	*59%*	*46%*	*54%*	*50%*	*50%*
Part-time faculty	**733**	**439**	**3077**	**2450**	**89**	**54**
Percentage	*63%*	*37%*	*56%*	*44%*	*62%*	*38%*

Table 1F: Nondoctoral Full-Time Faculty, Fall 2008

Full-time Faculty	GROUP							
	I, II, III, & Va		M		B		IV	
	Male	Female	Male	Female	Male	Female	Male	Female
Without a Doctorate	**315**	**450**	**449**	**494**	**1026**	**1242**	**45**	**45**
Tenured	14	10	67	37	393	242	2	0
Untenured, tenure-track	3	1	13	6	54	179	1	0
Postdoctoral appointments	1	0	0	0	0	0	0	0
Other non-tenure-track	297	439	369	451	579	821	41	45

Table 1G: Part-Time Faculty, Fall 2008

Part-time Faculty	GROUP							
	I, II, III, & Va		M		B		IV	
	Male	Female	Male	Female	Male	Female	Male	Female
Doctoral	316	101	227	110	553	219	71	33
Nondoctoral	417	338	839	648	1459	1473	18	21
Total	733	439	1066	759	2012	1692	89	54

From Table 2B we find that the total number of full-time doctoral positions filled in mathematics departments (Groups I, II, III, Va, M, and B combined) is 1,688 up from 1,385 last year (a increase of 22%); it is down 4% in Groups I, II, III, and Va combined and up 46% in Groups M and B combined. This year Groups I, II, III, and Va combined filled 635 doctoral positions, of which 253 (40%) were tenured/tenure-track positions. Last year these same groups filled 663 doctoral positions, of which 268 (40%) were tenured/tenure-track. Groups M and B combined filled 1,053 doctoral positions this year, and 725 (69%) of these were tenured/tenure-track positions. Last year these two groups filled 722 doctoral positions, of which 543 (75%) were tenured/tenure-track.

Departments were asked to report the number of doctoral hires into tenured/tenure-track positions filled by individuals who held a non-tenure-track position the previous year and of those, how many were in postdoctoral appointments. For Groups I, II, III, and Va combined, 136 individuals reported having held a non-tenure-track position the previous year (54% of the 253 tenure-track hires), with 86 (34%) having held a postdoctoral appointment the previous year. This compares with last year's figure of 115 (43%) positions filled by individuals who held a postdoctoral appointment the previous year. For Groups M and B combined, 211 individuals (29% of the 723 tenure-track hires) reported having held a non-tenure-track position the previous year, with 44 (6%) having held a postdoctoral appointment the previous year. This compares with last year's figure

Table 2A: Recruitment of Faculty with a Doctorate, Fall 2008

	GROUP									
	I Public	I Private	II	III	Va	I, II, III, & Va	M	B	I, II, III, Va, M, & B	IV
Posted Doctoral Positions										
Total number[1]	**170**	**143**	**238**	**147**	**24**	**723**	**327**	**959**	**2012**	**185**
(Standard error)						*(21)*	*(27)*	*(114)*	*(118)*	*(20)*
Tenured/tenure-track	71	43	126	112	14	367	252	593	1213	152
Open to new doctoral recipients	126	106	186	136	21	575	307	892	1776	129
Tenured/tenure-track	43	9	88	98	11	249	241	589	1081	98
Open at assoc/full level	25	19	25	23	3	96	39	60	195	71
Reported Hires for Above										
Total number	**149**	**129**	**215**	**135**	**18**	**646**	**275**	**893**	**1816**	**106**
Male doctoral hires	112	101	167	93	14	486	168	587	1243	69
Tenured/tenure-track	35	18	66	62	7	187	131	330	648	64
Female doctoral hires	35	26	46	38	5	148	70	226	444	35
Tenured/tenure-track	14	6	15	29	1	66	57	207	330	26
Male temporary hires	1	1	0	3	0	5	26	71	102	2
Female temporary hires	1	1	3	1	0	6	11	9	26	0
Total new doctoral hires	**56**	**75**	**90**	**49**	**9**	**280**	**106**	**371**	**758**	**47**
Male new doctoral hires	42	63	67	33	6	210	68	237	515	36
Tenured/tenure-track	4	3	11	21	0	39	44	28	111	26
Female new doctoral hires	14	13	23	16	3	70	38	135	243	10
Tenured/tenure-track	4	0	3	13	0	19	28	126	173	9
Unfilled positions	**21**	**14**	**23**	**13**	**6**	**77**	**52**	**66**	**196**	**62**

[1] Number of full-time doctoral positions under recruitment in 2007–2008 to be filled for 2008–2009.

Table 2B: A Summary of Recruitment of Faculty with a Doctorate, Fall 2008

	GROUP		
	I, II, III, & Va	M & B	IV
Posted Doctoral Positions			
Total number	**723**	**1289**	**185**
Tenured/tenure-track	367	846	152
Open to new doctoral recipients	575	1201	129
Tenured/tenure-track	249	832	98
Reported Hires for Above, excluding temporary hires			
Total doctoral hires	**635**	**1053**	**104**
Tenured/tenure-track	253	725	90
Previously in non-tenure-track	136	211	21
Previously in postdoc	86	45	16
Total new doctoral hires[1]	**280**	**478**	**47**
Tenured/tenure-track	58	226	35
Male	210	305	36
Tenured/tenure-track	39	72	26
Female	70	173	10
Tenured/tenure-track	19	154	9
Total not-new doctoral hires	**355**	**575**	**57**
Tenured/tenure-track	195	499	55
Male	276	452	33
Tenured/tenure-track	148	388	38
Female	78	123	24
Tenured/tenure-track	47	110	17

[1] New doctoral hires are individuals who have held a doctorate for less than one year at the time of hiring.

of 67 (12%) positions filled by individuals who held a postdoctoral appointment the previous year.

The estimated number of not-new doctoral hires in mathematics departments is 930, up from 750 last year. The total of not-new doctoral hires into tenured/tenure-track positions in all the mathematics groups combined is 694, up 45% from last year. It is down 11% in Groups I, II, III, and Va combined (to 195 from 220 last year), and up 93% in Groups M and B combined (499 from 259).

Figure 1 shows the number of full-time doctoral positions posted for all groups combined except Group IV, as well as the number of those that were tenured/tenure-track for the years 1996 to 2008. The number of positions posted and the number of available tenured/tenure-track positions steadily increased, reaching a maximum in 2001. Over the last eight years these numbers have shown some variability with this year's total number of posted positions being the highest reported since 2001.

Figure 1A shows the number of full-time doctoral positions filled for all groups combined, except Group IV, as well as the number of tenured/tenure-track for the years 2001 to 2008. This year the number of tenured/tenure-track positions has reached a seven-year high, just slightly higher than the number reported for fall 2001.

Faculty Attrition

Table 3 displays losses of full-time mathematical sciences faculty due to retirements and deaths between 1 September 2007 and 31 August 2008 for each departmental grouping. The fall 2008 faculty attrition rate for Groups I, II, III, Va, M, and B combined is 2.2%, and it is 1.3% for Group IV. For fall 2008, Group I (Pr) had the lowest attrition rate at 0.9%, while Group I (Pu) had the highest at 2.8%.

Figure 2 shows the trends in these attrition rates between 1995 and 2008. While the rates vary

Figure 1: Number of Full-Time Doctoral Positions under Recruitment
Groups I, II, III, Va, M, & B Combined, Fall 1996 to Fall 2008

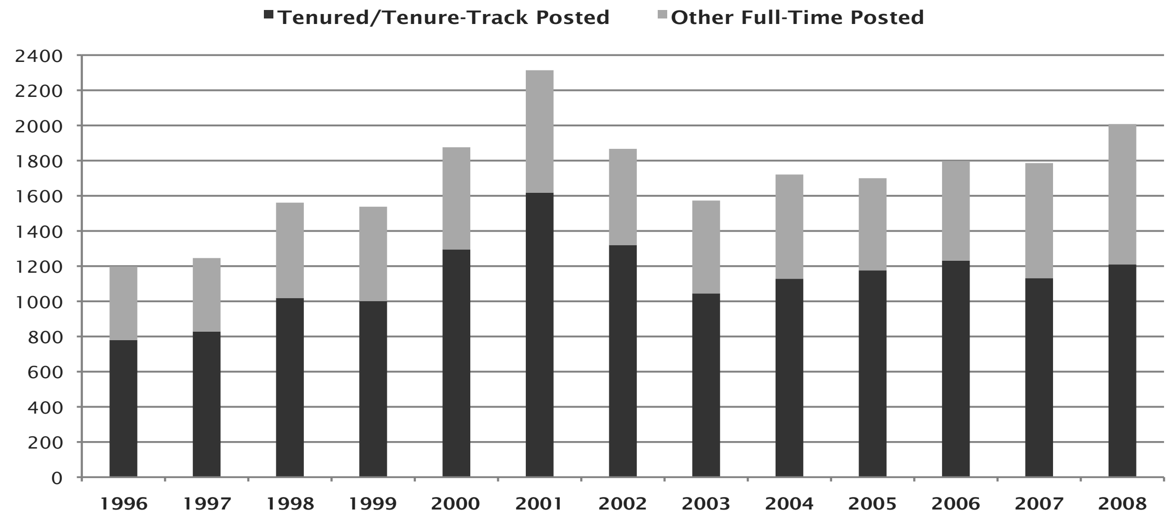


Figure 1A: Number of Full-Time Doctoral Positions Filled
Groups I, II, III, Va, M, & B Combined, Fall 2001 to Fall 2008

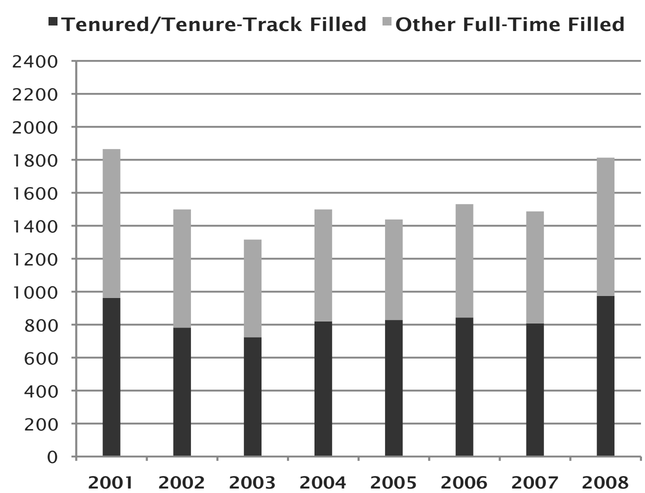


Table 2C: Positions Posted and Filled, Fall 2008

Positions	GROUP I, II, III, & Va	GROUP M & B	GROUP IV
Posted positions opened to new doctoral recipients	575	1201	129
% tenured/tenure-track	*43%*	*69%*	*76%*
Positions filled by new doctoral recipients	280	478	47
% tenured/tenure-track	*21%*	*47%*	*74%*
Positions filled by not-new doctoral recipients[1]	355	575	57
% tenured/tenure-track	*55%*	*87%*	*96%*

[1] Not-new doctoral recipients are individuals who have held their doctorate for more than one year.

from group to group and from year to year within each group, for most of the 1990s the dominant tend was one of increasing attrition for all groups combined. In the late 1990s attrition leveled off then began dropping in 2003, reaching the smallest rate of attrition this year.

Enrollment Profile and Degrees Awarded Profile

The Departmental Profile Survey obtained information about course enrollments and numbers of undergraduate degrees awarded in mathematical sciences departments. Tables 4A and 4B give the total undergraduate and total graduate enrollments in mathematics courses in fall 2008 for each group. The estimated total undergraduate enrollment in fall 2008 for all groups combined is 2,231,000. Table 4A gives these totals for fall 2003 to fall 2008. Total undergraduate enrollments for all groups combined is relatively unchanged from last year; Group B is the only group showing a decline (8%).

The historical data on enrollment numbers presented in Tables 4A and 4B for fall 2003 to fall 2008 suggest a trend of gradually increasing undergraduate and graduate enrollments.

Table 3: Faculty Deaths & Retirements,[1] Fall 2008

	GROUP									
	I Public	I Private	II	III	Va	I, II, III, & Va	M	B	I, II, III, Va, M, & B	IV
Full-time faculty who retired or died										
Total number	50	9	51	53	6	169	120	196	484	22
(Standard error)						*(7)*	*(11)*	*(31)*	*(33)*	*(4)*
Percentage	2.8%	0.9%	1.9%	2.3%	2.0%	2.1%	2.6%	2.1%	2.2%	1.3%

[1] Number and percentage of full-time faculty who were in the department in fall 2006 but were reported to have retired or died by fall 2008.

Figure 2: Faculty Retired/Died

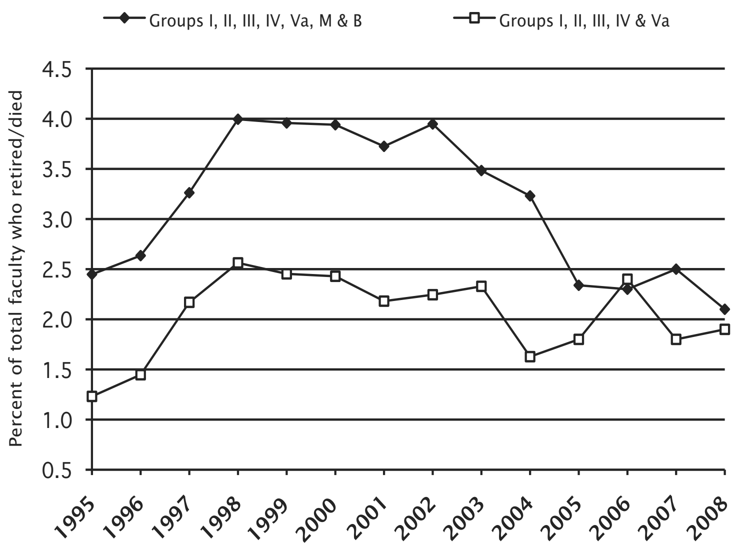


Table 4C gives the undergraduate enrollments per faculty member and the graduate enrollments per faculty member for each group. Table 4D gives the undergraduate enrollments per faculty member in each group for fall 2003 to fall 2008. With fall 2008 we see a slight increase in all groups except Group B. For a comprehensive survey of undergraduate courses, please refer to the report of the 2005 CBMS survey. This publication is available from the AMS website at `www.ams.org/cbms/`.

Undergraduate and Master's Degrees

Tables 5A and 5C display the (estimated) number of undergraduate and master's degrees reported for 2007–2008 for each departmental group. Table 5B shows the total undergraduate degrees awarded for the period 2003–2004 through 2007–2008. The number of undergraduate degrees awarded has increased from 23,930 in 2007 to 26,602 in 2008. Table 5D shows the total number of master's degrees awarded for the period 2003–2004 through 2007–2008. The number of master's degrees awarded in mathematics decreased from 4,291 reported in 2007 to 4,265 reported in 2008.

The reader should be aware that at least 40 of the 188 departments in the 2008 Group M population and at least 277 of the 1,039 departments in the 2008 Group B population also offer a computer science program in addition to their offerings in mathematics. In some instances, these computer programs account for a significant fraction of the department's undergraduate degrees. This year's estimated 26,602 undergraduate degrees awarded includes 1,045 in statistics and 2,347 in computer science. (The report of the 2005 CBMS survey provides a more comprehensive study of departmental bachelor's degrees.) Of the 4,265 master's degrees awarded, 375 were in statistics, and 402 were in computer science.

Graduate Student Profile

Table 6A summarizes information gathered by the 2008 Departmental Profile survey about graduate students enrolled in fall 2008. This table gives the number of full-time, full-time first-year, and part-time graduate students for each group of graduate departments. These same numbers are also given for female graduate students and for U.S. citizen graduate students.

The estimated total number of graduate students in all mathematics groups combined increased from 14,148 in 2007 to 14,279 in 2008, and the total number of full-time graduate students in Groups I, II, III, and Va combined decreased from 10,937 in 2007 to 10,883 in 2008. The number of U.S. citizen full-time graduate students in Groups I, II, III, and Va combined decreased 2% to 6,012. The number of first-year full-time students in Groups I, II, III, and Va combined decreased from 2,964 last year to 2,924 this year. The number of female full-time graduate students in Groups I, II, III, and Va combined decreased from 3,249 to 3,193.

In Group IV the number of full-time graduate students increased by 7% to 4,499 and the number of U.S. citizen full-time graduate students increased by 13% to 1,876. The first-year full-time graduate students in Group IV increased by 144 to 1,415 and the number of first-year full-time U.S. citizens remained stable at 561. The number of female full-time graduate students in Group IV increased from 2,020 to 2,113, a 5% increase.

The percentage of full-time graduate students who are U.S. citizens in the mathematics groups combined is 55% while the percentage of full-time graduate students who are U.S. citizens in Group IV is 42%; the percentage of women is 32% in mathematics groups combined and 47% in Group IV. The number of full-time graduate students in Group M increased from 3,211 to 3,396.

Table 4A: Total Undergraduate Course Enrollments (thousands)

Fall	GROUP								
	I Public	I Private	II	III	Va	M	B	IV	Total
2003	185	41	283	255	17	498	774	72	**2125**
2004	159	42	277	261	16	492	782	72	**2101**
2005	177	43	273	249	12	509	872	70	**2205**
2006	172	43	290	251	15	496	826	77	**2170**
2007	172	43	297	253	17	474	896	78	**2228**
2008	175	45	313	268	17	499	823	91	**2231**
(Standard error)[1]	*(0)*	*(1)*	*(6)*	*(4)*	*(0)*	*(10)*	*(40)*	*(3)*	*(50)*

[1] Standard errors reported as zero reflect rounding of values that are less than 500.

Table 4B: Total Graduate Course Enrollments (thousands)

Fall	GROUP							
	I Public	I Private	II	III	Va	M	IV	Total
2003	10	5	11	11	2	16	31	87
2004	9	4	12	10	2	12	31	81
2005	10	4	13	9	2	16	29	84
2006	9	4	13	10	2	15	29	82
2007	10	4	13	12	3	14	32	89
2008	11	5	13	13	3	15	31	90
(Standard error)[1]	*(0)*	*(0)*	*(0)*	*(0)*	*(0)*	*(1)*	*(1)*	*(1)*

[1] Standard errors reported as zero reflect rounding of values that are less than 500.

Table 4C: Undergraduate and Graduate Enrollments per Full-Time Faculty Member, Fall 2008

Fall	GROUP							
	I Public	I Private	II	III	Va	M	B	IV
Undergraduate Course Enrollments Number per full-time faculty member	97	43	119	117	60	109	86	52
Graduate Course Enrollments Number per full-time faculty member	6	5	5	6	9	3	—	18

Table 4D: Undergraduate Enrollments per Full-Time Faculty Member

Fall	GROUP							
	I Public	I Private	II	III	Va	M	B	IV
2003	104	42	113	121	46	121	89	46
2004	90	44	113	126	49	120	89	49
2005	96	44	108	116	43	113	91	43
2006	98	43	105	113	56	106	82	45
2007	96	42	109	114	56	105	100	46
2008	97	43	119	117	60	109	86	52

Table 5A: Undergraduate Degrees Awarded
(between July 1, 2007 and June 30, 2008)

	GROUP								
	I Public	I Private	II	III	Va	M	B	I, II, III, Va, M, & B	IV
Total Undergraduate Degrees Awarded	**2200**	**1039**	**2479**	**1911**	**262**	**4963**	**13748**	**26602**	**563**
(Standard error)	*(53)*	*(23)*	*(59)*	*(36)*	*(0)*	*(332)*	*(963)*	*(1023)*	*(43)*
Statistics only	35	4	66	84	0	161	694	1045	323
Computer science only	14	13	7	114	0	520	1681	2347	11
Female Undergraduate Degrees Awarded	**626**	**269**	**888**	**783**	**73**	**1984**	**6244**	**10868**	**241**
Statistics only	10	2	35	30	0	61	314	453	139
Computer science only	3	2	1	16	0	134	336	492	1

Table 5B: Undergraduate Degrees Awarded
Groups I, II, III, Va, M & B Combined

Fall	2004	2005	2006[1]	2007	2008
Total Undergraduate Degrees Awarded	24395	23432	24638	23930	26602
Female Undergraduate Degrees Awarded	10223	9264	9964	9310	10868
Percentage female	*42%*	*40%*	*40%*	*39%*	*41%*

[1] Numbers in this column reflect corrections of those previously reported. For further information visit at http://www.ams.org/employment/surveyreports.html.

The (estimated) number of part-time graduate students in Groups I, II, III, and Va remained realtively stable at 1,719 this year, and in Group IV increased 19% to 1,088. Group III has 891 (52%) of the part-time graduate students in the doctoral mathematics groups. In the doctoral mathematics groups, 38% of the part-time graduate students are females and 76% are U.S. citizens, and in Group IV 49% of the part-time graduate students are females and 47% are U.S. citizens. The number of Group M part-time graduate students decreased from 2,467 to 2,243. For Group M, 49% of the part-time graduate students are females and 89% are U.S. citizens.

Table 6B gives the total number of full-time and full-time first-year graduate students in Groups I, II, III, and Va combined, and the percentages of women and of U.S. citizens for fall 1999 through fall 2008 and the percentage of underrepresented minorities in each category for fall 2003 through fall 2008. From these data we can see that the total number of full-time graduate students in the doctoral mathematics groups had been generally increasing since 1999 reaching a high in 2006; enrollment has decreased slightly for the second consecutive year to 10,883. Similarly, the percent of full-time graduate students who are U.S. citizens, which had been increasing gradually since 2001, has dropped slightly this year. The percent of first-year full-time graduate students who are U.S. citizens had been increasing until 2004, when it reached 60%. After dropping slightly the next two years, it remains stable at 56% this year. The percentage of females among full-time graduate students in the combined mathematics groups has remained relatively stable over the 10-year period shown.

Previous Annual Survey Reports

The 2008 Annual Survey First Preliminary, First Report, Part II, and Second Reports were published in the *Notices of the AMS* in the February, March, and August 2009 issues respectively. The previous

Table 5C: Master's Degrees Awarded, Fall 2008

	GROUP							
	I Public	I Private	II	III	Va	M	I, II, III, Va & M	IV
Total Master's Degrees Awarded	**398**	**316**	**695**	**802**	**152**	**1902**	**4265**	**1410**
(Standard error)	*(0)*	*(24)*	*(22)*	*(18)*	*(0)*	*(108)*	*(114)*	*(70)*
Statistics only	38	3	41	131	3	159	375	1036
Computer science only	3	0	0	44	0	354	402	12
Female Master's Degrees Awarded	**100**	**76**	**287**	**308**	**38**	**922**	**1731**	**696**
Statistics only	13	2	24	66	1	86	192	506
Computer science only	2	0	0	11	0	182	195	5

version of this report, the 2007 Annual Survey Third Report was published in the *Notices of the AMS* in the November 2008 issue. 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`.

Acknowledgements

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 AMS 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.

Table 5D: Master's Degrees Awarded
Groups I, II, III, Va, M & B Combined

Fall	2004	2005	2006[1]	2007	2008
Total Master's Degrees Awarded	4620	4254	4267	4291	4265
Female Master's Degrees Awarded	2054	1699	1808	1717	1731
Percentage female	*44%*	*40%*	*42%*	*40%*	*41%*

[1] Numbers in this column reflect corrections of those previously reported. For further information visit at http://www.ams.org/employment/surveyreports.html.

Table 6A: Graduate Students, Fall 2008

	GROUP								
	I Public	I Private	II	III	Va	I, II, III, & Va	M	I, II, III, Va, & M	IV
Total Graduate Students									
Full-time	2865	1571	3401	2359	687	10883	3396	14279	4499
(Standard error)						*(90)*	*(254)*	*(302)*	*(137)*
First-year full-time	608	460	921	737	197	2924	1206	4129	1415
(Standard error)						*(35)*	*(71)*	*(103)*	*(67)*
Part-time	167	209	355	891	98	1719	2243	3963	1088
(Standard error)						*(44)*	*(209)*	*(237)*	*(101)*
Female Graduate Students									
Full-time	681	420	1077	833	181	3193	1309	4502	2113
First-year full-time	145	121	296	259	49	870	511	1382	688
Part-time	69	31	157	362	33	652	1106	1758	538
U.S. Citizen Graduate Students									
Full-time	1601	686	2059	1305	362	6012	2440	8452	1876
(Standard error)						*(57)*	*(173)*	*(192)*	*(62)*
First-year full-time	342	181	563	443	114	1643	818	2461	561
Part-time	134	117	302	692	64	1310	2002	3312	516
(Standard error)						*(34)*	*(165)*	*(182)*	*(70)*

Table 6B: Full-Time Graduate Students in Groups I, II, III, & Va by Sex and Citizenship, Fall 1999–2008

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Total full-time graduate students	**8838**	**9637**	**9361**	**9972**	**10444**	**10707**	**10565**	**10984**	**10937**	**10883**
Female	2766	3016	2899	3136	3215	3245	3111	3279	3249	3193
% Female	*31%*	*31%*	*31%*	*31%*	*31%*	*30%*	*29%*	*30%*	*30%*	*29%*
% U.S. citizen	*53%*	*53%*	*49%*	*51%*	*54%*	*55%*	*56%*	*56%*	*56%*	*55%*
% Underrepresented minorities[1]					*10.0%*	*9.0%*	*10.0%*	*9.0%*	*9.0%*	*9.0%*
Total first-year graduate students	**2664**	**2839**	**2875**	**2996**	**2711**	**3004**	**2832**	**2960**	**2964**	**2924**
Female	866	879	1014	1038	902	983	851	961	950	870
% Female	*33%*	*31%*	*35%*	*35%*	*33%*	*33%*	*30%*	*32%*	*32%*	*30%*
% U.S. citizen	*53%*	*54%*	*53%*	*55%*	*56%*	*60%*	*59%*	*55%*	*56%*	*56%*
% Underrepresented minorities					*12.0%*	*9.0%*	*10.0%*	*10.0%*	*10.0%*	*10.0%*

[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*.

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 comprise 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 the number of Group I departments from 39 to 48, the 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 doctoral-granting departments with scores in the 3.00–5.00 range. Group I Public and Group I Private are Group I doctoral-granting departments at public institutions and private institutions respectively.

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

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

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

Group V contains U.S. doctoral-granting departments (or programs) of applied mathematics/applied science, operations research, and management science.

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

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

Group B or Bachelor's contains U.S. departments granting a baccalaureate degree only.

Listings of the actual departments which comprise these groups are available on the AMS website at www.ams.org/outreach.

[1]Research-Doctorate Programs in the United States: Continuity and Change, *edited by Marvin L. Goldberger, Brendan A. Maher, and Pamela Ebert Flattau, National Academy Press, Washington, DC, 1995.*

[2]*These 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, *pages 257–67, and an analysis of the classifications was given in the June 1983* Notices, *pages 392–3.*

Remarks on Statistical Procedures

The questionnaire on which this report is based, "*Departmental Profile*", is sent to every doctoral department and starting with 2006 to every master's department. It is sent to a stratified random sample of Group B departments, the stratifying variable being the undergraduate enrollment at the institution.

The response rates vary substantially across the different department groups. For the doctoral departments it ranges between 60 and 80 percent. For Group M it ranges between 50 and 60 percent. For Group B, the response from the approximately 334 sampled departments drawn from the 1,039 total bachelor's departments typically ranges between 40 and 50 percent. For most of the data collected on the Departmental Profile form, the year-to-year changes in a given department's data are very small when compared to the variations among the departments within a given group. As a result of this, the most recent prior year's response is used for a nonresponding department, provided the response is within three years of the current survey. After the inclusion of prior responses, standard adjustments for the remaining nonresponse are then made to arrive at the estimates reported for the entire groups.

Beginning with the 2007 Annual Survey, standard errors were calculated for some of the key estimates for Groups I, II, III, and Va combined, for Groups M and B, and for Group IV. Standard errors are calculated using the variability in the data and can be used to measure how close our estimate is to the true value for the population. As an example, the number of full-time faculty in Group M is estimated at 4,578, with a standard error of 69. This means the actual number of full-time faculty in Group M is most likely between 4,578 plus or minus two standard errors, or between 4,701 and 4,425. This is much more informative than simply giving the estimate of 4,578.

Estimates are also given for parameters that are totals from all groups, such as the total number of full-time faculty. For example, an estimate of the total number of full-time faculty in all groups but group IV is 22,166, with a standard error of 367. Standard errors, when calculated for an estimate, appear in the tables in parentheses underneath the estimate.

About the cover

Through the Legendrian looking glass

In Joshua Sabloff's article "WHAT IS... a Legendrian knot?" Daniel Bennequin's account in *Astérisque* of his thesis appears at the head of the list of further reading. In pursuit of a cover image we went there first to see what kind of graphics the topic could offer. Bennequin's article is full of hand-drawn pictures, and imagery in mathematics was clearly important to him. When we wrote to him to ask what he would suggest as a relevant cover, his reply mumbled about "Alice" and "Legendrian butterflies" as well as other intriguing fantasies, so of course we accepted his offer to draw something for us.

There is some real mathematics involved. The images are of Legendrian trefoils, one right and one left, and implicit in the picture are two proofs that the right one is knotted. Bennequin says, "The colors recall the proof of the knottedness of the trefoil given by Zeeman, but the butterfly in itself offers another proof, because it has zero self-linking tau-invariant. The moral is that knot structure and contact structure are linked." (The now well-known tau-invariant was introduced in Bennequin's thesis.)

Bennequin tells us that the original idea of proof by coloring goes back to R. H. Fox in the mid-1950s, and that recently it has had a renaissance in the theory of quandles. For more information about color invariants of knots, take a look at the article "3-coloring and other elementary invariants of knots" by Jòzef Przytycki, to be found on the website `http://arxiv.org`.

—*Bill Casselman, Graphics Editor*
(`notices-covers@ams.org`)

Mathematics People

Guionnet Awarded 2009 Loève Prize

ALICE GUIONNET of the École Normale Supérieure de Lyon has been awarded the 2009 Line and Michel Loève International Prize in Probability. The prize, which carries a monetary award of US$30,000, was presented at a ceremony in Berkeley in October 2009.

Alice Guionnet received her Ph.D. in 1995 from Université Paris-Sud, advised by Gerard Ben Arous. Her thesis dealt with Langevin dynamics in the Sherrington–Kirkpatrick model of spin glasses via a large deviations approach. The study of dynamics for complex systems (spin systems, particle approximations to the nonlinear filtering equations and spin glasses, where logarithmic Sobolev inequalities in particular and concentration of measure methods in general are very relevant), and more specifically the study of aging phenomena, continue to be a component of her research to this day, with important collaborations with Boguslaw Zegarlinsky, Gerard Ben Arous, Amir Dembo, and Carlo Mazza. Maybe more important, it also naturally led her to what would become her main area of research and best-known work, namely the study of large random matrices. Starting with a proof of the large deviations principle for the spectral measure of Wigner matrices (with Ben Arous), which helped bring to the attention of probabilists the concept of noncommutative entropy coined by Voiculescu, she quickly realized that dynamics and concentration techniques can be adapted to this context and yield a systematic approach to many open questions. Results include the full large deviation principle for the spectral measure of generalized Gaussian matrices and concentration of the spectral measure in more general models (with Ofer Zeitouni) and later applications to the study of random matrix models, which had long been studied nonrigorously in mathematical physics. She has found rigorous arguments and elucidated connections with other mathematical fields in topics such as first- and second-order expansions of free energy and the connection with maps enumeration; stochastic analysis for random matrices and Dyson's Brownian motion; connections with "free probability"; and, most recently, the study of planar algebras. A partial list of collaborators includes B. Collins, V. Jones, D. Shlyakhtenko, and her students M. Maida and E. Maurel-Segala. This has been an extremely active field over the period, with many workers pursuing many partly overlapping techniques and problem domains. Her lecture notes from courses in 2003 and 2006, together with a forthcoming monograph (with Anderson and Zeitouni), have helped bring welcome clarity to the field.

The Loève Prize commemorates Michel Loève, professor at the University of California, Berkeley, from 1948 until his untimely death in 1979. The prize was established by his widow, Line, shortly before her death in 1992. Awarded every two years, it is intended to recognize outstanding contributions by researchers in probability who are under forty-five years old.

—David Aldous, University of California, Berkeley

Car and Parrinello Awarded 2009 Dirac Medal

ROBERTO CAR of Princeton University and MICHELE PARRINELLO of the Swiss Federal Institute of Technology (ETH Zürich) have been jointly awarded the 2009 Dirac Medal by the Abdus Salam International Centre for Theoretical Physics (ICTP). They were honored for their "revolutionary 'molecular dynamics' numerical simulation method for condensed matter". Their work, known as the Car–Parrinello method, combines quantitative electronic energy calculation, via a theory known as density functional theory (DFT), with Newtonian molecular dynamics simulation of the mechanical motion of atoms and molecules in real time. That method has provided an all-important quantitative understanding of the properties of matter, while also allowing scientists and laymen alike to visualize atoms in motion during physical and chemical processes.

The ICTP awarded its first Dirac Medal in 1985. Given in honor of P. A. M. Dirac, the medal is awarded annually on Dirac's birthday, August 8, to an individual or individuals who have made significant contributions to theoretical physics and mathematics. The medalists also receive a prize of US$5,000. An international committee of distinguished scientists selects the winners from a list of nominated candidates. The Dirac Medal is not awarded to Nobel Laureates, Fields Medalists, or Wolf Foundation Prize winners.

—From an ICTP announcement

MAA Awards Presented

The Mathematical Association of America (MAA) presented several awards for excellence in expository writing, teaching, and service at its Summer MathFest in Portland, Oregon, August 5–8, 2009.

The Carl B. Allendoerfer Awards are given for articles of expository excellence published in *Mathematics Magazine*. They carry a cash award of US$500. The awardees for 2009 are Vesna Stojanoska, Northwestern University, and Orlin Stoytchev, American University in Bulgaria, for "Touching the Z_2 in three-dimensional rotations", *Mathematics Magazine*, December 2008; and Jeff Suzuki, Brooklyn College, for "A brief history of impossibility", *Mathematics Magazine*, February 2008.

The Trevor Evans Awards are presented to authors of exceptional articles that are accessible to undergraduates and published in *Math Horizons*. The amount of the cash award is US$250. The awardees for 2009 are Richard A. Guyer, a medical student at the University of Virginia, for "Radiology paging a good mathematician: Why math can contribute more to medicine than you might think", *Math Horizons*, April 2008; and Randy K. Schwartz, Schoolcraft College, for "The birth of the meter", *Math Horizons*, September 2008.

The Lester R. Ford Awards are given for articles of expository excellence published in *The American Mathematical Monthly*. The award consists of US$500. The 2009 recipients are Michel Balinski, École Polytechnique, for "Fair majority voting (or how to eliminate gerrymandering)", *American Mathematical Monthly*, February 2008; Andrew Bashelor, United States Navy, Amy Ksir, United States Naval Academy, and Will Traves, United States Naval Academy, for their joint paper, "Enumerative algebraic geometry of conics", *American Mathematical Monthly*, October 2008; Andrew Granville, University of Montreal, for "Prime number patterns", *American Mathematical Monthly*, April 2008; Dan Kalman, American University, for "An elementary proof of Marden's theorem", *American Mathematical Monthly*, April 2008; and Mehrdad Khosravi, De Anza College, and Michael D. Taylor, University of Central Florida, for their joint paper, "The wedge product and analytic geometry", *American Mathematical Monthly*, August/September 2008.

The Merten M. Hasse Prize is given for a noteworthy expository paper appearing in an MAA publication, at least one of whose authors is a younger mathematician (usually defined as under the age of forty). It carries a cash award of US$1,000. The 2009 honorees are Andrew Bashelor, Amy Ksir, and Will Traves for their joint article "Enumerative algebraic geometry of conics", *American Mathematical Monthly*, October 2008.

The George Pólya Award is given for articles of expository excellence published in the *College Mathematics Journal*. It carries a cash award of US$500. The 2009 honorees are Lawrence Brenton, Wayne State University, for "Remainder wheels and group theory", *College Mathematics Journal*, March 2008; and Greg N. Frederickson, Purdue University, for "Designing a table both swinging and stable", *College Mathematics Journal*, September 2008.

The George Pólya Lectureship honors exposition of a particularly high quality. Judy Walker, University of Nebraska–Lincoln, was awarded the lectureship for 2009–2010 and 2010–2011.

The Henry L. Alder Award for Distinguished Teaching by a Beginning College or University Mathematics Faculty Member honors beginning college or university faculty members whose teaching has been extraordinarily successful and whose effectiveness in teaching undergraduate mathematics is shown to have had influence beyond their own classrooms.The prize carries a cash award of US$1,000. The prizes for 2009 were awarded to Scott Annin, California State University at Fullerton; Sommer Gentry, United States Naval Academy; and Jennifer McLoud-Mann, University of Texas at Tyler.

—From an MAA announcement

Kutzko Receives Presidential Award

Philip Kutzko of the University of Iowa has been awarded a Presidential Award for Excellence in Science, Mathematics, and Engineering Mentoring. He will be honored at the White House and receive a cash award of US$10,000.

The Presidential Award for Excellence in Science, Mathematics, and Engineering Mentoring is awarded each year to individuals or organizations and recognizes the crucial role that mentoring plays in the academic and personal development of students studying science or engineering and who belong to minority groups that are underrepresented in those fields. By offering their time, encouragement, and expertise to these students, mentors help ensure that the next generation of scientists and engineers will better reflect the diversity of the United States. The mentoring can involve students at any grade level from elementary through graduate school.

—From a White House announcement

2009 Ford Foundation Diversity Fellowships Awarded

The Ford Foundation has named the recipients of its Diversity Fellowships for 2009. The Ford Foundation's predoctoral, dissertation, and postdoctoral fellowship programs seek to increase the presence of underrepresented minorities on college faculties. Awardees later serve as role models and mentors for a new generation of scholars. Two awardees in the mathematical sciences have received Predoctoral Fellowships of US$20,000 a year for up to three years. Carlos E. Arreche of the University of Chicago is a student in algebra. Ashley Crump of Princeton University is student in applications of mathematics. In addition, a Dissertation Fellowship of US$21,000 for one year was awarded to Bianca Viray of the University of California, Berkeley, a student in algebra.

—From a Ford Foundation announcement

2009 International Mathematical Olympiad

The fiftieth International Mathematical Olympiad (IMO) was held in Bremen, Germany, July 10–22, 2009. The IMO is the preeminent mathematical competition for high-school-age students from around the world. This year 565 young mathematicians from 104 countries competed. The IMO consists of solving six extremely challenging mathematical problems in a nine-hour competition administered over two days.

The team from China finished first, with 221 points; each team member earned a gold medal. Japan finished second, with 212 points, followed by Russia (203), South Korea (188), and North Korea (183). The team from the United States finished sixth with 182 points and two gold medals.

The U.S. team consisted of John Berman (John T. Hoggard High School, Wilmington, North Carolina); Wenyu Cao (Phillips Academy, Andover, Massachusetts), Eric Larson (South Eugene High School, Eugene, Oregon), Delong Meng (Baton Rouge Magnet High School, Baton Rouge, Louisiana), Evan O'Dorney (Berkeley Math Circle, Berkeley, California), and Qinxuan Pan (Thomas Sprigg Wootton High School, Rockville, Maryland). Berman and Larson won gold medals; O'Dorney, Pan, Meng, and Cao won silver medals.

The Mathematical Association of America sponsors the U.S. team through its American Mathematics Competitions program, with travel support provided by a grant from the Army Research Office. Training for the team at the University of Nebraska–Lincoln is aided by a grant from the Akamai Foundation. Additional support for the team is provided by the National Council of Teachers of Mathematics.

—Elaine Kehoe

Brousseau Awarded Felix Klein Medal

Guy Brousseau of the University Institute for Teacher Education (IUFM), Aquitaine, and the University of Montreal has been awarded the first Felix Klein Medal of the International Commission on Mathematical Instruction (ICMI) for his essential contributions "to the development of mathematics education as a scientific field of research, through his theoretical and experimental work over four decades, and to the sustained effort he has made throughout his professional life to apply the fruits of his research to the mathematics education of both students and teachers." The ICMI is a commission of the International Mathematical Union (IMU). Its aim is to facilitate the transmission of information on all aspects of the theory and practice of contemporary mathematical education from an international perspective.

—From an ICMI announcement

Mathematics Opportunities

American Mathematical Society Centennial Fellowships

Invitation for Applications for Awards for 2010–2011
Deadline: December 1, 2009

Description: The AMS Centennial Research Fellowship Program makes awards annually to outstanding mathematicians to help further their careers in research. The number of fellowships to be awarded is small and depends on the amount of money contributed to the program. The Society supplements contributions as needed. One fellowship will be awarded for the 2010–11 academic year. A list of previous fellowship winners can be found at http://www.ams.org/prizes/centennial-fellowship.html.

Eligibility: The eligibility rules are as follows. The primary selection criterion for the Centennial Fellowship is the excellence of the candidate's research. Preference will be given to candidates who have not had extensive fellowship support in the past. Recipients may not hold the Centennial Fellowship concurrently with another research fellowship such as a Sloan or National Science Foundation Postdoctoral Fellowship. Under normal circumstances, the fellowship cannot be deferred. A recipient of the fellowship shall have held his or her doctoral degree for at least three years and not more than twelve years at the inception of the award (that is, received between September 1, 1998, and September 1, 2007). Applications will be accepted from those currently holding a tenured, tenure-track, postdoctoral, or comparable (at the discretion of the selection committee) position at an institution in North America. Applications should include a cogent plan indicating how the fellowship will be used. The plan should include travel to at least one other institution and should demonstrate that the fellowship will be used for more than reductions of teaching at the candidate's home institution. The selection committee will consider the plan in addition to the quality of the candidate's research and will try to award the fellowship to those for whom the award would make a real difference in the development of their research careers. Work in all areas of mathematics, including interdisciplinary work, is eligible.

Grant amount: The stipend for fellowships awarded for 2010–11 is expected to be US$77,000, with an additional expense allowance of about $7,700. Acceptance of the fellowship cannot be postponed.

Deadline: The deadline for receipt of applications is **December 1, 2009**. Awards will be announced in February 2010 or earlier if possible.

Application information: Application forms are available via the Internet at http://www.ams.org/employment/centflyer.html. For paper copies of the form, write to the Membership and Programs Department, American Mathematical Society, 201 Charles Street, Providence, RI 02904-2294; or send electronic mail to prof-serv@ams.org; or call 401-455-4105.

—AMS announcement

AMS Congressional Fellowship

The AMS, in conjunction with the American Association for the Advancement of Science (AAAS), will sponsor a Congressional Fellow from September 2010 through August 2011. The fellow will spend the year working on the staff of a member of Congress or a congressional committee as a special legislative assistant in legislative and policy areas requiring scientific and technical input. The fellowship is designed to provide a unique public policy learning experience, to demonstrate the value of science-government interaction, and to bring a technical background and external perspective to the decision-making process in Congress. The deadline for applications is **February 15, 2010**. Applicants should have a Ph.D. or an equivalent doctoral-level degree in the mathematical sciences by the application deadline. For further information, please consult the webpage at http://www.ams.org/government/congressfellowann.html or contact the AMS Washington Office at 202-588-1100, email: amsdc@ams.org.

—AMS Washington Office

Research Experiences for Undergraduates

The Research Experiences for Undergraduates (REU) program supports active research participation by undergraduate students in any of the areas of research funded by the National Science Foundation (NSF). Student research may be supported in two forms: REU supplements and REU sites.

REU supplements may be requested for ongoing NSF-funded research projects or may be included in proposals for new or renewal NSF grants or cooperative agreements.

REU sites are based on independent proposals to initiate and conduct undergraduate research participation projects for a number of students. REU site projects may be based on a single discipline or academic department or on interdisciplinary or multidepartment research opportunities with a strong intellectual focus. Proposals with an international dimension are welcomed. A partnership with the Department of Defense supports REU sites in research areas relevant to defense. Undergraduate student participants supported with NSF funds in either supplements or sites must be citizens or permanent residents of the United States or its possessions.

Students may not apply to NSF to participate in REU activities. Students apply directly to REU sites and should consult the directory of active REU sites on the Web at `http://www.nsf.gov/crssprgm/reu/reu_search.cfm`. The deadline for full proposals for REU sites is **October 22, 2009**. Deadline dates for REU supplements vary with the research program; contact the program director for more information. The full program announcement can be found at the website `http://www.nsf.gov/pubs/2009/nsf09598/nsf09598.htm?govDel=USNSF_25`.

—From an NSF announcement

NSF Graduate Research Fellowships

The National Science Foundation (NSF) awards Graduate Research Fellowships to graduating seniors and first-year graduate students. These are three-year fellowships awarded to U.S. students for full-time graduate study at the institutions of their choice. The fellowships include a stipend, tuition coverage, and possible international travel allowances. Awards are made based on the candidates' intellectual merit and potential for research achievement. The deadline for full proposals in mathematical sciences is **November 4, 2009**. For more information see `http://www.nsf.gov/pubs/2009/nsf09603/nsf09603.htm`.

—From an NSF announcement

Research Opportunities for U.S. Graduate Students in Asia and Australia

The National Science Foundation (NSF) is sponsoring a summer research program in Australia, China, Japan, Korea, Taiwan, New Zealand, and Singapore for U.S. graduate students during the summer of 2010. The East Asia and Pacific Summer Institutes (EAPSI) provide U.S. graduate students in science and engineering with first-hand research experience in Australia, China, Japan, Korea, Taiwan, New Zealand, or Singapore; an introduction to the science and science policy infrastructure of the respective location; and orientation to the culture and language. The primary goals of EAPSI are to introduce students to East Asian and Pacific science and engineering in the context of a research laboratory and to initiate personal relationships that will better enable them to collaborate with foreign counterparts in the future. The institutes last approximately eight weeks (ten weeks in Japan) from June to August and are administered in the United States by the NSF.

Applicants must be U.S. citizens or permanent residents. They must be enrolled at U.S. institutions in a research-oriented master's or Ph.D. program (including joint degree programs) in fields of science or engineering research and education that are supported by the NSF and that also are represented among the potential host institutions. International travel will be provided, and each awardee will receive an allowance of US$5,000.

The deadline for application materials to be postmarked is **December 8, 2009**. Proposers are required to prepare and submit all proposals for this announcement/solicitation through the FastLane system. Further information and detailed instructions are available at `http://www.nsf.gov/pubs/2008/nsf08603/nsf08603.htm`.

—From an NSF announcement

Jefferson Science Fellows Program

The Jefferson Science Fellows (JSF) program at the U.S. Department of State is intended to involve the American academic science, technology, and engineering communities in the formulation and implementation of U.S. foreign policy. Each fellow will spend one year at the U.S. Department of State or the U.S. Agency for International Development (USAID) for an on-site assignment in Washington, D.C., that may also involve extended stays at U.S. foreign embassies and/or missions. Each Fellow will receive a stipend of up to US$50,000. Following the fellowship year, the Jefferson Science Fellow will return to his or her academic career but will remain available to the U.S. Department of State for short-term projects over the following five years.

The JSF program is administered by the National Academies and supported through a partnership among the MacArthur Foundation, the Carnegie Corporation, the U.S. science, technology, and academic communities, professional scientific societies, and the U.S. Department of State. The deadline for applications is **January 15, 2010**. For further information, email: `jsf@nas.edu`, telephone 202-334-2643, or see the website `http://www7.nationalacademies.org/jefferson/`.

—From a National Academies announcement

AAUW Educational Foundation Fellowships and Grants

The American Association of University Women (AAUW) awards Selected Professions Fellowships to women who intend to pursue a full-time course of study at accredited institutions during the fellowship year in a designated degree program in which women's participation has traditionally been low. All women who are candidates for the master of science (M.S.) degree in mathematics or statistics are eligible to apply.

Applications are now available for Master's and First Professional Awards, which carry cash awards of between US$5,000 and US$18,000. The deadline for applications to be postmarked is **January 10, 2010**. The fellowship year runs from July 1, 2010, to June 30, 2011. For more information, see the AAUW's website at `http://www.aauw.org/fga/fellowships_grants/selected.cfm` or contact the AAUW Educational Foundation, Selected Professions Fellowships, Dept. 60, 301 ACT Drive, Iowa City, IA 52243-4030; telephone: 800/326-2289; email: `connect@aauw.org`.

—From an AAUW announcement

NRC-Ford Foundation Diversity Fellowships

The National Research Council (NRC) administers the Ford Foundation Diversity Fellowships program. The program seeks to promote the diversity of the nation's college and university faculties by increasing their ethnic and racial diversity, to maximize the educational benefits of diversity, and to increase the number of professors who can and will use diversity as a resource for enriching the education of all students. Predoctoral fellowships support study toward a Ph.D. or Sc.D.; dissertation fellowships offer support in the final year of writing the Ph.D. or Sc.D. thesis; postdoctoral fellowships offer one-year awards for Ph.D. recipients. Applicants must be U.S. citizens or nationals in research-based fields of study. Membership in one of the following groups will be considered a positive factor: Alaska Native (Eskimo, Aleut, or other indigenous peoples), Black/African American, Mexican American/Chicana/Chicano, Native American Indian, Native Pacific Islander (Hawaiian/Polynesian/Micronesian), or Puerto Rican.

Approximately forty predoctoral fellowships will be awarded for 2010. The awards provide three years of support and are made to individuals who, in the judgment of the review panels, have demonstrated superior academic achievement, are committed to a career in teaching and research at the college or university level, show promise of future achievement as scholars and teachers, and are well prepared to use diversity as a resource for enriching the education of all students. The annual stipend is US$21,000, with an institutional allowance of US$2,000. The deadline for applying online is **November 2, 2009**.

Approximately twenty dissertation fellowships will be awarded for 2010 and will provide one year of support for study leading to a Ph.D. or Sc.D. degree. The stipend for one year is US$21,000. The deadline for applying online is **November 9, 2009**. The postdoctoral fellowship program offers one year of postdoctoral support for individuals who have received their Ph.D.s no earlier than November 30, 2002, and no later than November 9, 2009. The stipend is US$40,000, with an employing institution allowance of US$1,500. Approximately eighteen postdoctoral fellowships will be awarded for 2009. The deadline for applying online is **November 9, 2009**.

More detailed information and applications are available at the website `http://sites.nationalacademies.org/PGA/FordFellowships/index.htm`. The postal address is: Fellowships Office, Keck 576, National Research Council, 500 Fifth Street, NW, Washington, DC 20001. The telephone number is 202-334-2872. The email address is `infofell@nas.edu`.

—From an NRC announcement

News from the Institut Mittag-Leffler

The Institut Mittag-Leffler, Djursholm, Sweden, announces its programs for the academic year 2010–11. The fall term 2010 will be devoted to *Quantum Information Theory*. The scientific steering committee consists of Mary Beth Ruskai (chair), Tufts University; Alexander Holevo, Steklov Mathematical Institute, Moscow; Erling Størmer, University of Oslo; Andreas Winter, University of Bristol, United Kingdom, and National University of Singapore; and Michael Wolf, University of Copenhagen.

The spring term 2011 will be devoted to *Algebraic Geometry with a View Towards Applications*. The scientific steering committee consists of Sandra di Rocco (chair), KTH, the Royal Institute of Technology, Stockholm; Alicia Dickenstein, University of Buenos Aires; Ragni Piene and Kristian Ranestad, University of Oslo; and Bernd Sturmfels, University of California, Berkeley. The application deadline for postdoctoral fellowships is **January 20, 2010**. Applications may be sent to Marie-Louise Koskull, email: `koskull@mittag-leffler.se`. The postal address is: Institut Mittag-Leffler, Auravägen 17, SE-182 60 Djursholm, Sweden.

For further information and application forms, see the website http://www.mittag-leffler.se/programs/1011/grants.php.

—Institut Mittag-Leffler announcement

News from the CRM

The Centre de Recerca Matemàtica (CRM) in Bellaterra, Spain, is commemorating its twenty-fifth anniversary with some special scientific programs.

October 19–24, 2009: Advanced Course on Shimura Varieties and *L*-Functions. Coordinators: F. Bars, L. Dieulefait, V. Rotger. Lecturers: S. W. Zhang, Columbia University; Bas Edixhoven, Leiden University; Andrei Yafaev, University College London.

December 9–12, 2009: Algebraic Cycles, Modular Forms, and Rational Points on Elliptic Curves. Coordinators: F. Bars, L. Dieulefait, V. Rotger. Lecturers: M. Bertolini, H. Darmon, and K. Prasanna.

January 25–29, 2010: Third International Conference on the Anthropological Theory of the Didactic. Lecturers: Michèle Artigue, Université de Paris 7; Yves Matheron, IUFM, Midi-Pyrénées, Toulouse; Robert Noirfalise, Université Clermont-Ferrand II; María Trigueros, Instituto Tecnológico Autónomo de México (ITAM); Carl Winslow, University of Copenhagen.

February 22–March 5, 2010: Arithmetic Geometry for Function Fields of Positive Characteristic. Coordinators: F. Bars, L. Dieulefait, V. Rotger. Lecturers: Gebhard Böckle, Universitaet Duisburg-Essen, Germany; Douglas Ulmer, University of Arizona.

March 17–26, 2010: Second International School on Geometry and Physics: Geometric Langlands and Gauge Theory. Coordinators: L. Alvarez-Cónsul, J. I. Burgos, O. García-Prada, I. Mundet. Lecturers: David Ben-Zvi, University of Texas, Austin; Olivier Biquard, Institut de Mathématique Jussieu, Paris; Tamás Hausel, University of Oxford; Anton Kapustin, California Institute of Technology; Tony Pantev, University of Pennsylvania.

For more information on the program and registration, see the website http://www.crm.cat/.

—From a CRM announcement

For Your Information

Morgan Appointed Director of Simons Center at Stony Brook

John Morgan of Columbia University has been appointed director of the Simons Center for Geometry and Physics at the State University of New York, Stony Brook. He received his Ph.D. in mathematics from Rice University in 1969. He has held postdoctoral and junior positions at Princeton University and the Massachusetts Institute of Technology and spent two years at the Institut des Hautes Études Scientifiques before joining the Columbia faculty in 1976. He chaired the mathematics department at Columbia from 1986 to 1988 and again from 2004 to 2008. He has been acting director of the Simons Center for the past year. His research interests lie at the interface of topology, geometry, algebraic geometry, and mathematical physics. He is a member of the National Academy of Sciences and the European Academy of Sciences and is an editor of the *Journal of the American Mathematical Society*. The Simons Center for Geometry and Physics was founded in 2007 with a gift from the James and Marilyn Simons Foundation.

Morgan said, "The past thirty-five years have seen a remarkable turn in the relationship of mathematics and physics, starting with the realization by C. N. Yang and Simons that each discipline was studying the same objects (connections on principal bundles or gauge theory) from its own perspective and for its own needs. This realization sparked the beginning of a serious attempt by both communities to bridge the gap between the subjects. From the mathematical perspective, a fundamental question is: What is the source and nature of the nonmathematically rigorous approach that has inspired so much of the recent activity in geometry, topology, and algebra, with questions and conjectures unlike anything that has been seen before? Examples of mathematics arising out of this interplay are Floer homology, Donaldson theory, Seiberg–Witten theory, mirror symmetry, Gromov–Witten theory, chiral algebras, the quantum field theory approach to the geometric Langlands program, a mathematically coherent treatment of perturbation theory and Feynmann diagrams, and the recent mathematical explanation of topological quantum field theories. From the physics perspective, the question is the flip side of this coin: What is the mathematical justification underlying, and what exactly are the rules of and the limits to, the art of quantization and string theory? Although there have been many examples of advances on these questions, the coherent picture of the relationship between the mathematics and physics involved remains a central mystery in both subjects.

"The goal of the Simons Center is to study this mystery from both sides of the divide. Its aim is to bring together mathematicians and physicists whose work, ideas, and questions can stimulate activity across the divide and/or take advantage of advances from the other side of the divide."

The center will bring together first-rate researchers with an interest in and a sympathy toward the other discipline, and out of this mix will come advances in both subjects. There are many places at which first-rate mathematics is done and many places at which first-rate physics is done, and in some instances communication exists across the barrier of the disciplines. "The Simons Center will be, I believe, the unique place where this communication and the resulting cross-fertilization will be central factors determining the choice of personnel for the center and the choice of topics of special concentration at the center," said Morgan.

The center's new building, due to be completed in September 2010, will house approximately thirty-five to forty researchers at any given time. The center is expected to have, besides the director, a faculty consisting of six permanent members, twelve postdoctoral research assistant professors for three-year periods, and approximately eighteen to twenty visitors in residence. In addition, week-long workshops will be held during the academic year, and a month-long summer school in physics is planned.

—Elaine Kehoe

Inside the AMS

AMS Sponsors NExT Fellows

Each year the AMS sponsors six Project NExT (New Experiences in Teaching) Fellows who are affiliated with Ph.D.-granting institutions and who show promise in mathematics research.

The names, affiliations, and areas of research of the 2009–2010 NExT Fellows are: Daniel Cranston, Virginia Commonwealth University, theoretical computer science (discrete mathematics); Nathaniel Eldredge, Cornell University, geometric partial differential equations; Paul Jenkins, Brigham Young University, number theory; Kelly McKinnie, University of Montana, algebra; Rebecca Schmitz, University of Minnesota, Toeplitz and composition operators and mathematics education; and Wenbo Tang, Arizona State University, differential equations and dynamical systems.

Project NExT (New Experiences in Teaching) is a professional development program for new or recent Ph.D.s in the mathematical sciences (including pure and applied mathematics, statistics, operations research, and mathematics education). It addresses all aspects of an academic career: improving the teaching and learning of mathematics, engaging in research and scholarship, and participating in professional activities. It also provides the participants with a network of peers and mentors as they assume these responsibilities. Each year sixty to eighty new Ph.D.s receive Project NExT Fellowships, which allow them to attend special events at the summer MathFest of the Mathematical Association of America and at the Joint Mathematics Meetings. The AMS also holds activities for the AMS NExT Fellows at the Joint Mathematics Meetings.

T. Christine Stevens, who cofounded Project NExT in 1994 with James R. C. Leitzel and who has been its sole director since 1998, has stepped down from her post. She has been replaced by Aparna Higgins of the University of Dayton. Stevens said, "The sixteen years that I have spent working on Project NExT have been exciting, enjoyable, and exhausting. I'm proud of what it has accomplished, and I'm grateful for the strong support that the AMS and other professional organizations have given to Project NExT. I look forward to its continued success under the able leadership of Aparna W. Higgins." Higgins had this to say about Stevens: "Her vision of Project NExT has been expansive and inclusive. Chris's planning of Project NExT activities has been detailed. Chris's enthusiasm for Project NExT and the Fellows has been inspiring. Her execution of the duties associated with the job has been skillful. Chris's dedication to Project NExT and the Project NExT Fellows, all 1,170 of them, has been evident every day of the last sixteen years." At the Summer Mathfest of the Mathematical Association of America (MAA), Chris Stevens was presented with a certificate that read in part: "Under Chris's inspirational leadership and wise guidance Project NExT has become one of the most successful programs in the history of the MAA, linking mathematicians at all stages of their careers and having a profound influence on the entire profession." As the new director, Higgins will continue to be supported by Judith Covington, Joseph Gallian, and Gavin LaRose. Higgins said, "The task would be daunting but for the fact that we were recruited and trained by Chris…. [She] infected us with her enthusiasm."

For further information about Project NExT, see the website `http://archives.math.utk.edu/projnext/`.

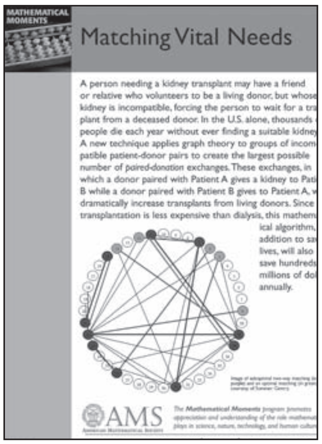
—Aparna Higgins, Project NExT

From the AMS Public Awareness Office

Mathematical Research Communities—2009. The 2009 Mathematics Research Communities (MRC) summer conferences, held at the Snowbird Resort in Utah, drew 120 early-career mathematicians. These conferences are part of the AMS program that includes special sessions at the Joint Mathematics Meetings, a longitudinal study, and a continuation of the connections and collaborations via an electronic network. This year's conferences were: *Mathematical Challenges of Relativity*, *Inverse Problems*, *Modern Markov Chains and Their Statistical Applications*, and *Harmonic Analysis*. "I was extremely moved by the level of enthusiasm and energy displayed by the participants at our workshop in general relativity," said Sergiu

Klainerman, co-organizer of the *Mathematical Challenges of Relativity* conference. "I have never been, I believe, in my entire career, to a more exciting meeting from this point of view, one in which both the young people and not so young, like myself, were talking mathematics almost nonstop, from early on at breakfast until late at night in the hospitality suite. The format of the MRC conferences enabled this magic to take place. Congratulations to AMS for this very unusual and successful initiative." See photographs and read more comments at `http://www.ams.org/ams/mrc-2009.html`.

Mathematical Moments. The 2009 set of Mathematical Moments includes "Predicting Climate", "Matching Vital



Needs" (increasing the number of live-donor kidney transplants), "Analyzing Data", and "Working It Out" (math and the Beatles). These and more than seventy other topics, some with podcast interviews and translated into other languages, are at `http://www.ams.org/mathmoments`.

Headlines & Deadlines. AMS members are invited to sign up to receive twice-monthly email notifications of news and announcements about programs, publications, and events, as well as alerts about deadlines for fellowship and grant applications, calls for proposals, and meeting registrations. The service provides a convenient way to have news that is posted on the AMS page—and some announcements and deadlines before they appear in *Notices*—delivered directly to you. It's easy to subscribe (and unsubscribe), at `http://www.ams.org/enews`.

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

Photograph of Atle Selberg

No photo credit was given for the photograph of Atle Selberg on the Great Wall of China (Table of Contents page and also on page 704), *Notices*, June/July 2009. The photograph was taken by Yangbo Ye.

—Sandy Frost

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

October 22, 2009: Full proposals for Research Experiences for Undergraduates (REU) sites. See "Mathematics Opportunities" in this issue.

November 2, 2009: Applications for NRC-Ford Foundation Predoctoral Fellowships. See `http://sites.nationalacademies.org/pga/FordFellowships/index.htm`; telephone: 202-334-2872; email: `infofell@nas.edu`; or contact Fellowships Office, Keck 576, National Research Council, 500 Fifth Street, NW, Washington, DC 20001.

November 4, 2009: Full proposals for NSF Graduate Research Fellowships. See "Mathematics Opportunities" in this issue.

November 9, 2009: Applications for NRC-Ford Foundation Dissertation and Postdoctoral Fellowships. See `http://sites.nationalacademies.org/pga/FordFellowships/index.htm`; telephone: 202-334-2872; email: `infofell@nas.edu`; or contact Fellowships Office, Keck 576, National Research Council, 500 Fifth Street, NW, Washington, DC 20001.

November 12, 2009: Full proposals for NSF Project ADVANCE Institutional Transformation (IT) and Institutional Transformation Catalyst (IT-Catalyst) awards. See `http://www.nsf.gov/pubs/2009/nsf09504/nsf09504.htm`.

November 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`.

December 1, 2009: Applications for AMS Centennial Fellowships. See `http://www.ams.org/employment/centflyer.html`; telephone 401-455-4105; email: `prof-serv@ams.org`; or contact the Membership and Programs Department, American Mathematical Society, 201 Charles Street, Providence, RI 02904-2294.

Where to Find It

A brief index to information that appears in this and previous issues of the *Notices*.

December 4, 2009: Entries for 2009 Ferran Sunyer i Balaguer Prize. See http://ffsb.iec.cat.

December 8, 2009: Applications for East Asia and Pacific Summer Institutes (EAPSI). See "Mathematics Opportunities" in this issue.

December 15, 2009: Applications for AMS Epsilon Fund grants. See http://www.ams.org/outreach/epsilon.html or contact the AMS Membership and Programs Department, telephone: 800-321-4267, ext. 4170; email: prof-serv@ams.org or by telephone at 800-321-4267, ext. 4170.

December 15, 2009: Nominations for the International Mathematical Union (IMU) Chern Medal Award. See http://www.mathunion.org/fileadmin/IMU/Prizes/Chern/.

January 10, 2010: Applications for AAUW Educational Foundation Fellowships and Grants. See "Mathematics Opportunities" in this issue.

January 15, 2010: Applications for AMS-AAAS Mass Media Summer Fellowships. See http://www.aaas.org/programs/education/MassMedia/, or contact Stacey Pasco, Manager, Mass Media Program, AAAS Mass Media Science and Engineering Fellows Program, 1200 New York Avenue, NW, Washington, DC 20005; telephone 202-326-6441; fax 202-371-9849; email: spasco@aaas.org. Also see http://www.ams.org/government/massmediaann.html or contact the AMS Washington Office, 1527 Eighteenth Street, NW, Washington, DC 20036; telephone 202-588-1100; fax 202-588-1853; email: amsdc@ams.org.

January 15, 2010: Applications for Jefferson Science Fellows Program. See "Mathematics Opportunities" in this issue.

February 1, 2010: Applications for AWM Travel Grants and Mentoring Travel Grants. See http://www.awm-math.org/travelgrants.html; telephone: 703-934-0163; email: awm@awm-math.org, or contact Association for Women in Mathematics, 11240 Waples Mill Road, Suite 200, Fairfax, VA 22030.

February 15, 2010: Applications for AMS-AAAS Congressional Fellowship. See "Mathematics Opportunities" in this issue.

April 15, 2010: Applications for fall 2010 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: +7095-291-65-01; email: mim@mccme.ru. For information on AMS scholarships see http://www.ams.org/outreach/mimoscow.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 1, 2010: Applications for AWM Travel Grants. See http://www.awm-math.org/travelgrants.html; telephone: 703-934-0163; or email: awm@awm-math.org. The postal address is: Association for Women in Mathematics, 11240 Waples Mill Road, Suite 200, Fairfax, VA 22030.

June 1, 2010: Applications for NSF's Enhancing the Mathematical Sciences Workforce in the Twenty-First Century (EMSW21) program. See http://www.nsf.gov/pubs/2005/nsf05595/nsf05595.htm.

October 1, 2010: Applications for AWM Travel Grants. See http://www.awm-math.org/travelgrants.html; telephone: 703-934-0163; email: awm@awm-math.org; or contact Association for Women in Mathematics, 11240 Waples Mill Road, Suite 200, Fairfax, VA 22030.

NSF Division of Mathematical Sciences

Listed below are names, email addresses, and telephone numbers for the program directors for the present academic year in the Division of Mathematical Sciences (DMS) of the National Science Foundation. The postal address is: Division of Mathematical Sciences, National Science Foundation, Room 1025, 4201 Wilson Boulevard, Arlington, VA 22230. The DMS Web page is http://www.nsf.gov/div/index.jsp?div=DMS.

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Division Secretary
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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.

The Annotated Turing: A Guided Tour Through Alan Turing's Historic Paper on Computability and the Turing Machine, by Charles Petzold. Wiley, June 2008. ISBN-13: 978-04702-290-57.

The Calculus of Friendship: What a Teacher and Student Learned About Life While Corresponding about Math, by Steven Strogatz. Princeton University Press, August 2009. ISBN-13: 978-06911-349-32.

Chez les Weils (French), by Sylvie Weil. Buchet-Chastel, January 2009. ISBN-13: 978-22830-236-93.

Crocheting Adventures with Hyperbolic Planes, by Daina Taimina. A K Peters, March 2009. ISBN-13: 978-15688-145-20.

Decoding the Heavens: A 2,000-Year-Old Computer—and the Century-Long Search to Discover Its Secrets, by Jo Marchant. Da Capo Press, February 2009. ISBN-13: 978-03068-174-27.

Dimensions, by Jos Leys, Etienne Ghys, and Aurélien Alvarez. DVD, 117 minutes. Available at http://www.dimensions-math.org.

Einstein's Mistakes: The Human Failings of Genius, by Hans C. Ohanian. W. W. Norton, September 2008. ISBN-13: 978-0393062939.

Embracing the Wide Sky: A Tour Across the Horizons of the Human Mind, by Daniel Tammet. Free Press, January 2009. ISBN-13: 978-14165-696-95.

Emmy Noether: The Mother of Modern Algebra, by M. B. W. Tent. A K Peters, October 2008. ISBN-13: 978-15688-143-08. (Reviewed October 2009.)

Euler's Gem: The Polyhedron Formula and the Birth of Topology, by David S. Richeson. Princeton University Press, September 2008. ISBN-13: 97-80691-1267-77.

Fighting Terror Online: The Convergence of Security, Technology and the Law, by Martin Charles Golumbic. Springer, 2008. ISBN: 978-0-387-73577-1.

Gaming the Vote (Why Elections Aren't Fair and What We Can Do About It), by William Poundstone. Hill and Wang, February 2009. ISBN-13: 978-08090-489-22.

Geekspeak: How Life + Mathematics = Happiness, by Graham Tattersall. Collins, September 2008. ISBN-13: 978-00616-292-42.

Geometric Origami, by Robert Geretschläger. Arbelos, October 2008. ISBN-13: 978-09555-477-13.

Hexaflexagons, Probability Paradoxes, and the Tower of Hanoi: Martin Gardner's First Book of Mathematical Puzzles and Games, by Martin Gardner. Cambridge University Press, September 2008. ISBN-13: 978-0-521-73525-4.

The Housekeeper and the Professor, by Yoko Ogawa. Picador, February 2009. ISBN-13: 978-03124-278-01.

How to Think Like a Mathematician: A Companion to Undergraduate Mathematics, by Kevin Houston. Cambridge University Press, March 2009. ISBN-13: 978-05217-197-80.

Is God a Mathematician? by Mario Livio. Simon & Schuster, January 2009. ISBN-13: 978-07432-940-58.

Kiss My Math: Showing Pre-Algebra Who's Boss, by Danica McKellar. Hudson Street Press, August 2008. ISBN-13: 978-1594630491.

The Last Theorem, by Arthur C. Clarke and Frederik Pohl. Del Rey, August 2008. ISBN-13: 978-0345470218.

Leonhard Euler and His Friends: Switzerland's Great Scientific Expatriate, by Luis-Gustave du Pasquier (translated by John S. D. Glaus). CreateSpace, July 2008. ISBN: 978-14348-332-73.

The Map of My Life, by Goro Shimura. Springer, September 2008. ISBN-13: 978-03877-971-44.

Unite!: The International Congress of Mathematicians: A Human Endeavor, by Guillermo P. Curbera. A K Peters, March 2009. ISBN-13: 978-15688-133-01.

Mathematics and the Aesthetic: New Approaches to an Ancient Affinity, edited by Nathalie Sinclair, David Pimm, and William Higginson. Springer, November 2006. ISBN-13: 978-03873-052-64. (Reviewed February 2009.)

Mathematics Emerging: A Sourcebook 1540–1900, by Jacqueline Stedall. Oxford University Press, November 2008. ISBN-13: 978-01992-269-00.

Mathematics in Ancient Iraq: A Social History, by Eleanor Robson. Princeton University Press, August 2008. ISBN-13: 978-06910-918-22.

Mathematics in India, by Kim Plofker. Princeton University Press, January 2009. ISBN-13: 978-06911-206-76.

Mathematics in 10 Lessons: The Grand Tour, by Jerry P. King. Prometheus Books, May 2009. ISBN: 978-1-59102-686-0.

Number and Numbers, by Alain Badiou. Polity, June 2008. ISBN-13: 978-07456-387-82.

The Numbers Game: The Commonsense Guide to Understanding Numbers in the News, in Politics, and in Life, by Michael Blastland and Andrew Dilnot. Gotham, December 2008. ISBN-13: 978-15924-042-30.

The Numerati, by Stephen Baker. Houghton Mifflin, August 2008. ISBN-13: 978-06187-846-08. (Reviewed October 2009.)

Origami, Eleusis, and the Soma Cube: Martin Gardner's Mathematical Diversions, by Martin Gardner. Cambridge University Press, September 2008. ISBN-13: 978-0-521-73524-7.

Our Days Are Numbered: How Mathematics Orders Our Lives, by Jason Brown. McClelland and Stewart, April 2009. ISBN-13: 978-07710-169-67.

Picturing the Uncertain World: How to Understand, Communicate, and Control Uncertainty Through Graphical Display, by Howard Wainer, Princeton University Press, April 2009. ISBN-13: 978-06911-375-99.

Plato's Ghost: The Modernist Transformation of Mathematics, by Jeremy Gray. Princeton University Press, September 2008. ISBN-13: 978-06911-361-03.

The Princeton Companion of Mathematics, edited by Timothy Gowers (June Barrow-Green and Imre Leader, associate editors). Princeton University Press, November 2008. ISBN-13: 978-06911-188-02. (Reviewed in this issue.)

Professor Stewart's Cabinet of Mathematical Curiosities, by Ian Stewart. Basic Books, December 2008. ISBN-13: 978-0-465-01302-9.

Pythagoras' Revenge: A Mathematical Mystery, by Arturo Sangalli. Princeton University Press, May 2009. ISBN-13: 978-06910-495-57.

Pythagorean Crimes, by Tefcros Michalides. Parmenides Publishing, September 2008. ISBN-13: 978-19309-722-78. (Reviewed January 2009.)

Recountings: Conversations with MIT Mathematicians, edited by Joel Segel. A K Peters, January 2009. ISBN-13: 978-15688-144-90.

Rock, Paper, Scissors: Game Theory in Everyday Life, by Len Fisher. Basic Books, November 2008. ISBN-13: 978-04650-093-81.

Sacred Mathematics: Japanese Temple Geometry, by Fukagawa Hidetoshi and Tony Rothman. Princeton University Press, July 2008. ISBN-13: 978-0-6911-2745-3.

The Shape of Content: An Anthology of Creative Writing in Mathematics and Science, edited by Chandler Davis, Marjorie Wikler Senechal, and Jan Zwicky. A K Peters, November 2008. ISBN-13: 978-15688-144-45.

Souvenirs sur Sofia Kovalevskaya (French), by Michèle Audin. Calvage et Mounet, October 2008. ISBN-13: 978-29163-520-53.

Strange Attractors: Poems of Love and Mathematics, edited by Sarah Glaz and JoAnne Growney. A K Peters, November 2008. ISBN-13: 978-15688-134-17. (Reviewed September 2009.)

Tools of American Math Teaching, 1800–2000, by Peggy Aldrich Kidwell, Amy Ackerberg-Hastings, and David Lindsay Roberts. Johns Hopkins University Press, July 2008. ISBN-13: 978-0801888144.

The Unfinished Game: Pascal, Fermat, and the Seventeenth-Century Letter That Made the World Modern, by Keith Devlin. Basic Books, September 2008. ISBN-13: 978-0-4650-0910-7.

The Unimaginable Mathematics of Borges' Library of Babel, by William Goldbloom Bloch. Oxford University Press, August 2008. ISBN-13: 978-01953-345-79.

What Is a Number?: Mathematical Concepts and Their Origins, by Robert Tubbs. Johns Hopkins University Press, December 2008. ISBN-13: 978-08018-901-85.

What's Happening in the Mathematical Sciences, by Dana Mackenzie. AMS, 2009. ISBN-13: 978-08218-447-86.

Why Does E=mc²? (And Why Should We Care?), by Brian Cox and Jeff Forshaw. Da Capo Press, July 2009. ISBN-13: 978-03068-175-88.

Backlog of Mathematics Research Journals

Journal (Print and Electronic)	Number issues per Year	Approximate Number Pages per Year	2008 Median Time (in Months) from: Submission to Final Acceptance	Acceptance to Print	Acceptance to Electronic Posting	Editor's Current Estimate of Waiting Time between Submission and Publication (in Months): Print	Electronic
Abstr. Appl. Anal.	*	800	3.5	3–9**	1.5	7–9**	2.5
Acta Inform.	8	640	2	2.5	2	2.5	1.5
Acta Math.	4	600	7	19	18	28	27
Adv. Difference Equ.	*	500	4	3–9**	1.5	7–9**	3
Adv. Math. Commun.	4	480	3.5	1	0.5	5	4
Aequationes Math.	6	640	8	15	15	23	14
Algorithmica	12	960	7	15	2	12	2
Amer. J. Math.	6	1876	NA	14	13	16–18	15–17
Ann. Appl. Probab.	6	2529	8	10	9	20	19
Ann. Mat. Pura Appl. (4)	4	720	4.8	9.1	1.2	13	6
Ann. of Math. (2)	6	3000	15	21	21	18	18
Ann. Probab.	6	2433	8	12	11	20	19
Ann. Statist.	6	2919	2	12	12	20	19
Arch. Hist. Exact. Sci.	6	696	3	5	2	5	2
Arch. Math. Logic	8	1040	16.3	10.6	5.7	25.2	20.3
Arch. Ration. Mech. Anal.	12	880	6	11	7	5	2
Balkan J. Geom. Appl.	2	260	4	6	1	6	6
Beitrage Algebra Geom.	2	610	14	8	6	14	16
Bound. Value Probl.	*	500	4	3–9**	1.5	7–9**	3
Bull. Aust. Math. Soc.	6	1056	2	9	8	11	10
Bull. Lond. Math. Soc.	6	1152	5	7.5	5	11	9
Bull. Soc. Math. France	4	600–630	8	6	5	6	5
Canad. J. Math.	6	1440	9	25	26	35	36
Canad. Math. Bull.	4	640	6	17	18	26	27
Cent. Eur. J. Math.	4	750	4.8	4	1.8	8	5
Combinatorica	6	750	6	6	3	6	3
Comm. Math. Phys.	24	6840	6	4	1.5	4	1
Commun. Pure Appl. Anal.	6	1800	4	7	6	11	10
Compos. Math.	6	1632	6	7	5.5	11	9
Comput. Math. Appl.	24	1600	6	5	2	5	2
Comput. Methods Funct. Theory	2	700	4	6	2	9	6
Computing	12	1052	9	3	2	6	5
Constr. Approx.	6	828	7	18	6	13	10
Des. Codes Cryptogr.	12	1600	7	5	1.5	4	2
Discrete Comput. Geom.	8	1440	8	11	3	17	9
Discrete Contin. Dyn. Syst.	12	4000	4	8	7	12	11
Discrete Contin. Dyn. Syst. Ser. B	12	3000	5	8	7	13	12
Duke Math. J.	15	3000	12	7	7	17	17
Fixed Point Theory Appl.	*	550	4	3–9**	1.5	7–9**	3
Found. Comput. Math.	6	750	10	13	4	19	13
Geom. Dedicata	6	1576	5	5	1	11	7

Journal (Print and Electronic)	Number issues per Year	Approximate Number Pages per Year	2008 Median Time (in Months) from: Submission to Final Acceptance	Acceptance to Print	Acceptance to Electronic Posting	Editor's Current Estimate of Waiting Time between Submission and Publication (in Months) Print	Electronic
Georgian Math. J.	4	810	5	10	8	13	11
Graphs Combin.	6	864	9	3	3	12	12
Houston J. Math.	4	1300	5	17	14	19	16
Illinois J. Math.	4	1400	6	10	9	14	12
Indag. Math. (N.S.)	4	650	3	9	12	8	8
Indiana Univ. Math. J.	6	3000	14	8	7	8	7
Int. J. Math. Math. Sci.	*	1000	4	3–9**	1.5	7–9**	3
Invent. Math.	12	2736	10	2.5	1	12.5	11
Inverse Probl. Imaging	4	700	6	3	2	3	2
Israel J. Math.	6	2664	6	18	16	26	22
J. Algebraic Geom.	4	800	8	9	3	14	12
J. Amer. Math. Soc.	4	1200	12.2	8.3	2.4	28.6	23.1
J. Anal. Math.	3	1188	15	12	12	15	15
J. Appl. Anal.	2	310	14	7	5	20	18
J. Appl. Math.	*	200	6	9–10**	1.5	7–9**	4
J. Appl. Math. Stoch. Anal.	*	300	5	9–10**	1.5	7–9**	4
J. Complexity	6	700	6	6	1	12	7
J. Comput. System Sci.	12	1600	14	2	1	14	14
J. Convex Anal.	4	1100	10	7	1	10	8
J. Differential Geom.	9	2025	6	6	2	5	2
J. Eur. Math. Soc. (JEMS)	6	1200	5.2	12	10	12	10
J. Geom. Anal.	4	1000	5	4	1	9	6
J. Ind. Manag. Optim.	4	800	9	4	NR	6	NR
J. Inequal. Appl.	*	1200	4	9–10**	1.5	7–9**	3
J. Integral Equations Appl.	4	600	10	20	18	18	16
J. Lie Theory	4	900	6	1.5	0.3	6	4.5
J. Lond. Math. Soc. (2)	6	1632	8	7	4.5	11	10
J. Math. Biol.	12	1776	11	14.9	3.9	22	14.9
J. Math. Phys.	12	10,500	1.5	2	NR	3	2.5
J. Mod. Dyn.	4	730	3.5	2.5	2.5	3.5	2.5
J. Operator Theory	4	900	8.19	22.76	20	29.38	27
J. Symbolic Logic	4	1350	8	8	6	17	13
J. Theoret. Probab.	4	1000	8	9	1	8	6
J. Topol.	4	1024	6.5	5	3.5	10	8
Linear Algebra Appl.	24	6000	5	5	1	10	6
Linear Multilinear Algebra	8	900	5	16	4	16	5.5
Manuscripta Math.	12	1632	8	3.9	2.2	11.9	10.2
Math. Ann.	12	3000	10	5.5	4.5	15	13
Math. Biosci. Eng.	4	840	3.5	2.5	2	6	5.5
Math. Comp.	4	2400	8.5	12.3	6.8	20	12.7
Math. Oper. Res.	4	1024	9	9	9	24	24
Math. Program.	10	1980	15.2	11.8	7.4	23.7	18.6
Math. Res. Lett.	6	1250	5	5	2	10	5
Math. Social Sci.	6	870	9	4	1	13	10
Math. Z.	12	2900	9.1	8.2	2.2	16	11
Methods Appl. Anal.	4	500–700	3–6	2–5	2–5	3–6	3–6
Michigan Math. J.	3	720	7	10	9	12	11
Monatsh. Math.	12	1200	6	9	4	16	10
Multiscale Model. Simul.	4	2000	6.3	14.4	4	14.3	10.3

Journal (Print and Electronic)	Number issues per Year	Approximate Number Pages per Year	2008 Median Time (in Months) from: Submission to Final Acceptance	Acceptance to Print	Acceptance to Electronic Posting	Editor's Current Estimate of Waiting Time between Submission and Publication (in Months): Print	Electronic
Netw. Heterog. Media	4	800	4.7	5.5	3.6	8.4	7
Numer. Math.	12	2400	13	6	4.5	15.5	14
Probab. Theory Related Fields	12	2016	11	14.9	3.9	22.1	14.9
Proc. Amer. Math. Soc.	12	4200	5.4	11.9	8.3	14.3	9.1
Proc. Lond. Math. Soc. (3)	6	1632	6	8	3	12	9
Publ. Math. Inst. Hautes Etudes Sci.	2	500	12.5	2.8	2.6	14	13.8
Q. J. Math.	4	512	6	9	1	18	7
Quart. Appl. Math.	4	800	7.6	10.3	7.4	18.4	16.4
Results Math.	8	800	6	15	13	15	13
Rocky Mountain J. Math.	6	2100	10	24	22	27	25
Semigroup Forum	6	1140	8	6	1.5	14	8
SIAM J. Appl. Math.	6	1800	9.4	8.8	3.8	18.2	13.2
SIAM J. Comput.	6	2550	17.7	15.2	4.4	31.7	22.1
SIAM J. Control Optim.	6	3300	12.6	16.5	4.4	27.6	17
SIAM J. Discrete Math.	4	1680	15.5	17.6	4.5	28.5	20
SIAM J. Math. Anal.	6	2580	8.1	12.9	4.5	21	12.6
SIAM J. Matrix Anal. Appl.	4	1800	13.8	14.8	4.8	28.6	18.6
SIAM J. Numer. Anal.	6	3300	11.3	19.2	4.6	27.3	15.9
SIAM J. Optim.	4	2000	12	14.6	4.9	25	16.9
SIAM J. Sci. Comput.	6	3300	10.1	19.1	4.7	25.1	14.8
SIAM Rev.	4	1000	8.9	13.5	12.5	22.4	21.4
Theory Comput. Syst.	8	720	8	12	2	8	2
Trans. Amer. Math. Soc.	12	6600	8.2	20.3	15.8	26.7	21.9

Journal (Print)	Number issues per Year	Approximate Number Pages per Year	2008 Median Time (in Months) from: Submission to Final Acceptance	Acceptance to Final Publication	Editor's Current Estimate of Waiting Time between Submission and Publication (in Months)
Mem. Amer. Math. Soc.	6***	3800	9.3	28.6	44.7

Journal (Electronic)	Number of Articles Posted in 2008	2008 Median Time (in days) from: Submission to Final Acceptance	Acceptance to Posting	Format(s)
Acta Math. Acad. Paedagog. Nyházi. (N.S.) www.emis.de/journals/AMAPN	42	74	59	pdf, ps
Appl. Math. E-Notes www.math.nthu.edu.tw/~amen/	36	180	180	pdf
Conform. Geom. Dyn. www.ams.org/journals/ecgd	15	183	57	pdf
Differ. Geom. Dyn. Syst. www.mathem.pub.ro/dgds/	36	150	250	pdf
Differ. Uravn. Protsessy Upr. www.math.spbu.ru/diffjournal/j/ru	18	20	3	pdf, tex, doc
Discrete Math. Theor. Comput. Science www.dmtcs.org/	32	420	14	pdf, ps

Journal (Electronic)	Number of Articles Posted in 2008	2008 Median Time (in days) from: Submission to Final Acceptance	Acceptance to Posting	Format(s)
Electron. J. Combin. www.combinatorics.org/	195	182	10	pdf, ps
Electron. J. Differential Equations ejde.math.txstate.edu	165	115	8	html, pdf, ps, tex
Electron. J. Qual. Theory Differ. Equ. www.math.u-szeged.hu/ejqtde	38	150	10	pdf, ps, dvi
Electron. Res. Announc. Math. Sci. www.math.psu.edu/era/	11	90	10	pdf
Electron. Trans. Numer. Anal.	26	174	119	html, pdf, ps
ESAIM Control Optim. Calc. Var. www.esaim-cocv.org/	76	248	150	pdf, tex
ESAIM Probab. Stat. www.esaim-ps.org/	22	365	300	pdf, tex
Homology, Homotopy Appl. www.intlpress.com/HHA/	30	247	63	html, pdf, ps, dvi
Integers www.integers-ejcnt.org	78	170	20	pdf, ps
J. Integer Seq. www.cs.uwaterloo.ca/journals/JIS/	40	140	7	html, pdf, ps, dvi, tex
JIPAM. J. Inequal. Pure Appl. Math. jipam.vu.edu.au/	120	100	60	pdf
LMS J. Comput. Math. www.lms.ac.uk/jcm/journal.html	16	185	59	html, pdf,†
M2AN Math. Model. Numer. Anal. www.esaim-m2an.org/	57	310	152	pdf, tex
New York J. Math. nyjm.albany.edu	31	150	20	pdf, ps, dvi
Represent. Theory www.ams.org/journals/ert	20	285	51	pdf
Sém. Lothar. Combin. www.mat.univie.ac.at/~slc/	13	192	10	pdf, ps, dvi, tex
SIAM J. Appl. Dyn. Syst. epubs.siam.org/SIADS/siads_toc.html	58	199	129	pdf, BibTeX
SIAM J. Imaging Sci. epubs.siam.org/journals/doc/SIAMDL-home/jrnls/top.jsp?key=SJISBI	19	168	111	pdf, BibTeX
Theory Appl. Categ. www.tac.mta.ca/tac/	31	202	5	html, pdf, ps, dvi
Theory of Comput. theoryofcomputing.org	9	180	10	pdf, ps, tex

NR means no response received. NA means not available or not applicable.
*Articles are published on an article-by-article basis.
**The print edition is printed only on demand and in the form of an archival volume.
***Starting with the November 2009 issue, this journal will be available in print and electronic formats.
†Add-ons (appendices, computer programs, graphics, animations, etc.) are provided as appropriate with no restriction on the format.

From the AMS Secretary

Bylaws of the American Mathematical Society

Article I

Officers

Section 1. There shall be a president, a president elect (during the even-numbered years only), an immediate past president (during the odd-numbered years only), three vice presidents, a secretary, four associate secretaries, a treasurer, and an associate treasurer.

Section 2. It shall be a duty of the president to deliver an address before the Society at the close of the term of office or within one year thereafter.

Article II

Board of Trustees

Section 1. There shall be a Board of Trustees consisting of eight trustees, five trustees elected by the Society in accordance with Article VII, together with the president, the treasurer, and the associate treasurer of the Society *ex officio*. The Board of Trustees shall designate its own presiding officer and secretary.

Section 2. The function of the Board of Trustees shall be to receive and administer the funds of the Society, to have full legal control of its investments and properties, to make contracts, and, in general, to conduct all business affairs of the Society.

Section 3. The Board of Trustees shall have the power to appoint such assistants and agents as may be necessary or convenient to facilitate the conduct of the affairs of the Society and to fix the terms and conditions of their employment. The Board may delegate to the officers of the Society duties and powers normally inhering in their respective corporative offices, subject to supervision by the Board. The Board of Trustees may appoint committees to facilitate the conduct of the financial business of the Society and delegate to such committees such powers as may be necessary or convenient for the proper exercise of those powers. Agents appointed, or members of committees designated, by the Board of Trustees need not be members of the Board.

Nothing herein contained shall be construed to empower the Board of Trustees to divest itself of responsibility for, or legal control of, the investments, properties, and contracts of the Society.

Article III

Committees

Section 1. There shall be eight editorial committees as follows: committees for the *Bulletin*, for the *Proceedings*, for the *Colloquium Publications*, for the *Journal*, for *Mathematical Surveys and Monographs*, for *Mathematical Reviews*; a joint committee for the *Transactions* and the *Memoirs*; and a committee for *Mathematics of Computation*.

Section 2. The size of each committee shall be determined by the Council.

Article IV

Council

Section 1. The Council shall consist of fifteen members at large and the following *ex officio* members: the officers of the Society specified in Article I, except that it shall include only one associate secretary, the chairman of each of the editorial committees specified in Article III, any former secretary for a period of two years following the terms of office, and members of the Executive Committee (Article V) who remain on the Council by the operation of Article VII, Section 4.

The chairman of any committee designated as a Council member may name a deputy from the committee as substitute. The associate secretary shall be the one charged with the scientific program of the meeting at which the Council meets except that at a meeting associated with no scientific meeting of the Society the secretary may designate the associate secretary.

Section 2. The Council shall formulate and administer the scientific policies of the Society and shall act in an advisory capacity to the Board of Trustees.

Section 3. In the absence of the secretary from any meeting of the Council, a member may be designated as acting secretary for the meeting, either by written authorization of the secretary, or, failing that, by the presiding officer.

Section 4. All members of the Council shall be voting members. Each member, including deputies and the designated associate secretary, shall have one vote. The method for settling matters before the Council at any meeting shall be by majority vote of the members present. If the result of a vote is challenged, it shall be the duty of the presiding officer to determine the true vote by a roll call. In a roll call vote, each Council member shall vote only once (although possibly a member of the Council in several capacities).

Section 5. Any five members of the Council shall constitute a quorum for the transaction of business at any meeting of the Council.

Section 6. Between meetings of the Council, business may be transacted. Votes shall be counted as specified in Section 4 of this Article, "members present" being replaced by "members voting". An affirmative vote on any proposal shall be declared if, and only if, (a) more than half of the total number of possible votes is received by the time announced for the closing of the polls, and (b) at least three-quarters of the votes received by then are affirmative. If five or more members request postponement at the time of voting, action on the matter at issue shall be postponed until the next meeting of the Council, unless either (1) at the discretion of the secretary, the question is made the subject of a second vote, in connection with which brief statements of reason, for and against, are circulated; or (2) the Council places the matter at issue before the Executive Committee for action.

Section 7. The Council may delegate to the Executive Committee certain of its duties and powers. Between meetings of the Council, the Executive Committee shall act for the Council on such matters and in such ways as the Council may specify. Nothing herein contained shall be construed as empowering the Council to divest itself of responsibility for formulating and administering the scientific policies of the Society.

Section 8. The Council shall also have power to speak in the name of the Society with respect to matters affecting the status of mathematics or mathematicians, such as proposed or enacted federal or state legislation; conditions of employment in universities, colleges, or business, research or industrial organizations; regulations, policies, or acts of governmental agencies or instrumentalities; and other items which tend to affect the dignity and effective position of mathematics.

With the exception noted in the next paragraph, a favorable vote of two-thirds of the entire membership of the Council shall be necessary to authorize any statement in the name of the Society with respect to such matters. With the exception noted in the next paragraph, such a vote may be taken only if written notice shall have been given to the secretary by the proposer of any such resolution not later than one month prior to the Council meeting at which the matter is to be presented, and the vote shall be taken not earlier than one month after the resolution has been discussed by the Council.

If, at a meeting of the Council, there are present twelve members, then the prior notification to the secretary may be waived by unanimous consent. In such a case, a unanimous favorable vote by those present shall empower the Council to speak in the name of the Society.

The Council may also refer the matter to a referendum of the entire membership of the Society and shall make such reference if a referendum is requested, prior to final action by the Council, by two hundred or more members. The taking of a referendum shall act as a stay upon Council action until the votes have been canvassed, and thereafter no action may be taken by the Council except in accordance with a plurality of the votes cast in the referendum.

Article V

Executive Committee

Section 1. There shall be an Executive Committee of the Council, consisting of four elected members and the following *ex officio* members: the president, the secretary, the president elect (during even-numbered years), and the immediate past president (during odd-numbered years).

Section 2. The Executive Committee of the Council shall be empowered to act for the Council on matters which have been delegated to the Executive Committee by the Council. If three members of the Executive Committee request that any matter be referred to the Council, the matter shall be so referred. The Executive Committee shall be responsible to the Council and shall report its actions to the Council. It may consider the agenda for meetings of the Council and may make recommendations to the Council.

Section 3. Each member of the Executive Committee shall have one vote. An affirmative vote on any proposal before the Executive Committee shall be declared if, and only if, at least four affirmative votes are cast for the proposal. A vote on any proposal may be determined at a meeting of the Executive Committee, but it shall not be necessary to hold a meeting to determine a vote.

Article VI

Executive Director

Section 1. There shall be an Executive Director who shall be a paid employee of the Society. The Executive Director shall have charge of the offices of the Society, except for the office of the secretary, and shall be responsible for the general administration of the affairs of the Society in accordance with the policies that are set by the Board of Trustees and by the Council.

Section 2. The Executive Director shall be appointed by the Board of Trustees with the consent of the Council. The terms and conditions of employment shall be fixed by the Board of Trustees, and the performance of the Executive Director will be reviewed regularly by the Board of Trustees.

Section 3. The Executive Director shall be responsible to and shall consult regularly with a liaison committee consisting of the president as chair, the secretary, the treasurer, and the chair of the Board of Trustees.

Section 4. The Executive Director shall attend meetings of the Board of Trustees, the Council, and the Executive Committee, but shall not be a member of any of these bodies.

Article VII

Election of Officers and Terms of Office

Section 1. The term of office shall be one year in the case of the president elect and the immediate past president; two years in the case of the president, the secretary, the associate secretaries, the treasurer, and the associate treasurer; three years in the case of vice presidents and members at large of the Council, one vice president and five members at large retiring annually; and five years in the case of the trustees. In the case of members of the editorial committees and appointed members of the communications committees, the term of office shall be determined by the Council. The term of office for elected members of the Executive Committee shall be four years, one of the elected members retiring annually. All terms of office shall begin on February 1 and terminate on January 31, with the exception that the officials specified in Articles I, II, III, IV, and V (excepting the president elect and immediate past president) shall continue to serve until their successors have been duly elected or appointed and qualified.

Section 2. The president elect, the vice presidents, the trustees, and the members at large of the Council shall be elected by ballot. The secretary shall send notification to each member of the Society about the slate of candidates and the voting procedure on or before October 10, and legitimate ballots received by an established deadline at least 30 days later will be counted. Each ballot shall contain one or more names proposed by the Council for each office to be filled, with blank spaces in which the voter may substitute other names. A plurality of all votes cast shall be necessary for election. In case of failure to secure a plurality for any office, the Council shall choose by ballot among the members having the highest number of votes. The secretary, the associate secretaries, the treasurer, and the associate treasurer shall be appointed by the Council in a manner designated by the Council. Each committee named in Article III shall be appointed by the Council in a manner designated by the Council. Each such committee shall elect one of its members as chairman in a manner designated by the Council.

Section 3. The president becomes immediate past president at the end of the term of office and the president elect becomes president.

Section 4. On or before February 15, the secretary shall send to all members of the Council a ballot containing two names for each place to be filled on the Executive Committee. The nominees shall be chosen by a committee appointed by the president. Members of the Council may vote for persons not nominated. Any member of the Council who is not an *ex officio* member of the Executive Committee (see Article V, Section 1) shall be eligible for election to the Executive Committee. In case a member is elected to the Executive Committee for a term extending beyond the regular term on the Council, that person shall automatically continue as a member of the Council during the remainder of that term on the Executive Committee.

Section 5. The president and vice presidents shall not be eligible for immediate re-election to their respective offices. A member at large or an *ex officio* member of the Council shall not be eligible for immediate election (or re-election) as a member at large of the Council.

Section 6. If the president of the Society should die or resign while a president elect is in office, the president elect shall serve as president for the remainder of the year and thereafter shall serve the regular two-year term. If the president of the Society should die or resign when no president elect is in office, the Council, with the approval of the Board of Trustees, shall designate one of the vice presidents to serve as president for the balance of the regular presidential term. If the president elect of the Society should die or resign before becoming president, the office shall remain vacant until the next regular election of a president elect, and the Society shall, at the next annual meeting, elect a president for a two-year term. If the immediate past president should die or resign before expiration of the term of office, the Council, with the approval of the Board of Trustees, shall designate a former president of the Society to serve as immediate past president during the remainder of the regular term of the immediate past president. Such vacancies as may occur at any time in the group consisting of the vice presidents, the secretary, the associate secretaries, the treasurer, and the associate treasurer shall be filled by the Council with the approval of the Board of Trustees. If a member of an editorial or communications committee should take temporary leave from duties, the Council shall then appoint a substitute. The Council shall fill from its own membership any vacancy in the elected membership of the Executive Committee.

Section 7. If any elected trustee should die while in office or resign, the vacancy thus created shall be filled for the unexpired term by the Board of Trustees.

Section 8. If any member at large of the Council should die or resign more than one year before the expiration of the term, the vacancy for the unexpired term shall be filled by the Society at the next annual meeting.

Section 9. In case any officer should die or decline to serve between the time of election and the time to assume office, the vacancy shall be filled in the same manner as if that officer had served one day of the term.

Article VIII

Members and Their Election

Section 1. Election of members shall be by vote of the Council or of its Executive Committee.

Section 2. There shall be four classes of members, namely, ordinary, contributing, corporate, and institutional.

Section 3. Application for admission to ordinary membership shall be made by the applicant on a blank provided by the secretary. Such applications shall not be acted upon until at least thirty days after their presentation to the Council (at a meeting or by mail), except in the case of members of other societies entering under special action of the Council approved by the Board of Trustees.

Section 4. An ordinary member may become a contributing member by paying the dues for such membership. (See Article IX, Section 3.)

Section 5. A university or college, or a firm, corporation, or association interested in the support of mathematics may be elected a corporate or an institutional member.

Article IX

Dues and Privileges of Members

Section 1. Any applicant shall be admitted to ordinary membership immediately upon election by the Council (Article VIII) and the discharge within sixty days of election of the first annual dues. Dues may be discharged by payment or by remission when the provision of Section 7 of this Article is applicable. The first annual dues shall apply to the year of election, except that any applicant elected after August 15 of any year may elect to have the first annual dues apply to the following year.

Section 2. The annual dues of an ordinary member of the Society shall be established by the Council with the approval of the Trustees. The Council, with the approval of the Trustees, may establish special rates in exceptional cases and for members of an organization with which the Society has a reciprocity agreement.

Section 3. The minimum dues for a contributing member shall be three-halves of the dues of an ordinary member per year. Members may, upon their own initiative, pay larger dues.

Section 4. The minimum dues of an institutional member shall depend on the scholarly activity of that member. The formula for computing these dues shall be established from time to time by the Council, subject to approval by the Board of Trustees. Institutions may pay larger dues than the computed minimum.

Section 5. The privileges of an institutional member shall depend on its dues in a manner to be determined by the Council, subject to approval by the Board of Trustees. These privileges shall be in terms of Society publications to be received by the institution and of the number of persons it may nominate for ordinary membership in the Society.

Section 6. Dues and privileges of corporate members of the Society shall be established by the Council subject to approval by the Board of Trustees.

Section 7. The dues of an ordinary member of the Society shall be remitted for any years during which that member is the nominee of an institutional member.

Section 8. After retirement from active service on account of age or on account of long-term disability, any ordinary or contributing member who is not in arrears of dues and with membership extending over at least twenty years may, by giving proper notification to the secretary, have dues remitted. Such a member shall receive the *Notices* and may request to receive *Bulletin* as privileges of membership during each year until membership ends.

Section 9. An ordinary or contributing member shall receive the *Notices* and *Bulletin* as privileges of membership during each year for which dues have been discharged.

Section 10. The annual dues of ordinary, contributing, and corporate members shall be due by January 1 of the year to which they apply. The Society shall submit bills for dues. If the annual dues of any member remain undischarged beyond what the Board of Trustees deems to be a reasonable time, the name of that member shall be removed from the list of members after due notice. A member wishing to discontinue membership at any time shall submit a resignation in writing to the Society.

Section 11. An eligible member may become a life member by making a one-time payment of dues. The criteria for eligibility and the amount of dues shall be established by the Council, subject to approval by the Board of Trustees. A life member is subsequently relieved of the obligation of paying dues. The status and privileges are those of ordinary members.

An eligible member of the Society by reciprocity who asserts the intention of continuing to be a member by reciprocity may purchase a life membership by a one-time payment of dues. The criteria for eligibility and the amount of dues shall be established by the Council, subject to approval by the Board of Trustees.

Article X

Meetings

Section 1. The annual meeting of the Society shall be held between the fifteenth of December and the tenth of February next following. Notice of the time and place of this meeting shall be sent by the secretary or an associate secretary to each member of the Society. The times and places of the annual and other meetings of the Society shall be designated by the Council.

Section 2. There shall be a business meeting of the Society only at the annual meeting. The agenda for the business meeting shall be determined by the Council. A business meeting of the Society can take action only on items notified to the full membership of the Society in the call for the meeting. A business meeting can act on items recommended to it jointly by the Council and the Board of Trustees; a majority of members present and voting is required for passage of such an item. A business meeting of the Society can place action items on the agenda for a future business meeting. Final action on an item proposed by a previous business meeting can be taken only provided there is a quorum of 400 members, a majority of members at a business meeting with a quorum being required for passage of such an item.

Section 3. Meetings of the Executive Committee may be called by the president. The president shall call a meeting at any time upon the written request of two of its members.

Section 4. The Council shall meet at the annual meeting of the Society. Special meetings of the Council may be called by the president. The president shall call a special meeting at any time upon the written request of five of its members. No special meeting of the Council shall be held unless written notice of it shall have been sent to all members of the Council at least ten days before the day set for the meeting.

Section 5. The Board of Trustees shall hold at least one meeting in each calendar year. Meetings of the Board of Trustees may be called by the president, the treasurer, or the secretary of the Society upon three days' notice of such meetings sent to each trustee. The secretary of the Society shall call a meeting upon the receipt of a written request of two of the trustees. Meetings may also be held by common consent of all the trustees.

Section 6. Papers intended for presentation at any meeting of the Society shall be passed upon in advance by a program committee appointed by or under the authority of the Council, and only such papers shall be presented as shall have been approved by such committee. Papers in form unsuitable for publication, if accepted for presentation, shall be referred to on the program as preliminary communications or reports.

Article XI

Publications

Section 1. The Society shall publish an official organ called the *Bulletin of the American Mathematical Society*. It shall publish four journals, known as the *Journal of the American Mathematical Society*, the *Transactions of the American Mathematical Society*, the *Proceedings of the American Mathematical Society*, and *Mathematics of Computation*. It shall publish a series of mathematical papers known as the *Memoirs of the American Mathematical Society*. The object of the *Journal*, *Transactions*, *Proceedings*, *Memoirs*, and *Mathematics of Computation* is to make known important mathematical researches. It shall publish a periodical called *Mathematical Reviews*, containing abstracts or reviews of current mathematical literature. It shall publish a series of volumes called *Colloquium Publications* which shall embody in book form new mathematical developments. It shall publish a series of monographs called *Mathematical Surveys and Monographs* which shall furnish expositions of the principal methods and results of particular fields of mathematical research. It shall publish a news periodical known as the *Notices of the American Mathematical Society*, containing programs of meetings, items of news of particular interest to mathematicians, and such other materials as the Council may direct.

Section 2. The editorial management of the publications of the Society listed in Section 1 of this article, with the exception of the *Notices*, shall be in the charge of the respective editorial committees as provided in Article III, Section 1. The editorial management of the *Notices* shall be in the hands of a committee chosen in a manner established by the Council.

Article XII

Indemnification

Any person who at any time serves or has served as a trustee or officer of the Society, or as a member of the Council, or, at the request of the Society, as a director or officer of another corporation, whether for profit or not for profit, shall be indemnified by the Society and be reimbursed against and for expenses actually and necessarily incurred in connection with the defense or reasonable settlement of any action, suit, legal or administrative proceeding, whether civil, criminal, administrative or investigative, threatened, pending or completed, to which that person is made a party by reason of being or having been such trustee, officer or director or Council member, except in relation to matters as to which the person shall be adjudged in such action, suit, or proceeding to be liable for negligence or misconduct in the performance of official duties. Such right of indemnification and reimbursement shall also extend to the personal representatives of any such person and shall be in addition to and not in substitution for any other rights to which such person or personal representatives may now or hereafter be entitled by virtue of the provisions of applicable law or of any other agreement or vote of the Board of Trustees, or otherwise.

Article XIII

Amendments

These bylaws may be amended or suspended on recommendation of the Council and with the approval of the membership of the Society, the approval consisting of an affirmative vote by two-thirds of the members present at a business meeting or of two-thirds of the members voting in a mail ballot in which at least ten percent of the members vote, whichever alternative shall have been designated by the Council, and provided notice of the proposed action and of its general nature shall have been given in the call for the meeting or accompanies the ballot in full.

As amended December 2003

AMS Lecturers, Officers, Prizes, and Funds

Colloquium Lecturers
James Pierpont, 1896
Maxime Bôcher, 1896
W. F. Osgood, 1898
A. G. Webster, 1898
Oskar Bolza, 1901
E. W. Brown, 1901
H. S. White, 1903
F. S. Woods, 1903
E. B. Van Vleck, 1903
E. H. Moore, 1906
E. J. Wilczynski, 1906
Max Mason, 1906
G. A. Bliss, 1909
Edward Kasner, 1909
L. E. Dickson, 1913
W. F. Osgood, 1913
G. C. Evans, 1916
Oswald Veblen, 1916
G. D. Birkhoff, 1920
F. R. Moulton, 1920
L. P. Eisenhart, 1925
Dunham Jackson, 1925
E. T. Bell, 1927
Anna Pell-Wheeler, 1927
A. B. Coble, 1928
R. L. Moore, 1929
Solomon Lefschetz, 1930
Marston Morse, 1931
J. F. Ritt, 1932
R. E. A. C. Paley, 1934
Norbert Wiener, 1934
H. S. Vandiver, 1935
E. W. Chittenden, 1936
John von Neumann, 1937
A. A. Albert, 1939
M. H. Stone, 1939
G. T. Whyburn, 1940
Oystein Ore, 1941
R. L. Wilder, 1942
E. J. McShane, 1943
Einar Hille, 1944
Tibor Radó, 1945
Hassler Whitney, 1946
Oscar Zariski, 1947
Richard Brauer, 1948
G. A. Hedlund, 1949
Deane Montgomery, 1951
Alfred Tarski, 1952
Antoni Zygmund, 1953
Nathan Jacobson, 1955
Salomon Bochner, 1956
N. E. Steenrod, 1957
J. L. Doob, 1959
S. S. Chern, 1960
G. W. Mackey, 1961
Saunders Mac Lane, 1963
C. B. Morrey, Jr., 1964
A. P. Calderón, 1965
Samuel Eilenberg, 1967
D. C. Spencer, 1968
J. W. Milnor, 1968
Raoul H. Bott, 1969
Harish-Chandra, 1969
R. H. Bing, 1970
Lipman Bers, 1971
Armand Borel, 1971
Stephen Smale, 1972
John T. Tate, 1972
M. F. Atiyah, 1973
E. A. Bishop, 1973
F. E. Browder, 1973
Louis Nirenberg, 1974
John G. Thompson, 1974
H. Jerome Keisler, 1975
Ellis R. Kolchin, 1975
Elias M. Stein, 1975
I. M. Singer, 1976
Jürgen K. Moser, 1976
William Browder, 1977
Herbert Federer, 1977
Hyman Bass, 1978
Philip A. Griffiths, 1979
George D. Mostow, 1979
Julia B. Robinson, 1980
Wolfgang M. Schmidt, 1980
Mark Kac, 1981
Serge Lang, 1981
Dennis Sullivan, 1982
Morris W. Hirsch, 1982
Charles L. Fefferman, 1983
Bertram Kostant, 1983
Barry Mazur, 1984
Paul H. Rabinowitz, 1984
Daniel Gorenstein, 1985
Karen K. Uhlenbeck, 1985
Shing-Tung Yau, 1986
Peter D. Lax, 1987
Edward Witten, 1987
Victor W. Guillemin, 1988
Nicholas Katz, 1989
William P. Thurston, 1989
Shlomo Sternberg, 1990
Robert D. MacPherson, 1991
Robert P. Langlands, 1992
Luis A. Caffarelli, 1993
Sergiu Klainerman, 1993
Jean Bourgain, 1994
Clifford H. Taubes, 1995
Andrew W. Wiles, 1996
Daniel W. Stroock, 1997
Gian-Carlo Rota, 1998
Helmut H. Hofer, 1999
Curtis T. McMullen, 2000
János Kollár, 2001
L. Craig Evans, 2002
Peter Sarnak, 2003
Sun-Yung Alice Chang, 2004
Robert K. Lazarsfeld, 2005
Hendrik W. Lenstra Jr., 2006
Andrei Okounkov, 2007
Wendelin Werner, 2008
Gregory Margulis, 2009

Gibbs Lecturers
M. I. Pupin, 1923
Robert Henderson, 1924
James Pierpont, 1925
H. B. Williams, 1926
E. W. Brown, 1927
G. H. Hardy, 1928
Irving Fisher, 1929
E. B. Wilson, 1930
P. W. Bridgman, 1931
R. C. Tolman, 1932
Albert Einstein, 1934
Vannevar Bush, 1935
H. N. Russell, 1936
C. A. Kraus, 1937
Theodore von Kármán, 1939
Sewall Wright, 1941
Harry Bateman, 1943
John von Neumann, 1944
J. C. Slater, 1945
S. Chandrasekhar, 1946
P. M. Morse, 1947
Hermann Weyl, 1948
Norbert Wiener, 1949
G. E. Uhlenbeck, 1950
Kurt Gödel, 1951
Marston Morse, 1952
Wassily Leontief, 1953
K. O. Friedrichs, 1954
J. E. Mayer, 1955
M. H. Stone, 1956
H. J. Muller, 1958
J. M. Burgers, 1959
Julian Schwinger, 1960
J. J. Stoker, 1961
C. N. Yang, 1962
C. E. Shannon, 1963
Lars Onsager, 1964
D. H. Lehmer, 1965
Martin Schwarzschild, 1966
Mark Kac, 1967
E. P. Wigner, 1968
R. L. Wilder, 1969
W. H. Munk, 1970
E. F. F. Hopf, 1971
F. J. Dyson, 1972
J. K. Moser, 1973

R. S. Woodward, 1899, 1900
E. H. Moore, 1901, 1902
T. S. Fiske, 1903, 1904
W. F. Osgood, 1905, 1906
H. S. White, 1907, 1908
Maxime Bôcher, 1909, 1910
H. B. Fine, 1911, 1912
E. B. Van Vleck, 1913, 1914
E. W. Brown, 1915, 1916
L. E. Dickson, 1917, 1918
Frank Morley, 1919, 1920
G. A. Bliss, 1921, 1922
Oswald Veblen, 1923, 1924
G. D. Birkhoff, 1925, 1926
Virgil Snyder, 1927, 1928
E. R. Hedrick, 1929, 1930
L. P. Eisenhart, 1931, 1932
A. B. Coble, 1933, 1934
Solomon Lefschetz, 1935, 1936
R. L. Moore, 1937, 1938
G. C. Evans, 1939, 1940
Marston Morse, 1941, 1942
M. H. Stone, 1943, 1944
T. H. Hildebrandt, 1945, 1946
Einar Hille, 1947, 1948
J. L. Walsh, 1949, 1950
John von Neumann, 1951, 1952
G. T. Whyburn, 1953, 1954
R. L. Wilder, 1955, 1956
Richard Brauer, 1957, 1958
E. J. McShane, 1959, 1960
Deane Montgomery, 1961, 1962
J. L. Doob, 1963, 1964
A. A. Albert, 1965, 1966
C. B. Morrey, Jr., 1967, 1968
Oscar Zariski, 1969, 1970
Nathan Jacobson, 1971, 1972
Saunders Mac Lane, 1973, 1974
Lipman Bers, 1975, 1976
R. H. Bing, 1977, 1978
Peter D. Lax, 1979, 1980
Andrew M. Gleason, 1981, 1982

Paul A. Samuelson, 1974
Fritz John, 1975
Arthur S. Wightman, 1976
Joseph B. Keller, 1977
Donald E. Knuth, 1978
Martin D. Kruskal, 1979
Kenneth G. Wilson, 1980
Cathleen Synge Morawetz, 1981
Elliott W. Montroll, 1982
Samuel Karlin, 1983
Herbert A. Simon, 1984
Michael O. Rabin, 1985
L. E. Scriven, 1986
Thomas C. Spencer, 1987
David P. Ruelle, 1988
Elliott H. Lieb, 1989
George B. Dantzig, 1990
Michael F. Atiyah, 1991
Michael E. Fisher, 1992
Charles S. Peskin, 1993
Robert M. May, 1994
Andrew J. Majda, 1995
Steven Weinberg, 1996
Persi Diaconis, 1997
Edward Witten, 1998
Nancy Kopell, 1999
Roger Penrose, 2000
Ronald L. Graham, 2001
Michael V. Berry, 2002
David B. Mumford, 2003
Eric Lander, 2004
Ingrid Daubechies, 2005
Michael Savageau, 2006
Peter D. Lax, 2007
Avi Wigderson, 2008
Percy Deift, 2009

Presidents
J. H. Van Amringe, 1889, 1890
J. E. McClintock, 1891-1894
G. W. Hill, 1895, 1896
Simon Newcomb, 1897, 1898

Julia B. Robinson, 1983, 1984
Irving Kaplansky, 1985, 1986
George Daniel Mostow, 1987, 1988
William Browder, 1989, 1990
Michael Artin, 1991, 1992
Ronald L. Graham, 1993, 1994
Cathleen Synge Morawetz, 1995, 1996
Arthur M. Jaffe, 1997, 1998
Felix E. Browder, 1999, 2000
Hyman Bass, 2001, 2002
David Eisenbud, 2003, 2004
James G. Arthur, 2005, 2006
James G. Glimm, 2007, 2008
George E. Andrews, 2009, 2010

Secretaries
T. S. Fiske, 1888-1895
F. N. Cole, 1896-1920
R. G. D. Richardson, 1921-1940
J. R. Kline, 1941-1950
E. G. Begle, 1951-1956
J. W. Green, 1957-1966
Everett Pitcher, 1967-1988
Robert M. Fossum, 1989-1998
Robert J. Daverman, 1999-

Treasurers
T. S. Fiske, 1890, 1891
Harold Jacoby, 1892-1894
R. S. Woodward, 1895, 1896
Harold Jacoby, 1897-1899
W. S. Dennett, 1900-1907
J. H. Tanner, 1908-1920
W. B. Fite, 1921-1929
G. W. Mullins, 1930-1936
P. A. Smith, 1937
B. P. Gill, 1938-1948
A. E. Meder, Jr., 1949-1964
W. T. Martin, 1965-1973
Franklin P. Peterson, 1974-1998
John M. Franks, 1999-

Prizes

The George David Birkhoff Prize in Applied Mathematics

This prize was established in 1967 in honor of Professor George David Birkhoff. The initial endowment was contributed by the Birkhoff family and there have been subsequent additions by others. It is awarded for an outstanding contribution to "applied mathematics in the highest and broadest sense." Currently, the prize amount is US$5,000, and it is awarded every three years. The award is made jointly by the American Mathematical Society and the Society for Industrial and Applied Mathematics. The recipient must be a member of one of these societies and a resident of the United States, Canada, or Mexico.

First award, 1968: To Jürgen K. Moser for his contributions to the theory of Hamiltonian dynamical systems, especially his proof of the stability of periodic solutions of Hamiltonian systems having two degrees of freedom and his specific applications of the ideas in connection with this work.

Second award, 1973: To Fritz John for his outstanding work in partial differential equations, in numerical analysis, and, particularly, in nonlinear elasticity theory; the latter work has led to his study of quasi–isometric mappings as well as functions of bounded mean oscillation, which have had impact in other areas of analysis.

Third award, 1973: To James B. Serrin for his fundamental contributions to the theory of nonlinear partial differential equations, especially his work on existence and regularity theory for nonlinear elliptic equations, and applications of his work to the theory of minimal surfaces in higher dimensions.

Fourth award, 1978: To Garrett Birkhoff for bringing the methods of algebra and the highest standards of mathematics to scientific applications.

Fifth award, 1978: To Mark Kac for his important contributions to statistical mechanics and to probability theory and its applications.

Sixth award, 1978: To Clifford A. Truesdell for his outstanding contributions to our understanding of the subjects of rational mechanics and nonlinear materials, for his efforts to give precise mathematical formulation to these classical subjects, for his many contributions to applied mathematics in the fields of acoustic theory, kinetic theory, and nonlinear elastic theory, and the thermodynamics of mixtures, and for his major work in the history of mechanics.

Seventh award, 1983: To Paul R. Garabedian for his important contributions to partial differential equations, to the mathematical analysis of problems of transonic flow and airfoil design by the method of complexification, and to the development and application of scientific computing to problems of fluid dynamics and plasma physics.

Eighth award, 1988: To Elliott H. Lieb for his profound analysis of problems arising in mathematical physics.

Ninth award, 1994: To Ivo Babuška for important contributions to the reliability of finite element methods, the development of a general framework for finite element error estimation, and the development of *p* and *h-p* finite element methods; and to S. R. S. Varadhan for important contributions to the martingale characterization of diffusion processes, to the theory of large deviations for functionals of occupation times of Markov processes, and to the study of random media.

Tenth award, 1998: To Paul H. Rabinowitz for his deep influence on the field of nonlinear analysis.

Eleventh award, 2003: To John Mather for being a mathematician of exceptional depth, power, and originality; and to Charles S. Peskin for devoting much of his career to understanding the dynamics of the human heart and bringing an extraordinarily broad range of expertise to bear on this problem.

Twelfth award, 2006: To Cathleen Synge Morawetz for her deep and influential work in partial differential equations, most notably in the study of shock waves, transonic flow, scattering theory, and conformally invariant estimates for the wave equation.

Thirteenth award, 2009: To Joel Smoller for his leadership, originality, depth, and breadth of work in dynamical systems, differential equations, mathematical biology, shock wave theory, and general relativity.

Next award: January 2012

The Bôcher Memorial Prize

This prize, the first to be offered by the AMS, was founded in memory of Professor Maxime Bôcher, who served as president of the AMS 1909–1910. The original endowment was contributed by members of the Society. It is awarded for a notable paper in analysis published during the preceding six years. To be eligible, the author should be a member of the American Mathematical Society or the paper should have been published in a recognized North American journal. Currently, the US$5,000 prize is awarded every three years.

First (preliminary) award, 1923: To G. D. Birkhoff for his memoir *Dynamical systems with two degrees of freedom*. Transactions of the American Mathematical Society **18** (1917), pp. 199–300.

Second award, 1924: To E. T. Bell for his memoir *Arithmetical paraphrases. I, II*, Transactions of the American Mathematical Society **22** (1921), pp. 1–30, 198–219; and to Solomon Lefschetz for his memoir *On certain numerical invariants with applications to Abelian varieties*, Transactions of the American Mathematical Society **22** (1921), pp. 407–482.

Third award, 1928: To J. W. Alexander for his memoir *Combinatorial analysis situs*, Transactions of the American Mathematical Society **28** (1926), pp. 301–329.

Fourth award, 1933: To Marston Morse for his memoir *The foundations of a theory of the calculus of variations in the large in m-space*, Transactions of the American Mathematical Society **31** (1929), pp. 379–404; and to Norbert Wiener for his memoir, *Tauberian theorems*, Annals of Mathematics, Series 2, **33** (1932), pp. 1–100.

Fifth award, 1938: To John von Neumann for his memoir *Almost periodic functions and groups. I, II*, Transactions of the American Mathematical Society **36** (1934), pp. 445–492; and **37** (1935), pp. 21–50.

Sixth award, 1943: To Jesse Douglas for his memoirs *Green's function and the problem of Plateau*, American Journal of Mathematics **61** (1939), pp. 545–589; *The most general form of the problem of Plateau*, American Journal of Mathematics **61** (1939), pp. 590–608; and *Solution of the inverse problem of the calculus of variations*, Proceedings of the National Academy of Sciences **25** (1939), pp. 631–637.

Seventh award, 1948: To A. C. Schaeffer and D. C. Spencer for their memoir *Coefficients of schlicht functions. I, II, III, IV*, Duke Mathematical Journal **10** (1943), pp. 611–635; **12** (1945), pp. 107–125; and the Proceedings of the National Academy of Sciences **32** (1946), pp. 111–116; **35** (1949), pp. 143–150.

Eighth award, 1953: To Norman Levinson for his contributions to the theory of linear, nonlinear, ordinary, and partial differential equations contained in his papers of recent years.

Ninth award, 1959: To Louis Nirenberg for his work in partial differential equations.

Tenth award, 1964: To Paul J. Cohen for his paper *On a conjecture of Littlewood and idempotent measures*, American Journal of Mathematics **82** (1960), pp. 191–212.

Eleventh award, 1969: To I. M. Singer in recognition of his work on the index problem, especially his share in two joint papers with Michael F. Atiyah, *The index of elliptic operators. I, III*, Annals of Mathematics, Series 2, **87** (1968), pp. 484–530, 546–604.

Twelfth award, 1974: To Donald S. Ornstein in recognition of his paper *Bernoulli shifts with the same entropy are isomorphic*, Advances in Mathematics **4** (1970), pp. 337–352.

Thirteenth award, 1979: To Alberto P. Calderón in recognition of his fundamental work on the theory of singular integrals and partial differential equations, and in particular for his paper *Cauchy integrals on Lipschitz curves and related operators*, Proceedings of the National Academy of Sciences, USA, **74** (1977), pp. 1324–1327.

Fourteenth award, 1984: To Luis A. Caffarelli for his deep and fundamental work in nonlinear partial differential equations, in particular his work on free boundary problems, vortex theory, and regularity theory.

Fifteenth award, 1984: To Richard B. Melrose for his solution of several outstanding problems in diffraction theory and scattering theory and for developing the analytical tools needed for their resolution.

Sixteenth award, 1989: To Richard M. Schoen for his work on the application of partial differential equations to differential geometry, in particular his completion of the solution to the Yamabe Problem in *Conformal deformation of a Riemannian metric to constant scalar curvature*, Journal of Differential Geometry **20** (1984), pp. 479–495.

Seventeenth award, 1994: To Leon Simon for his profound contributions toward understanding the structure of singular sets for solutions of variational problems.

Eighteenth award, 1999: To Demetrios Christodoulou for his contributions to the mathematical theory of general relativity, to Sergiu Klainerman for his contributions to nonlinear hyperbolic equations, and to Thomas Wolff for his work in harmonic analysis.

Nineteenth award, 2002: To Daniel Tataru for his fundamental paper *On global existence and scattering for the wave maps equations*, Amer. Jour. Math. **123** (2001), no. 1, pp. 37–77; and to Terence Tao for his recent fundamental breakthrough on the problem of critical regularity in Sobolev spaces of the wave maps equations, *Global regularity of wave maps I. Small critical Sobolev norm in high dimensions*, Int. Math. Res. Notices (2001), no. 6, pp. 299–328, and *Global regularity of wave maps II. Small energy in two dimensions*, to appear in Comm. Math. Phys. (2001 or early 2002); and to Fanghua Lin for his fundamental contributions to our understanding of the Ginzburg-Landau (GL) equations with a small parameter.

Twentieth award, 2005: To Frank Merle for his fundamental work in the analysis of nonlinear dispersive equations.

Twenty-first award, 2008: To Alberto Bressan for his fundamental works on hyperbolic conservation laws; and to Charles Fefferman for his many fundamental contributions to different areas of analysis; and to Carlos Kenig for his important contributions to harmonic analysis, partial differential equations, and nonlinear dispersive PDE.

Next award: January 2011.

The Frank Nelson Cole Prize in Algebra

This prize (and the Frank Nelson Cole Prize in Number Theory) was founded in honor of Professor Frank Nelson Cole on the occasion of his retirement as secretary of the American Mathematical Society after twenty-five years of service and as editor-in-chief of the *Bulletin* for twenty-one years. The original fund was donated by Professor Cole from moneys presented to him on his retirement and was augmented by contributions from members of the Society. The fund was later doubled by his son, Charles A. Cole. The prize is for a notable paper in algebra published during the preceding six years. To be eligible, the author should be a member of the American Mathematical Society or the paper should have been published in a recognized North American journal. Currently, the US$5,000 prize is awarded every three years.

First award, 1928: To L. E. Dickson for his book *Algebren und ihre Zahlentheorie*, Orell Füssli, Zürich and Leipzig, 1927.

Second award, 1939: To A. Adrian Albert for his papers on the construction of Riemann matrices published in the Annals of Mathematics, Series 2, **35** (1934) and **36** (1935).

Third award, 1944: To Oscar Zariski for four papers on algebraic varieties published in the American Journal of Mathematics **61** (1939) and **62** (1940), and in the Annals of Mathematics, Series 2, **40** (1939) and **41** (1940).

Fourth award, 1949: To Richard Brauer for his paper *On Artin's L-series with general group characters*, Annals of Mathematics, Series 2, **48** (1947), pp. 502–514.

Fifth award, 1954: To Harish–Chandra for his papers on representations of semisimple Lie algebras and groups, and particularly for his paper *On some applications of the universal enveloping algebra of a semisimple Lie algebra*, Transactions of the American Mathematical Society **70** (1951), pp. 28–96.

Sixth award, 1960: To Serge Lang for his paper *Unramified class field theory over function fields in several variables*, Annals of Mathematics, Series 2, **64** (1956), pp. 285–325; and to Maxwell A. Rosenlicht for his papers *Generalized Jacobian varieties*, Annals of Mathematics, Series 2, **59** (1954), pp. 505–530, and *A universal mapping property of generalized Jacobians*, Annals of Mathematics, Series 2, **66** (1957), pp. 80–88.

Seventh award, 1965: To Walter Feit and John G. Thompson for their joint paper *Solvability of groups of odd order*, Pacific Journal of Mathematics **13** (1963), pp. 775–1029.

Eighth award, 1970: To John R. Stallings for his paper *On torsion-free groups with infinitely many ends*, Annals of Mathematics, Series 2, **88** (1968), pp. 312–334; and to Richard G. Swan for his paper *Groups of cohomological dimension one*, Journal of Algebra **12** (1969), pp. 585–610.

Ninth award, 1975: To Hyman Bass for his paper *Unitary algebraic K-theory*, Springer Lecture Notes in Mathematics 343, 1973; and to Daniel G. Quillen for his paper *Higher algebraic K-theories*, Springer Lecture Notes in Mathematics 341, 1973.

Tenth award, 1980: To Michael Aschbacher for his paper *A characterization of Chevalley groups over fields of odd order*, Annals of Mathematics, Series 2, **106** (1977), pp. 353–398; and to Melvin Hochster for his paper *Topics in the homological theory of commutative rings*, CBMS Regional Conference Series in Mathematics, Number 24, American Mathematical Society, 1975.

Eleventh award, 1985: To George Lusztig for his fundamental work on the representation theory of finite groups of Lie type. In particular for his contributions to the classification of the irreducible representations in characteristic zero of the groups of rational points of reductive groups over finite fields, appearing in *Characters of Reductive*

Groups over Finite Fields, Annals of Mathematics Studies 107, Princeton University Press, 1984.

Twelfth award, 1990: To Shigefumi Mori for his outstanding work on the classification of algebraic varieties and, in particular, for his paper *Flip theorem and the existence of minimal models for 3-folds*, Journal of the American Mathematical Society **1** (1988), pp. 117–253.

Thirteenth award, 1995: To Michel Raynaud and David Harbater for their solution of Abhyankar's conjecture. This work appeared in the papers *Revêtements de la droite affine en caractéristique p* > 0, Invent. Math. **116** (1994), pp. 425–462 (Raynaud); and *Abhyankar's conjecture on Galois groups over curves*, Invent. Math. **117** (1994), pp. 1–25 (Harbater).

Fourteenth award, 2000: To Andrei Suslin for his work on motivic cohomology, and to Aise Johan de Jong for his important work on the resolution of singularities by generically finite maps.

Fifteenth award, 2003: To Hiraku Nakajima for his work in representation theory and geometry.

Sixteenth award, 2006: To János Kollár for his outstanding achievements in the theory of rationally connected varieties and for his illuminating work on a conjecture of Nash.

Seventeenth award, 2009: To Christopher Hacon and James McKernan for their groundbreaking joint work on higher dimensional birational algebraic geometry.

Next award: January 2012.

The Frank Nelson Cole Prize in Number Theory

This prize (and the Frank Nelson Cole Prize in Algebra) was founded in honor of Professor Frank Nelson Cole on the occasion of his retirement as secretary of the American Mathematical Society after twenty-five years of service and as editor-in-chief of the *Bulletin* for twenty-one years. The original fund was donated by Professor Cole from moneys presented to him on his retirement and was augmented by contributions from members of the Society. The fund was later doubled by his son, Charles A. Cole. The prize is for a notable paper in number theory published during the preceding six years. To be eligible, the author should be a member of the American Mathematical Society or the paper should have been published in a recognized North American journal. Currently, the US$5,000 prize is awarded every three years.

First award, 1931: To H. S. Vandiver for his several papers on Fermat's last theorem published in the *Transactions of the American Mathematical Society* and in the *Annals of Mathematics* during the preceding five years, with special reference to a paper entitled *On Fermat's last theorem*, Transactions of the American Mathematical Society 31 (1929), pp.-613–642.

Second award, 1941: To Claude Chevalley for his paper *La théorie du corps de classes*, Annals of Mathematics, Series 2, 41 (1940), pp.-394–418.

Third award, 1946: To H. B. Mann for his paper *A proof of the fundamental theorem on the density of sums of sets of positive integers*, Annals of Mathematics, Series 2, 43 (1942), pp.-523–527.

Fourth award, 1951: To Paul Erdős for his many papers in the theory of numbers, and in particular for his paper *On a new method in elementary number theory which leads to an elementary proof of the prime number theorem*, Proceedings of the National Academy of Sciences 35 (1949), pp.-374–385.

Fifth award, 1956: To John T. Tate for his paper *The higher dimensional cohomology groups of class field theory*, Annals of Mathematics, Series 2, **56** (1952), pp. 294–297.

Sixth award, 1962: To Kenkichi Iwasawa for his paper *Gamma extensions of number fields*, Bulletin of the American Mathematical Society **65** (1959), pp. 183–226; and to Bernard M. Dwork for his paper *On the rationality of the zeta function of an algebraic variety*, American Journal of Mathematics **82** (1960), pp. 631–648.

Seventh award, 1967: To James B. Ax and Simon B. Kochen for a series of three joint papers: *Diophantine problems over local fields. I, II, III*, American Journal of Mathematics **87** (1965), pp. 605–630, 631–648; and Annals of Mathematics, Series 2, **83** (1966), pp. 437–456.

Eighth award, 1972: To Wolfgang M. Schmidt for the following papers: *On simultaneous approximation of two algebraic numbers by rationals*, Acta Mathematica (Uppsala) **119** (1967), pp. 27–50; *T-numbers do exist*, Symposia Mathematica, IV, Academic Press, 1970, pp. 1–26; *Simultaneous approximation to algebraic numbers by rationals*, Acta Mathematica (Uppsala) **125** (1970), pp. 189–201; *On Mahler's T-numbers*, Proceedings of Symposia in Pure Mathematics 20, American Mathematical Society, 1971, pp. 275–286.

Ninth award, 1977: To Goro Shimura for his two papers *Class fields over real quadratic fields and Heche operators*, Annals of Mathematics, Series 2, **95** (1972), pp. 130–190; and *On modular forms of half integral weight*, Annals of Mathematics, Series 2, **97** (1973), pp. 440–481.

Tenth award, 1982: To Robert P. Langlands for pioneering work on automorphic forms, Eisenstein series and product formulas, particularly for his paper *Base change for GL(2)*, Annals of Mathematics Studies 96, Princeton University Press, 1980; and to Barry Mazur for outstanding work on elliptic curves and Abelian varieties, especially on rational points of finite order, and his paper *Modular curves and the Eisenstein ideal*, Publications Mathematiques de l'Institut des Hautes Études Scientifiques **47** (1977), pp. 33–186.

Eleventh award, 1987: To Dorian M. Goldfeld for his paper *Gauss's class number problem for imaginary quadratic fields*, Bulletin of the American Mathematical Society **13** (1985), pp. 23–37; and to Benedict H. Gross and Don B. Zagier for their paper *Heegner points and derivatives of L-series*, Inventiones Mathematicae **84** (1986), pp. 225–320.

Twelfth award, 1992: To Karl Rubin for his work in the area of elliptic curves and Iwasawa theory, with particular reference to his papers *Tate-Shafarevich groups and L-functions of elliptic curves with complex multiplication* and *The "main conjectures" of Iwasawa theory for imaginary quadratic fields;* and to Paul Vojta for his work on Diophantine problems, with particular reference to his paper *Siegel's theorem in the compact case*.

Thirteenth award, 1997: To Andrew J. Wiles for his work on the Shimura-Taniyama conjecture and Fermat's Last Theorem, published in *Modular elliptic curves and Fermat's Last Theorem*, Ann. of Math. 141 (1995), pp. 443–551.

Fourteenth award, 2002: To Henryk Iwaniec for his fundamental contributions to analytic number theory, and to Richard Taylor for several outstanding advances in algebraic number theory.

Fifteenth award, 2005: To Peter Sarnak for his fundamental contributions to number theory and in particular his book *Random Matrices, Frobenius Eigenvalues and Monodromy*, written jointly with his Princeton colleague Nicholas Katz.

Sixteenth award, 2008: To Manjul Bhargava for his revolutionary work on higher composition laws.

Next award: January 2011.

The Levi L. Conant Prize

This prize was established in 2000 in honor of Levi L. Conant to recognize the best expository paper published in either the *Notices of the AMS* or the *Bulletin of the AMS* in the preceding five years. Levi L. Conant was a mathematician at Worcester Polytechnic Institute. His will provided for funds to be donated to the AMS upon his wife's death. The US$1,000 prize is awarded annually.

First award, 2001: To Carl Pomerance for his paper "A tale of two sieves", *Notices of the AMS* **43**, no. 12 (1996), pp. 1473–1485.

Second award, 2002: To Elliott H. Lieb and Jakob Yngvason for their article "A guide to entropy and the Second Law of Thermodynamics", *Notices of the AMS* **45**, no. 5 (1998), pp. 571–581.

Third award, 2003: To Nicholas Katz and Peter Sarnak for their expository paper "Zeroes of zeta functions and symmetry", *Bulletin of the AMS* **36** (1999), pp. 1–26.

Fourth award, 2004: To Noam D. Elkies for his enlightening two-part article "Lattices, linear codes, and invariants", *Notices of the AMS* **47**, no. 10 (2000), Part I, pp. 1238–1245; no. 11, Part II, pp. 1382–1391.

Fifth award, 2005: To Allen Knutson and Terence Tao for their stimulating article "Honeycombs and sums of Hermitian matrices", *Notices of the AMS* **48**, no. 2 (2001), pp. 175–186.

Sixth award, 2006: To Ronald Solomon for his article "A brief history of the classification of the finite simple groups", *Bulletin of the AMS* **38** (2001), no. 3, 315–352.

Seventh award, 2007: To Jeffrey Weeks for his article "The Poincare dodecahedral space and the mystery of the missing fluctuations," *Notices of the AMS* **51** (2004) no. 6, 610–619.

Eighth award, 2008: To J. Brian Conrey for his article "The Riemann Hypothesis", *Notices of the AMS* **50** (2003) no. 3, 341-353; and to Shlomo Hoory, Nathan Linial, and Avi Wigderson for their article "Expander graphs and their applications", *Bulletin of the AMS* **43** (2006), no. 4, 439-561.

Ninth award, 2009: To Jeffrey Weeks for his article "The Poincaré dodecahedral space and the mystery of the missing fluctuations", *Notices of the AMS* **51** (2004) no. 6, 610-619.

Next award: January 2010.

Joseph L. Doob Prize

This prize was established by the AMS in 2003 to recognize a single, relatively recent, outstanding research book that makes a seminal contribution to the research literature, reflects the highest standards of research exposition, and promises to have a deep and long-term impact in its area. The book must have been published within the six calendar years preceding the year in which it is nominated. Books may be nominated by members of the Society, by members of the selection committee, by members of AMS editorial committees, or by publishers. The US$5,000 prize is awarded every three years.

The prize (originally called the Book Prize) was endowed in 2005 by Paul and Virginia Halmos and renamed in honor of Joseph L. Doob. Paul Halmos (Professor Emeritus at Santa Clara University) was Doob's first Ph.D. student. Doob received his Ph.D. from Harvard in 1932 and three years later joined the faculty at the University of Illinois, where he remained until his retirement in 1978. He worked in probability theory and measure theory, served as AMS president in 1963–1964, and received the AMS Steele Prize in 1984 "for his fundamental work in establishing probability as a branch of mathematics." Doob passed away on June 7, 2004, at the age of ninety-four.

First award, 2005: To William P. Thurston for his book *Three-Dimensional Geometry and Topology*, edited by Silvio Levy.

Second award, 2008: To Enrico Bombieri and Walter Gubler for their book *Heights in Diophantine Geometry* (Cambridge University Press, 2006).

Next award: January 2011.

Leonard Eisenbud Prize for Mathematics and Physics

This prize was established in 2006 in memory of the mathematical physicist, Leonard Eisenbud (1913–2004), by his son and daughter-in-law, David and Monika Eisenbud. Leonard Eisenbud was a student of Eugene Wigner. He was particularly known for the book, *Nuclear Structure* (1958), which he co-authored with Wigner. A friend of Paul Erdős, he once threatened to write a dictionary of "English to Erdős and Erdős to English." He was one of the founders of the Physics Department at SUNY Stony Brook, where he taught from 1957 until his retirement in 1983. In later years he became interested in the foundations of quantum mechanics and in the interaction of physics with culture and politics, teaching courses on the anti-science movement. His son, David, was President of the American Mathematical Society 2003–2004.

The prize will honor a work or group of works that brings the two fields closer together. Thus, for example, the prize might be given for a contribution to mathematics inspired by modern developments in physics or for the development of a physical theory exploiting modern mathematics in a novel way.

The US$5,000 prize will be awarded every three years for a work published in the preceding six years.

First award, 2008: To Hirosi Ooguri, Andrew Strominger, and Cumrun Vafa for their paper "Black hole attractors and the topological string", *Physical Review D* (3) **70** (2004), 106007.

Next award: January 2011.

The Delbert Ray Fulkerson Prize

The Fulkerson Prize for outstanding papers in the area of discrete mathematics is sponsored jointly by the Mathematical Programming Society (MPS) and the American Mathematical Society (AMS). Up to three awards of US$1,500 each are presented at each (triennial) International Symposium of the MPS. Originally, the prizes were paid out of a memorial fund administered by the AMS that was established by friends of the late Delbert Ray Fulkerson to encourage mathematical excellence in the fields of research exemplified by his work. The prizes are now funded by an endowment administered by the MPS.

First award, 1979: To Richard M. Karp for *On the computational complexity of combinatorial problems*, Networks, **5** (1975), pp. 45–68; to Kenneth Appel and Wolfgang Haken for *Every planar map is four colorable*, Part I: *Discharging*, Illinois Journal of Mathematics **21** (1977), pp. 429–490; and to Paul D. Seymour for *The matroids with the max-flow min-cut property*, Journal of Combinatorial Theory, Series B, **23** (1977), pp. 189–222.

Second award, 1982: To D. B. Judin and A. S. Nemirovskii for *Informational complexity and effective methods of solution for convex extremal problems*, Ekonomika i Matematicheskie Metody **12** (1976), pp. 357–369; to L. G. Khachiyan for *A polynomial algorithm in linear programming*, Akademiia Nauk SSSR. Doklady **244** (1979), pp. 1093–1096; to G. P. Egorychev for *The solution of van der Waerden's problem for permanents*, Akademiia Nauk SSSR. Doklady **258** (1981), pp. 1041–1044; D. I. Falikman for *A proof of the van der Waerden conjecture on the permanent of a doubly stochastic matrix*, Matematicheskie Zametki **29** (1981), pp. 931–938; and to M. Grötschel, L. Lovasz, and A. Schrijver for *The ellipsoid method and its consequences in combinatorial optimization*, Combinatorica **1** (1981), pp. 169–197.

Third award, 1985: To Jozsef Beck, for *Roth's estimate of the discrepancy of integer sequences is nearly sharp*, Combinatorica **1** (4) (1981), pp. 319–325; to H. W. Lenstra Jr. for *Integer programming with a fixed number of variables*, Mathematics of Operations Research **8** (4) (1983), pp. 538–548; and to Eugene M. Luks for *Isomorphism of graphs of bounded valence can be tested in polynomial time*, Journal of Computer and System Sciences **25** (1) (1982), pp. 42–65.

Fourth award, 1988: To Éva Tardos for *A strongly polynomial minimum cost circulation algorithm*, Combinatorica **5** (1985), pp. 247–256; and to Narendra Karmarkar for *A new polynomial-time algorithm for linear programming*, Combinatorica **4** (1984), pp. 373–395.

Fifth award, 1991: To Martin Dyer, Alan Frieze, and Ravi Kannan for *A random polynomial time algorithm for approximating the volume of convex bodies*, Journal of the Association for Computing Machinery **38**/1 (1991), pp. 1–17; to Alfred Lehman for *The width-length inequality and degenerate projective planes*, W. Cook and P. D. Seymour (eds.), *Polyhedral Combinatorics*, DIMACS Series in Discrete Mathematics and Theoretical Computer Science 1, American Mathematical Society, 1990, pp. 101–105; and to Nikolai E. Mnev for *The universality theorems on the classification problem of configuration varieties and convex polytope varieties*, O. Ya. Viro (ed.), *Topology and Geometry–Rohlin Seminar*, Lecture Notes in Mathematics 1346, Springer–Verlag, Berlin, 1988, pp. 527–544.

Sixth Award, 1994: To Lou Billera for *Homology of smooth splines: Generic triangulations and a conjecture of Strang*, Transactions of the AMS **310** (1988), pp. 325–340; to Gil Kalai for *Upper bounds for the diameter and height of graphs of the convex polyhedra*, Discrete and Computational Geometry **8** (1992), pp. 363–372; and to Neil Robertson, Paul D. Seymour, and Robin Thomas for *Hadwiger's conjecture for K6; free graphs*, Combinatorica **13** (1993), pp. 279–361.

Seventh award, 1997: To Jeong Han Kim for *The Ramsey number R*(3,*t*) *has order of magnitude*, which appeared in Random Structures and Algorithms **7** (1995) no. 3, pp. 173–207.

Eighth award, 2000: To Michel X. Goemans and David P. Williamson for *Improved approximation algorithms for the maximum cut and satisfiability problems using semi-definite programming*, Journal of the Association for Computing Machinery **42** (1995), no. 6, pp. 1115–1145; and to Michele Conforti, Gerard Cornuejols, and M. R. Rao for *Decomposition of balanced matrices*, Journal of Combinatorial Theory, Series B **77** (1999), no. 2, pp. 292–406.

Ninth award, 2003: To J. F. Geelen, A. M. H. Gerards, and A. Kapoor for *The excluded minors for GF(4)-representable matroids*, Journal of Combinatorial Theory Series B, **79** (2000), no. 2, pp. 247–299; to Bertrand Guenin for *A characterization of weakly bipartite graphs*, Journal of Combinatorial Theory Series B, **83** (2001), no. 1, pp. 112–168; to Satoru Iwata, Lisa Fleischer, and Satoru Fujishige for *A combinatorial strongly polynomial algorithm for minimizing submodular functions*, Journal of the ACM, **48** (July 2001), no. 4, pp. 761–777; and to Alexander Schrijver for *A combinatorial algorithm minimizing submodular functions in strongly polynomial time,* Journal of Combinatorial Theory, Series B, **80** (2000), no. 2, pp. 346–355.

Tenth award, 2006: To Manindra Agrawal, Neeraj Kayal and Nitin Saxena, *PRIMES is in P*, Annals of Mathematics, Volume 160, issue 2, 2004, Pp. 781–793; and to Mark Jerrum, Alistair Sinclair and Eric Vigoda, *A polynomial-time approximation algorithm for the permanent of a matrix with nonnegative entries*, J. ACM, Volume 51, Issue 4, 2004, pp. 671–697; and to Neil Robertson and Paul D. Seymour, *Graph Minors. XX. Wagner's conjecture*, Journal of Combinatorial Theory, Series B, **92** (2004), no. 2, pp. 325–357.

Eleventh award, 2009: To M. Chudnovsky, N. Robertson, P. Seymour, and R. Thomas, *The strong perfect graph theorem*, Annals of Mathematics **164** (2006) 51-229; and to D. A. Spielman and S.-H. Teng, *Smoothed analysis of algorithms: Why the simplex algorithm usually takes polynomial time*, Journal of ACM **51** (2004) 385-463; and to Thomas C. Hales, *A proof of the Kepler conjecture*, Annals of Mathematics **162** (2005) 1063-1183; and to Samuel P. Ferguson, *Sphere Packings, V. Pentahedral Prisms*, Discrete and Computational Geometry **33** (2006) 167-204.

Next award: August 2012.

E. H. Moore Research Article Prize

This prize was established in 2002 in honor of E. H. Moore. Among other activities, Moore founded the Chicago branch of the American Mathematical Society, served as the Society's sixth president (1901–1902), delivered the Colloquium Lectures in 1906, and founded and nurtured the *Transactions of the AMS.* The US$5,000 prize will be awarded every three years for an outstanding research article to have appeared in one of the AMS primary research journals (namely, the *Journal of the AMS*, *Proceedings of the AMS*, *Transactions of the AMS*, *Memoirs of the AMS*, *Mathematics of Computation*, *Electronic Journal of Conformal Geometry and Dynamics*, and *Electronic Journal of Representation Theory*) during the six calendar years ending a full year before the meeting at which the prize is awarded.

First award, 2004: To Mark Haiman for *Hilbert schemes, polygraphs, and the Macdonald positivity conjecture*, Journal of the AMS **14** (2001), pp. 941–1006.

Second award, 2007: To Ivan Shestakov and Ualbai Umirbaev for their two ground-breaking papers, both published in the Journal of the American Mathematical Society: *The tame and the wild automorphisms of polynomial rings in three variables*, **17** (2004), no. 1, 197–227; and *Poisson brackets and two-generated subalgebras of rings of polynomials*, **17** (2004), no. 1, 181–196.

Next award: January 2010.

The Frank and Brennie Morgan Prize for Outstanding Research in Mathematics by an Undergraduate Student

This prize, which was established in 1995, is to be awarded to an undergraduate student (or students having submitted joint work) for outstanding research in mathematics. It is entirely endowed by a gift from Mrs. Frank (Brennie) Morgan. Any student who is an undergraduate in a college or university in Canada, Mexico, or the United States or its possessions is eligible to be considered for this US$1,000 prize, which is to be awarded annually. The award is made jointly by the American Mathematical Society, the Mathematical Association of America, and the Society for Industrial and Applied Mathematics.

First award, 1995: To Kannan Soundararajan for truly exceptional research in analytic number theory. Honorable mention: Kiran Kedlaya.

Second award, 1996: To Manjul Bhargava for truly outstanding mathematical research in algebra. Honorable mention: Lenhard L. Ng.

Third award, 1997: To Jade Vinson for wide-ranging research in analysis and geometry. Honorable mention: Vikaas Sohal.

Fourth award, 1998: To Daniel Biss for his remarkable breadth, as well as depth. The most exciting aspect of his submission was his extension of a category which more closely binds the associations between combinatorial group theory and combinatorial topology. Honorable mention: Aaron E. Archer.

Fifth award, 1999: To Sean McLaughlin for his proof of the Dodecahedral Conjecture, a major problem in discrete geometry related to, but distinct from, Kepler's sphere-packing problem and a conjecture that has resisted the efforts of the strongest workers in this area for nearly sixty years. Honorable mention: Samit Dasgupta.

Sixth award, 2000: To Jacob Lurie for his paper "On simply laced Lie algebras and their miniscule representations". Honorable mention: Wai Ling Yee.

Seventh award, 2001: To Ciprian Manolescu for making a fundamental advance in the field by giving an elegant construction of Floer homology. Honorable mention: Michael A. Levin.

Eighth award, 2002: To Joshua Greene for his work in combinatorics.

Ninth award, 2003: To Melanie Wood for research on Belyi-extending maps and *P*-orderings. Honorable mention: Karen Yeats.

Tenth award, 2004: To Reid W. Barton for his paper "Packing densities of patterns". Honorable mention: Po-Shen Loh.

Eleventh award, 2006: To Jacob Fox for a most astounding collection of research papers by any undergraduate mathematician.

Twelfth award, 2007: To Daniel Kane for establishing a research record that would be the envy of many professional mathematicians.

Thirteenth award, 2008: To Aaron Pixton for five impressive papers he has written, in addition to his Princeton senior thesis.

Fourteenth award, 2009: To Nathan Kaplan for four impressive papers in algebraic number theory.

Next award: January 2010.

David P. Robbins Prize

This prize was established in 2005 in memory of David P. Robbins by members of his family. Robbins, who died in 2003, received his Ph.D. in 1970 from MIT. He was a long-time member of the Institute for Defense Analysis Center for Communications Research and a prolific mathematician whose work (much of it classified) was in discrete mathematics. The prize is for a paper with the following characteristics: it shall report on novel research in algebra, combinatorics, or discrete mathematics and shall have a significant experimental component; and it shall be on a topic which is broadly accessible and shall provide a simple statement of the problem and clear exposition of the work. The US$5,000 prize will be awarded every three years.

First award, 2007: To Samuel P. Ferguson and Thomas C. Hales, for the paper *A proof of the Kepler conjecture*, by Thomas C. Hales, Annals of Mathematics, **162** (2005), 1065–1185 (Section 5 of this paper is jointly authored with Ferguson).

Next award: January 2010.

The Ruth Lyttle Satter Prize in Mathematics

The prize was established in 1990 using funds donated by Joan S. Birman in memory of her sister, Ruth Lyttle Satter. Professor Birman requested that the prize be established to honor her sister's commitment to research and to encouraging women in science. The US$5,000 prize is awarded every two years to recognize an outstanding contribution to mathematics research by a woman in the previous six years.

First award, 1991: To Dusa McDuff for her outstanding work during the past five years on symplectic geometry.

Second award, 1993: To Lai-Sang Young for her leading role in the investigation of the statistical (or ergodic) properties of dynamical systems.

Third award, 1995: To Sun-Yung Alice Chang for her deep contributions to the study of partial differential equations on Riemannian manifolds and in particular for her work on extremal problems in spectral geometry and the compactness of isospectral metrics within a fixed conformal class on a compact 3-manifold.

Fourth award, 1997: To Ingrid Daubechies for her deep and beautiful analysis of wavelets and their applications.

Fifth award, 1999: To Bernadette Perrin-Riou for her number theoretical research on p-adic L-functions and Iwasawa Theory.

Sixth award, 2001: To Karen E. Smith for her outstanding work in commutative algebra, and to Sijue Wu for her work on a long-standing problem in the water wave equation.

Seventh award, 2003: To Abigail Thompson for her outstanding work in 3-dimensional topology.

Eighth award, 2005: To Svetlana Jitomirskaya for her pioneering work on nonpertubative quasiperiodic localization, in particular for results in her papers (1) *Metal-insulator transition for the almost Mathieu operator*, Ann. of Math. (2) **150** (1999), no. 3, pp. 1159–1175; and (2) with J. Bourgain, *Absolutely continuous spectrum for 1D quasiperiodic operators*, Invent. Math. **148** (2002), no. 3, pp. 453–463.

Ninth award, 2007: To Claire Voisin for her deep contributions to algebraic geometry, and in particular for her recent solutions to two long-standing open problems: the Kodaira problem (*On the homotopy types of compact Kähler and complex projective manifolds*, Inventiones Mathematicae, **157** (2004), no. 2, 329–343) and Green's Conjecture (*Green's canonical syzygy conjecture for generic curves of odd genus*, Compositio Mathematica, **141** (2005), no. 5, 1163–1190; and *Green's generic syzygy conjecture for curves of even genus lying on a K3 surface*, Journal of the European Mathematical Society, **4** (2002), no. 4, 363–404).

Tenth award, 2009: To Laure Saint-Raymond for her fundamental work on the hydrodynamic limits of the Boltzmann equation in the kinetic theory of gases.

Next award: January 2011.

The Leroy P. Steele Prize for Lifetime Achievement
The Leroy P. Steele Prize for Mathematical Exposition
The Leroy P. Steele Prize for Seminal Contribution to Research

These prizes were established in 1970 in honor of George David Birkhoff, William Fogg Osgood, and William Caspar Graustein and are endowed under the terms of a bequest from Leroy P. Steele. From 1970 to 1976 one or more prizes were awarded each year for outstanding published mathematical research; most favorable consideration was given to papers distinguished for their exposition and covering broad areas of mathematics. In 1977 the Council of the AMS modified the terms under which the prizes are awarded. Since then, up to three prizes have been awarded each year in the following categories: (1) for the cumulative influence of the total mathematical work of the recipient, high level of research over a period of time, particular influence on the development of a field, and influence on mathematics through Ph.D. students; (2) for a book or substantial survey or expository research paper; (3) for a paper, whether recent or not, that has proved to be of fundamental or lasting importance in its field, or a model of important research. In 1993 the Council formalized the three categories of the prize by naming each of them: (1) The Leroy P. Steele Prize for Lifetime Achievement, (2) The Leroy P. Steele Prize for Mathematical Exposition, and (3) The Leroy P. Steele Prize for Seminal Contribution to Research. Each of these three US$5,000 prizes is awarded annually.

Special Note: Beginning with the 1994 prize, there has been a five-year cycle of fields for the Seminal Contribution to Research Award. That cycle would have the 2008 prize awarded in discrete mathematics (discrete mathematics alternates with logic every five years), then analysis in 2009, algebra in 2010, applied mathematics in 2011, geometry/topology in 2012, and then logic in 2013, renewing the cycle.

August 1970: To Solomon Lefschetz for his paper *A page of mathematical autobiography*, Bulletin of the American Mathematical Society **74** (1968), pp. 854–879.

August 1971: To James B. Carrell for his paper, written jointly with Jean A. Dieudonne, *Invariant theory, old and new*, Advances in Mathematics **4** (1970), pp. 1–80.

August 1971: To Jean A. Dieudonné for his paper *Algebraic geometry*, Advances in Mathematics **3** (1969), pp. 223–321; and for his paper, written jointly with James B. Carrell, *Invariant theory, old and new*, Advances in Mathematics **4** (1970), pp. 1–80.

August 1971: To Phillip A. Griffiths for his paper *Periods of integrals on algebraic manifolds*, Bulletin of the American Mathematical Society **76** (1970), pp. 228–296.

August 1972: To Edward B. Curtis for his paper *Simplicial homotopy theory*, Advances in Mathematics **6** (1971), pp. 107–209.

August 1972: To William J. Ellison for his paper *Waring's problem*, American Mathematical Monthly **78** (1971), pp. 10–36.

August 1972: To Lawrence F. Payne for his paper *Isoperimetric inequalities and their applications*, SIAM Review **9** (1967), pp. 453–488.

August 1972: To Dana S. Scott for his paper *A proof of the independence of the continuum hypothesis*, Mathematical Systems Theory **1** (1967), pp. 89–111.

January 1975: To Lipman Bers for his paper *Uniformization, moduli, and Kleinian groups*, Bulletin of the London Mathematical Society **4** (1972), pp. 257–300.

January 1975: To Martin D. Davis for his paper *Hilbert's tenth problem is unsolvable*, American Mathematical Monthly **80** (1973), pp. 233–269.

January 1975: To Joseph L. Taylor for his paper *Measure algebras*, CBMS Regional Conference Series in Mathematics, Number 16, American Mathematical Society, 1972.

August 1975: To George W. Mackey for his paper *Ergodic theory and its significance for statistical mechanics and probability theory*, Advances in Mathematics **12** (1974), pp. 178–286.

August 1975: To H. Blaine Lawson for his paper *Foliations*, Bulletin of the American Mathematical Society **80** (1974), pp. 369–418.

1976, 1977, 1978: No awards were made.

January 1979: To Salomon Bochner for his cumulative influence on the fields of probability theory, Fourier analysis, several complex variables, and differential geometry.

January 1979: To Hans Lewy for three fundamental papers: *On the local character of the solutions of an atypical linear differential equation in three variables and a related theorem for regular functions of two complex variables*, Annals of Mathematics, Series 2, **64** (1956), pp. 514–522; *An example of a smooth linear partial differential equation without solution*, Annals of Mathematics, Series 2, **66** (1957), pp. 155–158; and *On hulls of holomorphy*, Communications in Pure and Applied Mathematics **13** (1960), pp. 587–591.

August 1979: To Antoni Zygmund for his cumulative influence on the theory of Fourier series, real variables, and related areas of analysis.

August 1979: To Robin Hartshorne for his expository research article *Equivalence relations on algebraic cycles and subvarieties of small codimension*, Proceedings of Symposia in Pure Mathematics, volume 29, American Mathematical Society, 1975, pp. 129–164; and his book *Algebraic Geometry*, Springer–Verlag, Berlin and New York, 1977.

August 1979: To Joseph J. Kohn for his fundamental paper *Harmonic integrals on strongly convex domains. I, II*, Annals of Mathematics, Series 2, **78** (1963), pp. 112–248; and 79 (1964), pp.-450–472.

August 1980: To André Weil for the total effect of his work on the general course of twentieth-century mathematics, especially in the many areas in which he has made fundamental contributions.

August 1980: To Harold M. Edwards for mathematical exposition in his books *Riemann's Zeta Function*, Pure and Applied Mathematics, number 58, Academic Press, New York and London, 1974; and *Fermat's Last Theorem*, Graduate Texts in Mathematics, number 50, Springer-Verlag, New York and Berlin, 1977.

August 1980: To Gerhard P. Hochschild for his significant work in homological algebra and its applications.

August 1981: To Oscar Zariski for his work in algebraic geometry, especially his fundamental contributions to the algebraic foundations of this subject.

August 1981: To Eberhard Hopf for three papers of fundamental and lasting importance: *Abzweigung einer periodischen Lösung von einer stationären Lösung eines Differential systems*, Berichte über die Verhandlungen der Sächsischen Akademie der Wissenschaften zu Leipzig. Mathematisch–Naturwissenschaftliche Klasse **95** (1943), pp. 3–22; *A mathematical example displaying features of turbulence*, Communications on Applied Mathematics **1** (1948), pp. 303–322; and *The partial differential equation* $u_t+uu_x=u_{xx}$, Communications on Pure and Applied Mathematics **3** (1950), pp. 201–230.

August 1981: To Nelson Dunford and Jacob T. Schwartz for their expository book *Linear Operators*, Part I, *General Theory*, 1958; Part II, *Spectral Theory*, 1963; Part III, *Spectral Operators*, 1971, Interscience Publishers, New York.

August 1982: To Lars V. Ahlfors for his expository work in *Complex Analysis,* McGraw-Hill Book Company, New York, 1953; and in *Lectures on Quasiconformal Mappings,* D. Van Nostrand Co., Inc., New York, 1966; and *Conformal Invariants,* McGraw-Hill Book Company, New York, 1973.

August 1982: To Tsit-Yuen Lam for his expository work in his book *Algebraic Theory of Quadratic Forms* (1973), and four of his papers: *K_0 and K_1—an introduction to algebraic K-theory* (1975), *Ten lectures on quadratic forms over fields* (1977), *Serre's conjecture* (1978), and *The theory of ordered fields* (1980).

August 1982: To John W. Milnor for a paper of fundamental and lasting importance, *On manifolds homeomorphic to the -sphere*, Annals of Mathematics (2) **64** (1956), pp. 399–405.

August 1982: To Fritz John for the cumulative influence of his total mathematical work, high level of research over a period of time, particular influence on the development of a field, and influence on mathematics through Ph.D. students.

August 1983: To Paul R. Halmos for his many graduate texts in mathematics and for his articles on how to write, talk, and publish mathematics.

August 1983: To Steven C. Kleene for three important papers which formed the basis for later developments in generalized recursion theory and descriptive set theory: *Arithmetical predicates and function quantifiers*, Transactions of the American Mathematical Society **79** (1955), pp. 312–340; *On the forms of the predicates in the theory of constructive ordinals (second paper)*, American Journal of Mathematics **77** (1955), pp. 405–428; and *Hierarchies of number-theoretic predicates*, Bulletin of the American Mathematical Society **61** (1955), pp. 193–213.

August 1983: To Shiing-Shen Chern for the cumulative influence of his total mathematical work, high level of research over a period of time, particular influence on the development of the field of differential geometry, and influence on mathematics through Ph.D. students.

August 1984: To Elias M. Stein for his book *Singular Integrals and the Differentiability Properties of Functions*, Princeton University Press, 1970.

August 1984: To Lennart Carleson for his papers *An interpolation problem for bounded analytic functions*, American Journal of Mathematics **80** (1958), pp. 921– 930; *Interpolation by bounded analytic functions and the Corona problem*, Annals of Mathematics (2) **76** (1962), pp. 547–559; and *On convergence and growth of partial sums of Fourier series*, Acta Mathematica **116** (1966), pp. 135–157.

August 1984: To Joseph L. Doob for his fundamental work in establishing probability as a branch of mathematics and for his continuing profound influence on its development.

August 1985: To Michael Spivak for his five-volume set *A Comprehensive Introduction to Differential Geometry* (second edition), Publish or Perish, 1979.

August 1985: To Robert Steinberg for three papers on various aspects of the theory of algebraic groups: *Representations of algebraic groups*, Nagoya Mathematical Journal **22** (1963), pp. 33–56; *Regular elements of semisimple algebraic groups*, Institut des Hautes Études Scientifiques Publications Mathématiques **25** (1965), pp. 49–80; and *Endomorphisms of linear algebraic groups*, Memoirs of the American Mathematical Society **80** (1968).

August 1985: To Hassler Whitney for his fundamental work on geometric problems, particularly in the general theory of manifolds, in the study of differentiable functions on closed sets, in geometric integration theory, and in the geometry of the tangents to a singular analytic space.

January 1986: To Donald E. Knuth for his expository work *The Art of Computer Programming*, 3 volumes (first edition, 1968; second edition, 1973).

January 1986: To Rudolf E. Kalman for his two fundamental papers: *A new approach to linear filtering and prediction problems*, Journal of Basic Engineering **82** (1960), pp. 35–45; and *Mathematical description of linear dynamical systems,* SIAM Journal on Control and Optimization **1** (1963), pp. 152–192; and for his contribution to a third paper (with R. S. Bucy), *New results in linear filtering and prediction theory*, Journal of Basic Engineering **83D** (1961), pp. 95–108.

January 1986: To Saunders Mac Lane for his many contributions to algebra and algebraic topology, and in particular for his pioneering work in homological and categorical algebra.

August 1987: To Martin Gardner for his many books and articles on mathematics and particularly for his column "Mathematical Games" in *Scientific American*.

August 1987: To Herbert Federer and Wendell Fleming for their pioneering paper *Normal and integral currents*, Annals of Mathematics **72** (1960), pp. 458–520.

August 1987: To Samuel Eilenberg for his fundamental contributions to topology and algebra, in particular for his classic papers on singular homology and his work on axiomatic homology theory, which had a profound influence on the development of algebraic topology.

August 1988: To Sigurdur Helgason for his books *Differential Geometry and Symmetric Spaces*, Academic Press, 1962; *Differential Geometry, Lie Groups, and Symmetric Spaces,* Academic Press, 1978; and *Groups and Geometric Analysis,* Academic Press, 1984.

August 1988: To Gian-Carlo Rota for his paper *On the foundations of combinatorial theory, I. Theory of Möbius functions*, Zeitschrift für Wahrscheinlichkeitstheorie und Verwandte Gebiete, volume 2 (1964), pp. 340–368.

August 1988: To Deane Montgomery for his lasting impact on mathematics, particularly mathematics in America. He is one of the founders of the modern theory of transformation groups and is particularly known for his contributions to the solution of Hilbert's fifth problem.

August 1989: To Daniel Gorenstein for his book *Finite Simple Groups, An Introduction to Their Classification,* Plenum Press, 1982; and his two survey articles, *The classification of finite simple groups* and *Classifying the finite simple groups*, Bulletin of the American Mathematical Society **1** (1979), pp. 43–199; and **14** (1986), pp. 1–98, respectively.

August 1989: To Alberto P. Calderón for his paper *Uniqueness in the Cauchy problem for partial differential equations*, American Journal of Mathematics **80** (1958), pp. 16–36.

August 1989: To Irving Kaplansky for his lasting impact on mathematics, particularly mathematics in America. By his energetic example, his enthusiastic exposition, and his overall generosity, he has made striking changes in mathematics and has inspired generations of younger mathematicians.

August 1990: To R. D. Richtmyer for his book *Difference Methods for Initial-Value Problems*, Interscience, first edition, 1957; and second edition, with K. Morton, 1967.

August 1990: To Bertram Kostant for his paper *On the existence and irreducibility of certain series of representations*, Lie Groups and Their Representations (1975), pp. 231–329.

August 1990: To Raoul Bott for having been instrumental in changing the face of geometry and topology with his incisive contributions to characteristic classes, *K*-theory, index theory, and many other tools of modern mathematics.

August 1991: To Jean-François Trèves for *Pseudodifferential and Fourier Integral Operators*, Volumes 1 and 2, Plenum Press, 1980.

August 1991: To Eugenio Calabi for his fundamental work on global differential geometry, especially complex differential geometry.

August 1991: To Armand Borel for his extensive contributions in geometry and topology, the theory of Lie groups, their lattices and representations and the theory of automorphic forms, the theory of algebraic groups and their representations, and extensive organizational and educational efforts to develop and disseminate modern mathematics.

January 1993: To Jacques Dixmier for his books *von Neumann Algebras* (*Algèbres de von Neumann*), Gauthier-Villars, Paris, 1957; *C*-Algebras* (*Les C*-Algèbres et leurs Representations*), Gauthier-Villars, Paris, 1964; and *Enveloping Algebras* (*Algèbres Enveloppantes*), Gauthier-Villars, Paris, 1974.

January 1993: To James Glimm for his paper *Solution in the large for nonlinear hyperbolic systems of conservation laws*, Communications on Pure and Applied Mathematics, **XVIII** (1965), pp. 697–715.

January 1993: To Peter D. Lax for his numerous and fundamental contributions to the theory and applications of linear and nonlinear partial differential equations and functional analysis, for his leadership in the development of computational and applied mathematics, and for his extraordinary impact as a teacher.

August 1993 – Mathematical Exposition: To Walter Rudin for his books *Principles of Mathematical Analysis*, McGraw-Hill, 1953, 1964, and 1976; and *Real and Complex Analysis*, McGraw-Hill, 1966, 1974, and 1976.

August 1993 – Seminal Contribution to Research: To George Daniel Mostow for his paper *Strong rigidity of locally symmetric spaces*, Annals of Mathematics Studies, number **78**, Princeton University Press, 1973.

August 1993 – Lifetime Achievement: To Eugene B. Dynkin for his foundational contributions to Lie algebras and probability theory over a long period and his production of outstanding research students in both Russia and the United States, countries to whose mathematical life he has contributed so richly.

August 1994 – Mathematical Exposition: To Ingrid Daubechies for her book *Ten Lectures on Wavelets*, CBMS, volume 61, SIAM, 1992.

August 1994 – Seminal Contribution to Research: To Louis de Branges for his proof of the Bieberbach Conjecture.

August 1994 – Lifetime Achievement: To Louis Nirenberg for his numerous basic contributions to linear and nonlinear partial differential equations and their application to complex analysis and differential geometry.

August 1995 – Mathematical Exposition: To Jean-Pierre Serre for his 1970 book *Cours d'Arithmétique*, with its English translation, published in 1973 by Springer Verlag, *A Course in Arithmetic*.

August 1995 – Seminal Contribution to Research: To Edward Nelson for the following two papers in mathematical physics, characterized by leaders of the field as extremely innovative: *A quartic interaction in two dimensions* in *Mathematical Theory of Elementary Particles*, MIT Press, 1966, pp. 69–73; and *Construction of quantum fields from Markoff fields* in Journal of Functional Analysis **12** (1973), pp. 97–112. In these papers he showed for the first time how to use the powerful tools of probability theory to attack the hard analytic questions of constructive quantum field theory, controlling renormalizations with estimates in the first paper, and in the second turning Euclidean quantum field theory into a subset of the theory of stochastic processes.

August 1995 – Lifetime Achievement: To John T. Tate for scientific accomplishments spanning four and a half decades. He has been deeply influential in many of the important developments in algebra, algebraic geometry, and number theory during this time.

August 1996 – Mathematical Exposition: To Bruce C. Berndt for the four volumes, *Ramanujan's Notebooks*, Parts I, II, III, and IV (Springer, 1985, 1989, 1991, and 1994).

August 1996 – Mathematical Exposition: To William Fulton for his book *Intersection Theory*, Springer-Verlag, Ergebnisse series, 1984.

August 1996 – Seminal Contribution to Research: To Daniel Stroock and S. R. S. Varadhan for their four papers: *Diffusion processes with continuous coefficients I and II*, Comm. Pure Appl. Math. **22** (1969), pp. 345–400, pp. 479–530; *On the support of diffusion processes with applications to the strong maximum principle*, Sixth Berkeley Sympos. Math. Statist. Probab., vol. III, 1970, pp. 333–360; *Diffusion processes with boundary conditions*, Comm. Pure Appl. Math. **34** (1971), pp. 147–225; *Multidimensional diffusion processes*, Springer-Verlag, 1979.

August 1996 – Lifetime Achievement: To Goro Shimura for his important and extensive work on arithmetical geometry and automorphic forms; concepts introduced by him were often seminal and fertile ground for new developments, as witnessed by the many notations in number theory that carry his name and that have long been familiar to workers in the field.

January 1997 – Mathematical Exposition: To Anthony W. Knapp for his book *Representation Theory of Semisimple Groups (An overview based on examples)*, Princeton University Press, 1986, a beautifully written book which starts from scratch but takes the reader far into a highly developed subject.

January 1997 – Seminal Contribution to Research: To Mikhael Gromov for his paper *Pseudo-holomorphic curves in symplectic manifolds*, Inventiones Math. **82** (1985), pp. 307–347, which revolutionized the subject of symplectic geometry and topology and is central to much current research activity, including quantum cohomology and mirror symmetry.

January 1997 – Lifetime Achievement: To Ralph S. Phillips for being one of the outstanding analysts of our time. His early work was in functional analysis: his beautiful theorem on the relation between the spectrum of a semigroup and its infinitesimal generator is striking as well as very useful in the study of PDEs. His extension theory for dissipative linear operators predated the interpolation approach to operator theory and robust control. He made major contributions to acoustical scattering theory in his joint work with Peter Lax, proving remarkable results on local energy decay and the connections between poles of the scattering matrix and the analytic properties of the resolvent. He later extended this work to a spectral theory for the automorphic Laplace operator, relying on the Radon transform on horospheres to avoid Eisenstein series. In the last fifteen years, Ralph Phillips has done brilliant work, in collaboration with others, on spectral theory for the Laplacian on symmetric spaces, on the existence and stability of cusp forms for general noncompact quotients of the hyperbolic plane, on the explicit construction of sparse optimal expander graphs, and on the structure of families of isospectral sets in two dimensions (the collection of drums that sound the same).

January 1998 – Lifetime Achievement: To Nathan Jacobson for his many contributions to research, teaching, exposition, and the mathematical profession. Few mathematicians have been as productive over such a long career or have had as much influence on the profession as has Professor Jacobson.

January 1998 – Seminal Contribution to Research: To Herbert Wilf and Doron Zeilberger for their joint paper *Rational functions certify combinatorial identities*, Journal of the American Mathematical Society **3** (1990), pp. 147–158.

January 1998 – Mathematical Exposition: To Joseph Silverman for his books *The Arithmetic of Elliptic Curves*, Graduate Texts in Mathematics, volume 106, Springer-Verlag, New York and Berlin, 1986; and *Advanced Topics in the Arithmetic of Elliptic Curves*, Graduate Texts in Mathematics, volume 151, Springer-Verlag, New York, 1994.

January 1999 – Lifetime Achievement: To Richard V. Kadison. For almost half a century, Professor Kadison has been one of the world leaders in the subject of operator algebras, and the tremendous flourishing of this subject in the last thirty years is largely due to his efforts.

January 1999 – Seminal Contribution to Research: To Michael G. Crandall for two seminal papers: *Viscosity solutions of Hamilton-Jacobi equations* (joint with P.-L. Lions), Trans. Amer. Math. Soc. **277** (1983), pp. 1–42; and *Generation of semi-groups of nonlinear transformations on general Banach spaces* (joint with T. M. Liggett), Amer. J. Math. **93** (1971), pp. 265–298.

January 1999 – Seminal Contribution to Research: To John F. Nash for his remarkable paper *The embedding problem for Riemannian manifolds*, Ann. of Math. (2) **63** (1956), pp. 20–63.

January 1999 – Mathematical Exposition: To Serge Lang for his many books. Among Lang's most famous texts are *Algebra*, Addison-Wesley, Reading, MA, 1965; second edition, 1984; third edition, 1993; and *Algebraic Number Theory,* Addison-Wesley, Reading, MA, 1970; second edition, Graduate Texts in Mathematics, volume 110, Springer-Verlag, New York, 1994.

January 2000 – Lifetime Achievement: To Isadore M. Singer. Singer's series of five papers with Michael F. Atiyah on the Index Theorem for elliptic operators (which appeared in 1968–71) and his three papers with Atiyah and V. K. Patodi on the Index Theorem for manifolds with boundary (which appeared in 1975–76) are among the great classics of global analysis.

January 2000 – Seminal Contribution to Research: To Barry Mazur for his paper *Modular curves and the Eisenstein ideal* in Publications Mathematiques de l'Institut des Hautes Études Scientifiques, **47** (1978), pp. 33–186.

January 2000 – Mathematical Exposition: To John H. Conway in recognition of his many expository contributions in automata, the theory of games, lattices, coding theory, group theory, and quadratic forms.

January 2001 – Lifetime Achievement: To Harry Kesten for his many and deep contributions to probability theory and its applications.

January 2001 – Seminal Contribution to Research: To Leslie F. Greengard and Vladimir Rokhlin for the paper *A fast algorithm for particle simulations*, J. Comput. Phys. **73**, no. 2 (1987), pp. 325–348.

January 2001 – Mathematical Exposition: To Richard P. Stanley in recognition of the completion of his two-volume work *Enumerative Combinatorics.*

January 2002 – Lifetime Achievement: To Michael Artin for helping to weave the fabric of modern algebraic geometry and to Elias Stein for making fundamental contributions to different branches of analysis.

January 2002 – Seminal Contribution to Research: To Mark Goresky and Robert MacPherson for the papers *Intersection homology theory*, Topology **19** (1980), no. 2, pp. 135–162 (IH1); and *Intersection homology. II*, Invent. Math. **72** (1983), no. 1, pp. 77–129 (IH2).

January 2002 – Mathematical Exposition: To Yitzhak Katznelson for his book on harmonic analysis.

January 2003 – Lifetime Achievement: To Ron Graham for being one of the principal architects of the rapid development worldwide of discrete mathematics in recent years and to Victor Guillemin for playing a critical role in the development of a number of important areas in analysis and geometry.

January 2003 – Seminal Contribution to Research: To Ronald Jensen for his paper *The fine structure of the constructible hierarchy*, Annals of Mathematical Logic **4** (1972), 229–308 pp.; and to Michael Morley for his paper *Categoricity in power*, Transactions of the AMS **114** (1965), pp. 514–538.

January 2003 – Mathematical Exposition: To John B. Garnett for his book *Bounded Analytic Functions*, Pure and Applied Mathematics, volume 96, Academic Press, Inc. [Harcourt Brace Jovanovich, Publishers], New York and London, 1981.

January 2004 – Lifetime Achievement: To Cathleen Synge Morawetz for greatly influencing mathematics in the broad sense throughout her long and distinguished career.

January 2004 – Seminal Contribution to Research: To Lawrence C. Evans and Nicolai V. Krylov for the "Evans-Krylov theorem", as first established in the papers: Lawrence C. Evans, *Classical solutions of fully nonlinear convex, second order elliptic equations*, Communications in Pure and Applied Mathematics **35** (1982), no. 3, pp. 333–363; and N. V. Krylov, *Boundedly inhomogeneous elliptic and parabolic equations*, Izvestiya Akad. Nauk SSSR, Ser. Mat. **46** (1982), no. 3, pp. 487–523; translated in Mathematics of the USSR, Izvestiya **20** (1983), no. 3, pp. 459–492.

January 2004 – Mathematical Exposition: To John W. Milnor in recognition of a lifetime of expository contributions ranging across a wide spectrum of disciplines, including topology, symmetric bilinear forms, characteristic classes, Morse theory, game theory, algebraic K-theory, iterated rational maps,…and the list goes on.

January 2005 – Lifetime Achievement: To Israel M. Gelfand for profoundly influencing many fields of research through his own work and through his interactions with other mathematicians and students.

January 2005 – Seminal Contribution to Research: To Robert P. Langlands for his paper *Problems in the theory of automorphic forms*, Springer Lecture Notes in Math., volume 170, 1970, pp. 18–86. This is the paper that introduced what are now known as the Langlands conjectures.

January 2005 – Mathematical Exposition: To Branko Grünbaum for his book *Convex Polytopes.*

January 2006 – Lifetime Achievement: To Frederick W. Gehring for being a leading figure in the theory of quasiconformal mappings for over fifty years; and to Dennis

P. Sullivan for his fundamental contributions to many branches of mathematics.

January 2006 – Seminal Contribution to Research: To Clifford S. Gardner, John M. Greene, Martin D. Kruskal, and Robert M. Miura for their paper *KortewegdeVries equation and generalizations. VI. Methods for exact solution*, Comm. Pure Appl. Math. **27** (1974), 97–133.

January 2006 – Mathematical Exposition: To Lars V. Hörmander for his book, *The Analysis of Linear Partial Differential Operators*.

January 2007 – Lifetime Achievement: To Henry P. McKean for his rich and magnificent mathematical career and for his work in analysis, which has a strong orientation towards probability theory.

January 2007 – Seminal Contribution to Research: To Karen Uhlenbeck for her foundational contributions in analytic aspects of mathematical gauge theory. These results appeared in the two papers: *Removable singularities in Yang-Mills fields*, Communications in Mathematical Physics, **83** (1982), 11–29 and *Connections with L:P bounds on curvature*, Communications in Mathematical Physics, **83** (1982), 31–42.

January 2007 – Mathematical Exposition: To David Mumford for his beautiful expository accounts of a host of aspects of algebraic geometry, including *The Red Book of Varieties and Schemes* (Springer, 1988).

January 2008 – Lifetime Achievement: To George Lusztig for entirely reshaping representation theory, and, in the process, changing much of mathematics.

January 2008 – Seminal Contribution to Research: To Endre Szemerédi for his paper *On sets of integers containing no k elements in arithmetic progression*, Acta Arithmetica XXVII (1975), 199-245.

January 2008 – Mathematical Exposition: To Neil Trudinger for his book *Elliptic Partial Differential Equations of Second Order*, written with the late David Gilbarg.

January 2009 – Lifetime Achievement: To Luis Caffarelli, one of the world's greatest mathematicians studying nonlinear partial differential equations (PDE).

January 2009 – Seminal Contribution to Research: To Richard Hamilton for his paper *Three-manifolds with positive Ricci curvature*, J. Differential Geom. **17** (1982), 255-306.

January 2009 – Mathematical Exposition: To I. G. MacDonald for his book *Symmetric Functions and Hall Polynomials* (second edition, Clarendon Press, Oxford University Press, 1995).

Next awards: January 2010.

The Oswald Veblen Prize in Geometry

This prize was established in 1961 in memory of Professor Oswald Veblen through a fund contributed by former students and colleagues. The fund was later doubled by the widow of Professor Veblen. The prize is awarded for research in geometry or topology that has appeared during the past six years in a recognized North American journal. Currently, the US$5,000 prize is awarded every three years.

First award, 1964: To C. D. Papakyriakopoulos for his papers *On solid tori*, Annals of Mathematics, Series 2, **66** (1957), pp. 1–26; and *On Dehn's lemma and the asphericity of knots*, Proceedings of the National Academy of Sciences **43** (1957), pp. 169–172.

Second award, 1964: To Raoul Bott for his papers *The space of loops on a Lie group*, Michigan Mathematical Journal **5** (1958), pp. 35–61; and *The stable homotopy of the classical groups*, Annals of Mathematics, Series 2, **70** (1959), pp. 313–337.

Third award, 1966: To Steven Smale for his contributions to various aspects of differential topology.

Fourth award, 1966: To Morton Brown and Barry Mazur for their work on the generalized Schoenflies theorem.

Fifth award, 1971: To Robion C. Kirby for his paper *Stable homeomorphisms and the annulus conjecture*, Annals of Mathematics, Series 2, **89** (1969), pp. 575–582.

Sixth award, 1971: To Dennis P. Sullivan for his work on the Hauptvermutung summarized in the paper *On the Hauptvermutung for manifolds*, Bulletin of the American Mathematical Society **73** (1967), pp. 598–600.

Seventh award, 1976: To William P. Thurston for his work on foliations.

Eighth award, 1976: To James Simons for his work on minimal varieties and characteristic forms.

Ninth award, 1981: To Mikhael Gromov for his work relating topological and geometric properties of Riemannian manifolds.

Tenth award, 1981: To Shing-Tung Yau for his work in nonlinear partial differential equations, his contributions to the topology of differentiable manifolds, and for his work on the complex Monge-Ampère equation on compact complex manifolds.

Eleventh award, 1986: To Michael H. Freedman for his work in differential geometry and, in particular, the solution of the four-dimensional Poincaré conjecture.

Twelfth award, 1991: To Andrew J. Casson for his work on the topology of low-dimensional manifolds and to Clifford H. Taubes for his foundational work in Yang-Mills theory.

Thirteenth award, 1996: To Richard Hamilton for his continuing study of the Ricci flow and related parabolic equations for a Riemannian metric, and to Gang Tian for his contributions to geometric analysis.

Fourteenth award, 2001: To Jeff Cheeger for his work in differential geometry, to Yakov Eliashberg for his work in symplectic and contact topology, and to Michael J. Hopkins for his work in homotopy theory.

Fifteenth award, 2004: To David Gabai in recognition of his work in geometric topology, in particular, the topology of 3-dimensional manifolds.

Sixteenth award, 2007: To Peter Kronheimer and Tomasz Mrowka for their joint contributions to both three- and four-dimensional topology through the development of deep analytical techniques and applications; and to Peter Ozsváth and Zoltán Szabó for their contributions to 3- and 4-dimensional topology through their Heegaard Floer homology theory.

Next award: January 2010.

The Albert Leon Whiteman Memorial Prize

This prize was established in 1998 using funds donated by Mrs. Sally Whiteman in memory of her husband, Albert Leon Whiteman, to recognize notable exposition and exceptional scholarship in the history of mathematics. Starting in 2009, the US$5,000 prize will be awarded every three years.

First award, 2001: To Thomas Hawkins to recognize an outstanding historian of mathematics whose current research and numerous publications display the highest standards of mathematical and historical sophistication.

Second award, 2005: To Harold M. Edwards to pay tribute to his many publications over several decades that have fostered a greater understanding and appreciation of the history of mathematics, expecially the theory of algebraic numbers.

Third award, 2009: To Jeremy John Gray for his many historical works, which have not only shed great light on the history of modern mathematics but also have given an example of the ways in which historical scholarship can contribute to the understanding of mathematics and its philosophy.

Next award: January 2012.

The Norbert Wiener Prize in Applied Mathematics

This prize was established in 1967 in honor of Professor Norbert Wiener and was endowed by a fund from the Department of Mathematics of the Massachusetts Institute of Technology. The prize is awarded for an outstanding contribution to "applied mathematics in the highest and broadest sense". The award is made jointly by the American Mathematical Society and the Society for Industrial and Applied Mathematics. The recipient must be a member of one of these societies and a resident of the United States, Canada, or Mexico. Beginning in 2004, the US$5,000 prize will be awarded every three years.

First award, 1970: To Richard E. Bellman for his pioneering work in the area of dynamic programming and for his related work on control, stability, and differential-delay equations.

Second award, 1975: To Peter D. Lax for his broad contributions to applied mathematics, in particular, for his work on numerical and theoretical aspects of partial differential equations and on scattering theory.

Third award, 1980: To Tosio Kato for his distinguished work in the perturbation theory of quantum mechanics.

Fourth award, 1980: To Gerald B. Whitham for his broad contributions to the understanding of fluid dynamical phenomena and his innovative contributions to the methodology through which that understanding can be constructed.

Fifth award, 1985: To Clifford S. Gardner for his contributions to applied mathematics in the areas of supersonic aerodynamics, plasma physics and hydromagnetics, and especially for his contributions to the truly remarkable development of inverse scattering theory for the solution of nonlinear partial differential equations.

Sixth award, 1990: To Michael Aizenman for his outstanding contribution of original and nonperturbative mathematical methods in statistical mechanics, by means of which he was able to solve several long open important problems concerning critical phenomena, phase transitions, and quantum field theory; and to Jerrold E. Marsden for his outstanding contributions to the study of differential equations in mechanics: he proved the existence of chaos in specific classical differential equations; his work on the momentum map, from abstract foundations to detailed applications, has had great impact.

Seventh award, 1995: To Hermann Flaschka for deep and original contributions to our understanding of completely integrable systems, and to Ciprian Foias for basic contributions to operator theory, analysis, and dynamics and their applications.

Eighth award, 2000: To Alexandre J. Chorin in recognition of his seminal work in computational fluid dynamics, statistical mechanics, and turbulence; and to Arthur T. Winfree in recognition of his profound impact on the field of biological rhythms, otherwise known as coupled nonlinear oscillators.

Ninth award, 2004: To James A. Sethian for his seminal work on the computer representation of the motion of curves, surfaces, interfaces, and wave fronts, and for his brilliant applications of mathematical and computational ideas to problems in science and engineering.

Tenth award, 2007: To Craig Tracy and Harold Widom for their deep and original work on Random Matrix Theory, a subject which has remarkable applications across the scientific spectrum, from the scattering of neutrons off large nuclei to the behavior of the zeros of the Riemann zeta-function.

Next award: January 2010.

Awards

AMS Centennial Fellowships

A Research Fellowship Fund was established by the AMS in 1973 to provide one-year fellowships for research in mathematics. In 1988 the Fellowship was renamed to honor the AMS Centennial. The number of fellowships granted each year depends on the contributions received; the Society supplements contributions as needed. The primary selection criterion for the Centennial Fellowship is the excellence of the candidate's research. A recipient of the fellowship shall have held his or her doctoral degree for at least three years and not more than twelve years at the inception of the award. Applications will be accepted from those currently holding a tenured, tenure-track, postdoctoral, or comparable (at the discretion of the selection committee) position at an institution in North America. The amount of the fellowship varies each year. See the last entry on the list below to find the amount and number of fellowships awarded most recently. To make a contribution to the Centennial Fellowship Fund, see `http://www.ams.org/development/centennialfund.html`. To apply for a Centennial Fellowship, see `http://www.ams.org/employment/centflyer.html`.

First award, 1974–1975: Fred G. Abramson, James Li-Ming Wang.

Second award, 1975–1976: Terence J. Gaffney, Paul Nèvai, George M. Reed.

Third award, 1976–1977: Fredric D. Ancel, Joseph A. Sgro.

Fourth award, 1977–1978: Steven Kalikow, Charles Patton, Duong-Hong Phong, David Vogan.

Fifth award, 1978–1979: Alan Dankner, David Harbater, Howard Hiller, Steven P. Kerckhoff, Robert C. McOwen.

Sixth award, 1979–1980: Scott W. Brown, Jeffrey E. Hoffstein, Jeffry N. Kahn, James E. McClure, Rick L. Smith, Mark Steinberger.

Seventh award, 1980–1981: Robert K. Lazarsfeld, Thomas H. Parker, Robert Sachs.

Eighth award, 1981–1982: Lawrence Man-Hou Ein, Mark Williams.

Ninth award, 1982–1983: Nicholas J. Kuhn.

Tenth award, 1983–1984: Russell David Lyons.

Eleventh award, 1984–1985: Richard Timothy Durrett.

Twelfth award, 1985–1986: R. Michael Beals.

Thirteenth award, 1986–1987: Dinakar Ramakrishnan.

Fourteenth award, 1987–1988: Richard Hain, Bill Jacob.

Fifteenth award, 1988–1989: Steven R. Bell, Don M. Blasius, David Gabai.

Sixteenth award, 1989–1990: Isaac Y. Efrat, John M. Lee, Ralf J. Spatzier.

Seventeenth award, 1990–1991: Michael Anderson, Carolyn Gordon, Steven Mitchell.

Eighteenth award, 1991–1992: Daniel Bump, Kari Vilonen.

Nineteenth award, 1992–1993: Krzysztof Burdzy, William Menasco, David Morrison.

Twentieth award, 1993–1994: Jacques Hurtubise, Andre Scedrov, David Webb.

Twenty-first award, 1994–1995: Patricia E. Bauman, David E. Marker.

Twenty-second award, 1995–1996: Rafael de la Llave, William Gordon McCallum, Kent Edward Orr.

Twenty-third award, 1996–1997: Yi Hu, Robert McCann, Alexander Voronov, Jiaping Wang.

Twenty-fourth award, 1997–1998: Ovidiu Costin, Fred Diamond, Gang Liu, Zhongwei Shen, Stephanie Frank Singer.

Twenty-fifth award, 1998–1999: Mark Andrea A. de Cataldo, Stavros Garoufalidis, Sándor Kovács, Yanguang Li.

Twenty-sixth award, 1999–2000: Charles W. Rezk, Bin Wang, Changyou Wang, Tonghai Yang.

Twenty-seventh award, 2000–2001: Siqi Fu, Christopher Herald, Wei-Dong Ruan, Vasily Strela.

Twenty-eighth award, 2001–2002: Ivan Dimitrov, Ravi Vakil, Jiahong Wu, Meijun Zhu.

Twenty-ninth award, 2002–2003: Albert C. Fannjiang, Wee Teck Gan, Ravi Kumar Ramakrishna.

Thirtieth award, 2003–2004: Henry H. Kim, John E. Meier.

Thirty-first award, 2004–2005: Jinho Baik, Nitu Kitchloo.

Thirty-second award, 2005–2006: Yuan-Pin Lee, Mihnea Popa.

Thirty-third award, 2006–2007: Christopher Hacon, Bryna Kra.

Thirty-fourth award, 2007–2008: Martin Kassabov.

Thirty-fifth award, 2008–2009: Christopher Hoffman.

Thirty-sixth award, 2009–2010: Antonio Montalban.

Next award (for 2010–2011 academic year): June 2010.

JPBM Communications Award

This award was established by the Joint Policy Board for Mathematics (JPBM) in 1988 to reward and encourage communicators who, on a sustained basis, bring mathematical ideas and information to nonmathematical audiences. Both mathematicians and nonmathematicians are eligible. Currently, the US$1,000 award is made annually. JPBM is a collaborative effort of the American Mathematical Society, the Mathematical Association of America, the Society for Industrial and Applied Mathematics, and the American Statistical Association.

First award, 1988: To James Gleick for sustained and outstanding contributions in communicating mathematics to the general public.

Second award, 1990: To Hugh Whitemore for contributions to communicating mathematics to the public in his play *Breaking the Code*, which chronicles the brilliant but troubled life of British mathematician Alan Turing.

Third award, 1991: To Ivars Peterson for exceptional skill in communicating mathematics to the general public over the last decade.

Fourth award, 1993: To Joel Schneider for *Square One TV*.

Fifth award, 1994: To Martin Gardner, for authoring numerous books and articles about mathematics, including his long-running *Scientific American* column “Mathematical Games”, and his books *Fads and Fallacies in the Name of Science* and *Mathematical Carnival*.

Sixth award, 1996: To Gina Kolata for consistently giving outstanding coverage to many of the most exciting breakthroughs in mathematics and computer science over the past twenty years.

Seventh award, 1997: To Philip J. Davis for being a prolific communicator of mathematics to the general public.

Eighth award, 1998: To Constance Reid for writing about mathematics with grace, knowledge, skill, and clarity.

Ninth award, 1999: To Ian Stewart for communicating the excitement of science and mathematics to millions of people around the world for more than twenty years. Also a “Special Communications Award” to John Lynch and Simon Singh for their exceptional contributions to public understanding of mathematics through their documentary on Andrew Wiles and the Fermat Conjecture, entitled *Fermat’s Last Theorem* (shown on *NOVA* as “The Proof”).

Tenth award, 2000: To Sylvia Nasar for *A Beautiful Mind*, her biography of John Forbes Nash Jr.

Eleventh award, 2001: To Keith J. Devlin for his many contributions to public understanding of mathematics through great numbers of radio and television appearances; public talks; books; and articles in magazines, newsletters, newspapers, journals, and online.

Twelfth award, 2002: To Helaman and Claire Ferguson for dazzling the mathematical community and a far wider public with exquisite sculptures embodying mathematical ideas, along with artful and accessible essays and lectures elucidating the mathematical concepts.

Thirteenth award, 2003: To Robert Osserman for being an erudite spokesman for mathematics, communicating its charm and excitement to thousands of people from all walks of life.

2004: No award given.

Fourteenth award, 2005: To Barry Cipra for writing about mathematics of every kind—from the most abstract to the most applied—for nearly twenty years. His lucid explanations of complicated ideas at the frontiers of research have appeared in dozens of articles in newspapers, magazines, and books.

Fifteenth award, 2006: To Roger Penrose for the discovery of Penrose tilings, which have captured the public's imagination, and for an extraordinary series of books that brought the subject of consciousness to the public in mathematical terms.

Sixteenth award, 2007: To Steven H. Strogatz for making a consistent effort to reach out to a wider audience. He has made significant contact with the wider scientific community. The style of his book, *Sync: The Emerging Science of Spontaneous Order* (2003), and its sales indicate that it is intended for and has reached an even wider audience. The volume of this work is impressive, but the quality and breadth are spectacular as well.

Seventeenth award, 2008: To Carl Bialik for increasing the public's understanding of mathematical concepts.

Eighteenth award, 2009: To George Csicsery for communicating the beauty and fascination of mathematics and the passion of those who pursue it.

Next award: January 2010.

AMS Epsilon Awards for Young Scholars Programs

In 1999 the American Mathematical Society started the Epsilon Fund to help support existing summer programs for mathematically talented high school students. The name for the fund was chosen in remembrance of the late Paul Erdős, who was fond of calling children "epsilons". At its meeting in November 2000, the AMS Board of Trustees approved the Society's engagement in a sustained effort to raise an endowment for the Epsilon Fund. In addition, a Board-designated fund of US$500,000 was created as a start for the endowment. As a start for the program, the AMS used money from its Program Development Fund to award Epsilon grants for activities during summers 2000, 2001, 2002, and 2003. Once the Epsilon Fund endowment has reached the targeted amount of US$2,000,000, the AMS intends to award a total of US$100,000 in Epsilon grants each year. To make a contribution to the Epsilon Fund, see `http://www.ams.org/development/epsilon.html`. To apply for an Epsilon grant, see `http://www.ams.org/employment/epsilon.html`.

First awards, 2000: To All Girls/All Math (University of Nebraska, Lincoln), Hampshire College Summer Studies in Mathematics, Mathcamp, PROMYS (Boston University), Ross Young Scholars Program (Ohio State University), SWT Honors Summer Math Camp (Southwest Texas State University), and the University of Michigan Math Scholars.

Second awards, 2001: To All Girls/All Math (University of Nebraska), Mathcamp (Port Huron, Michigan), Michigan Math & Science Scholars (University of Michigan, Ann Arbor), Mathematics Scholars Academy (Oklahoma State University), Hampshire College Summer Studies in Mathematics (Hampshire College), PROMYS (Boston University), Young Scholars Program (University of Chicago), and Ross Mathematics Program (The Ohio State University).

Third awards, 2002: To All Girls/All Math (University of Nebraska), Hampshire College Summer Studies in Mathematics (Amherst, Massachusetts), Mathcamp (Mathematics Foundation of America), Michigan Math and Science Scholars (University of Michigan, Ann Arbor), PROMYS (Boston University), Ross Mathematics Program (The Ohio State University), SWT Honors Summer Math Camp (Southwest Texas State University), and University of Chicago Young Scholars Program.

Fourth awards, 2003: To All Girls/All Math (University of Nebraska), Canada/USA Mathcamp (Mathematics Foundation of America), Hampshire College Summer Studies in Mathematics (Amherst, Massachusetts), PROMYS (Boston University), Ross Mathematics Program (The Ohio State University), Stanford University Mathematics Camp (Stanford University), SWT Honors Summer Math Camp (Southwest Texas State University), and University of Chicago Young Scholars Program.

Fifth awards, 2004: To Ross Mathematics Program (The Ohio State University), Texas State University Honors Summer Math Camp, PROMYS (Boston University), Canada/USA Mathcamp (Mathematics Foundation of America), Hampshire College Summer Studies in Mathematics (Amherst, Massachusetts), All Girls/All Math (University of Nebraska), University of Chicago Young Scholars Program, and MathPath (MathPath Foundation).

Sixth awards, 2005: To All Girls/All Math Summer Camp for High School Girls (University of Nebraska, Lincoln), Canada/USA Mathcamp (Reed College, Portland, Oregon), Hampshire College Summer Studies in Mathematics (Hampshire College, Amherst, Massachusetts), MathPath, (Colorado College, Colorado Springs), Michigan Math and Science Scholars Program (University of Michigan, Ann Arbor), PROMYS (Boston University), Ross Mathematics Program (The Ohio State University), Texas State Honors Summer Math Camp (Texas State University, San Marcos), and University of Chicago Young Scholars Program.

Seventh awards, 2006: To All Girls/All Math Summer Camp for High School Girls (University of Nebraska, Lincoln), Canada/USA Mathcamp (University of Puget Sound, Tacoma, Washington), Hampshire College Summer Studies in Mathematics (Hampshire College, Amherst, Massachusetts), MathPath, (University of California, Santa Cruz), Michigan Math and Science Scholars Program (University of Michigan, Ann Arbor), PROMYS (Boston University), Puerto Rico Opportunities for Talented Students in Mathematics (PROTaSM) (University of Puerto Rico, Mayaguez), Ross Mathematics Program (Ohio State University, Columbus), Summer Explorations and Research Collaborations for High School Girls (SEARCH) (Mount Holyoke College, South Hadley, Massachusetts), Texas State Honors Summer Math Camp (Texas State University, San Marcos), Texas Tech University Summer Mathematics Academy (Texas Tech University, Lubbock), and University of Chicago Young Scholars Program (University of Chicago).

Eighth awards, 2007: Hampshire College Summer Studies in Mathematics, Amherst, Massachusetts; Michigan Math and Science Scholars Summer Program, University of Michigan, Ann Arbor; PROMYS, Boston University; Ross Mathematics Program, Ohio State University, Columbus; Summer Explorations and Research Collaborations for High School Girls (SEARCH), Mount Holyoke College, South Hadley, Massachusetts; and Texas State University Honors Summer Math Camp, Texas State University, San Marcos.

Ninth awards, 2008: All Girls/All Math, University of Nebraska, Lincoln; Hampshire College Summer Studies in Mathematics, Amherst, Massachusetts; MathPath, University of Vermont, Burlington; Michigan Math and Science Scholars Summer Program, University of Michigan, Ann Arbor; PROMYS, Boston University; PROTaSM (Puerto Rico Opportunities for Talented Students in Mathematics), University of Puerto Rico, Mayaguez; Ross Mathematics Program, Ohio State University, Columbus; and Texas State University Honors Summer Math Camp, Texas State University, San Marcos.

Tenth awards, 2009: Achievement in Mathematics Program (AMP), Lamar University; All Girls/All Math, University of Nebraska, Lincoln; Hampshire College Summer Studies in Mathematics (HCSSiM), Hampshire College; MathPath, Colorado College, Colorado Springs; Michigan Math and Science Scholars Summer Program, University of Michigan, Ann Arbor; PROMYS (Program in Mathematics for Young Scientists), Boston University; PROTaSM (Puerto Rico Opportunities for Talented Students in Mathematics), University of Puerto Rico, Mayagüez Campus; Research Science Institute, Massachusetts Institute of Technology; Ross Mathematics Program, Ohio State University, Columbus; Texas State University Honors Summer Math Camp, Texas State University, San Marcos.

Next awards (for summer 2010): May 2010.

Award for an Exemplary Program or Achievement in a Mathematics Department

This award was established in 2004 to recognize a department which has distinguished itself by undertaking an unusual or particularly effective program of value to the mathematics community, internally or in relation to the rest of society. Examples might include a department that runs a notable minority outreach program, a department that has instituted an unusually effective industrial mathematics internship program, a department that has promoted mathematics so successfully that a large fraction of its university's undergraduate population majors in mathematics, or a department that has made some form of innovation in its research support to faculty and/or graduate students or which has created a special and innovative environment for some aspect of mathematics research. Departments of mathematical sciences in North America that offer at least a bachelor's degree in mathematical sciences are eligible. The US$1,200 prize will be awarded annually. The initial award was presented at the January 2006 Joint Mathematics Meetings.

Nomination process: A letter of nomination may be submitted by one or more individuals. Nomination of the writer's own institution is permitted. The letter should describe the specific program(s) for which the department in being nominated as well as the achievements which make the program(s) an outstanding success and may include any ancillary documents which support the success of the program(s). The letter should not exceed two pages, with supporting documentation not to exceed an additional three pages. Nominations should be submitted to the Office of the Secretary. Nominations received by September 15 will be considered for the award presented the following January.

First award, 2006: Harvey Mudd College.

Second award, 2007: University of California, Los Angeles (UCLA).

Third award, 2008: University of Iowa. See also `http://www.ams.org/notices/200805/tx080500599p.pdf`.

Fourth award, 2009: University of Nebraska-Lincoln. See also `http://www.ams.org/notices/200905/rtx090500622p.pdf`.

Next award: Spring 2010.

The Award for Mathematics Programs that Make a Difference

This award was established in 2005 in response to a recommendation from the AMS's Committee on the Profession that the AMS compile and publish a series of profiles of programs that:
1) aim to bring more persons from underrepresented minority backgrounds into some portion of the pipeline beginning at the undergraduate level and leading to advanced degrees in mathematics and professional success, or retain them once in the pipeline;
2) have achieved documentable success in doing so; and are replicable models.
Two programs are highlighted annually.

First award, 2006: Summer Institute in Mathematics for Undergraduates (SIMU), Universidad de Puerto Rico, Humacao; and Graduate Program, Department of Mathematics, University of Iowa.

Second award, 2007: Enhancing Diversity in Graduate Education (EDGE), Bryn Mawr College and Spelman College; and Mathematical Theoretical Biology Institute (MTBI), Arizona State University.

Third award, 2008: Summer Undergraduate Mathematical Science Research Institute (SUMSRI), Miami University (Ohio) and Mathematics Summer Program in Research and Learning (Math SPIRAL), University of Maryland, College Park. See citations and descriptions of programs. See *Notices of the AMS* article.

Fourth award, 2009: Department of Mathematics at the University of Mississippi and the Department of Statistics at North Carolina State University. See citations and descriptions of programs.

Next award: Spring 2010.

The Karl Menger Memorial Awards

Family members of the late Karl Menger were the major contributors to a fund established at Duke University. The majority of the income from this fund is to be used by the Society for annual awards at the International Science and Engineering Fair.

First award, 1990: Daniel K. Dugger, Joshua Erlich, Joshua B. Fischman, Min-Horng Chen, Matthew Baker, Michael L. Harrison, Virginia A. DiDomizio.

Second award, 1991: Monwhea Jeng, Hans Christian Gromoll, Jesse L. Tseng, Andrew Olstrom Dittmer, Matthew A. Neimark, Rageshree Ramachandran, Jeb E. Willenbring.

Third award, 1992: Mahesh Kalyana Mahanthappa, Harrison Kwei Tsai, Andrew Olstrom Dittmer, Jonobie Dale Baker, Joshua Brody, Yen-Hsiang Li, Robert Jordon Pollack.

Fourth award, 1993: Mahesh Kalyana Mahanthappa, Steve Shaw-Tang Chien, Andrew Olstrom Dittmer, Moon Duchin, Robert Michael Kirby II, Sarah Ann Lord, Anna Ruth Terry.

Fifth award, 1994: Davesh Maulik, Eric Matthew Dennis, Sarah Ann Lord, Timothy Stephen Eller, Rahul Manu Kohli, Fam-ye Lin, Benedek Valko, Mary Kathleen Clavenna, Vinay Kumak Goyal-Singhal, Jan Kristian Haugland, Wes Andres Watters, Ian George Zacharia.

Sixth award, 1995: Davesh Maulik, Benjamin Michael Goetz, Jacob Lurie, Daniel Kalman Biss, Samit Dasgupta, Yueh-Hsing Lin, Claus Mazanti Sorensen, Theodore Haw-Yun Hwa, Samuel Jacob Klein Jr., Katherine Anne Paur, Bridget Helen Penny, Scott Nicholas Sanders.

Seventh award, 1996: Davesh Maulik, Nicholas Karl Eriksson, Logan Joseph Kleinwaks, Eric Jon Landquist, Vanesa Miranda-Diaz, Jason Charles Stone, Lauren Kiyomi Williams, Ryan Thomas Hebert, Kendrick Norris Kay, Scott Nicholas Sanders, Claus Mazanti Sorensen, Yvette Karen Wood.

Eighth award, 1997: Davesh Maulik, Nicholas Eriksson, Jeremy Rahe, Jennifer Pelka, Yen-Jen Chen, Sylvain Halle, Melanie Schechter, Matthew Seligman, Thomas Mack, Susannah Rutherglen, Jy-Ying Janet Chen, Chun-Hsiang Fu, Daniel Ying-Jeh Little.

Ninth award, 1998: Jonathan Adam Kelner, Michael Yanchee Lee, Daniel Yamins, Alexey Evgenjevitch Eroshin, Sarah Flannery, Jeremy Ryan Rahe, Jennifer Rose Walk, Richard Lee Barnes, Matthew Christopher Ong, David Carl Rennard, Anna Welling Salamon, Hui Yu.

Tenth award, 1999: Amit Kumar Sabharwal, Andrew Chi, Jennifer Lynn Pelka, Ching-Tang Chen, C. Andrew McManus, Jennifer Rose Walk, Heidi Lee Williams, Jack Nelson Bewley, Adam Douglas Bryant, Jason A. Loy, John William Pope, Bryce Leitner Roberts.

Eleventh award, 2000: Jayce R. Getz, Aadel Ahmed Chaudhuri, Zachary Howard Cohn, Ching Tang Chen, Elaine Pei-San Gee, Siarhei Markouski, Ilya Malakhovsky, Vassily Vladimirovich Starodubtsev, Daniel Richard Green, Daniyar Z. Kamenov, Craig Allan Schroeder.

Twelfth award, 2001: Abdur Rasheed Sabar, Yuri Georgievich Kudryashov, Serge A. Tishchenko, Jason Wah Lone Chiu, Craig Allen Schroeder, Hasuk Francis Song, Daniel Wichs, Jennifer Shyamala Sayaka Balakrishnan, Christopher Ryan Bruner, Lindsey Jo Cable, Michael Harry Kaleta, Matthew Howard Stemm, Heon Joon Choe, Jesse Scott Trana.

Thirteenth awards, 2002: Jacob Licht, Matthew Aaron Tesch, Andrew Michael Korth, Chun-Chen Yeh, Liang Chen, Ashum Karahanovich Kaibhanov, Amanda Bryce Shaw, Mary Augusta Brazelton, Nikita Rozenblyum, Jonathan Charles Zweig, Boris O. Figovsky, Ronli Phyllis Diakow.

Fourteenth awards, 2003: Andrew Michael Leifer, Raymund Chun-Hung To, David Guillaume Pothier, Alexandr V. Medvedev, Ethan James Street, Hyeyoun Chung, Anatoly Preygel, Lester Wayne Mackey, Evgeniy E. Loharu, Sergey O. Ivanov, Robert Shea Bracco, Brian Todd Rice, Alexey V. Baran, Evgeny A. Amosov, Artem G. Viktorov, Jeremy Takashi Warshauer, Alan Craig Taylor, Hannah Chung.

Fifteenth awards, 2004: Brett Alexander Harrison, Ilya Gurwich, Brian Todd Rice, Sam Jay Lewallen, Brianna Rachel Satinoff, Huan-Chun Yeh, Ning Zhang, Carolos Eduardo Arreche-Aguayo, Tair Assangali, Nurlan Bakitzhanov, Allison Paige Berke, Ginger Beardslee Howell, Nimish P. Ramanlal.

Sixteenth awards, 2005: Scott Duke Kominers, Samuel Mohun Bhagwat, Matthew Ryan Tierney, Elad Oster, John Michael Sillcox, Carlos Manuel Fonseca, Manuel Luis Rivera, Niket Ranjan Pandey, Robert Thomas Cordwell, Paul Francis Jacobs, Valentina N. Dobrovolskaya, Vladimir N. Trubnikov, Oleg V. Mikhaylovsky, Mikhail A. Ptichkin.

Seventeenth awards, 2006: Michael Anthony Viscardi, Daniel Abraham Litt, Brett Alexander Harrison, Anarghya A. Vardhana, Gleb A. Pogudin, Nicholas Michael Wage, Sohan Venkat, Meelap Vijay Shah, Manuel Luis Rivera-Morales, Bakhytzhan Baizhanov.

Eighteenth awards, 2007: Dmitry Vaintrob, Cheng-Tao Chung, Daniel K. Bezdek, Christopher Lopez, Hagai Helman, Albert C. Liu, Nikita M. Savushkin, Lado Meskhishvili, Almas U. Abdulla, Avi W. Levy, Ardit Kroni, Alexey S. Telishev.

Nineteenth awards, 2008: Alexander Lee Churchill, Shravani Mikkilineni, David Alex Rosengarten, Eric Kerner Larson, Alex Hao Chen, Paul Myer Kominers, Matthew Michael Wage, Swara Satya Kopparty, Sana Raoof, Nurlan Taiganov, Artem A. Timoshenko, Sarah Lee Sellers.

Twentieth awards, 2009: Joshua Vekhter, Andrei Triffo, Yale Wang Fan, Almas Abdulla, Sarah Lee Sellers, Sohini Sengupta, Sameer Kirtikumar Deshpande, Jeffrey Chan, Alicia Zhang, Martin Augustine Camacho, Michael Christopher Yurko, Wenhan Cui, Matthew Henry Stoffregen, Nilesh Tripuraneni.

Next awards: June 2010.

Public Policy Award

This award was established in 2007 by the American Mathematical Society (AMS) to recognize a public figure for sustained and exceptional contributions to public policies that foster support for research, education, and innovation. The award will be given annually, starting in 2009.

The Award for Distinguished Public Service

This award was established by the AMS Council in response to a recommendation from their Committee on Science Policy. The award is presented every two years to a research mathematician who has made a distinguished contribution to the mathematics profession during the preceding five years.

First award, 1990: To Kenneth M. Hoffman for his outstanding leadership in establishing channels of communication between the mathematical community and makers of public policy as well as the general public.

Second award, 1992: To Harvey B. Keynes for his multifaceted efforts to revitalize mathematics education, especially for young people.

Third award, 1993: To Isadore M. Singer in recognition of his outstanding contributions to his profession, to science more broadly, and to the public good by bringing the best of mathematics and his own insights to bear on the activities of the National Academy of Sciences; on committees of the National Research Council, including the two so-called David Committees on the health of the mathematical sciences, and the Committee on Science, Engineering, and Public Policy; on the President's Science Advisory Council; on decisions of Congress, through testimony concerning the support of mathematics and mathematical research; and on a host of critical situations over many years in which his wisdom and intervention helped gain a hearing for the problems of his community and the contributions it makes to the nation.

Fourth award, 1995: To Donald J. Lewis for his many contributions to mathematical education, mathematics policy, and mathematical research and administration during a career that has spanned several decades.

Fifth award, 1997: No award made.

Sixth award, 1998: To Kenneth C. Millett for his work devoted to underrepresented minority students in the mathematical sciences. Professor Millett founded the University of California, Santa Barbara, Achievement Program and directed the mathematics component of the Summer Academic Research Internship and the Summer Institute in Mathematics and Science at UCSB.

Seventh award, 2000: To Paul J. Sally Jr. for the quality of his research, for his service to the [American Mathematical] Society as trustee, but more importantly for his many efforts in improvement of mathematics education for the nation's youth and especially for members of minority and underrepresented groups and for his longitudinal mentoring of students, in particular the mathematics majors at Chicago.

Eighth award, 2002: To Margaret H. Wright for notable contributions to the federal government and the scientific community and for encouraging women and minority students.

Ninth award, 2004: To Richard A. Tapia for inspiring and teaching thousands of people (from elementary school students to senior citizens) to study and appreciate the mathematical sciences.

Tenth award, 2006: To Roger Howe for his multifaceted contributions to mathematics and to mathematics education.

Eleventh award, 2008: To Herbert Clemens for his superb research in complex algebraic geometry, his continuing efforts in education, and his seminal role in the founding and continuation of the Park City/IAS Mathematics Institute.

Next award: January 2010.

Citation for Public Service

To provide encouragement and recognition for contributions to public service activities in support of mathematics, the Council of the Society established the Citation for Public Service. The award is no longer being made.

First award, 1991: Andre Z. Manitius for the contributions he made to the mathematical community while employed in the Division of Mathematical Sciences at the National Science Foundation.

Second award, 1992: Marcia P. Sward for her contributions toward establishing and directing the Mathematical Sciences Education Board from its inception in the fall of 1985 until August 1989.

Third award, 1998: Liang-Shin Hahn and Arnold E. Ross. Liang-Shin Hahn for carrying forward and developing the New Mexico High School Mathematics Contest and for exposition and popularization of mathematics attractive to and suitable for potential candidates for the contest and others with similar intellectual interests. Arnold E. Ross for inspiring generations of young people through the summer mathematics programs he created and has continued to run for nearly 40 years.

AAS-AMS-APS Public Service Award

This award was established in 1999 by the American Mathematical Society (AMS), the American Astronomical Society (AAS), and the American Physical Society (APS) to recognize a public figure for his or her sustained and exceptional contributions to public policies that foster support for research, education, and industrial innovation in the physical sciences and mathematics. As of January 2007, the AMS no longer participates in this award, but instead offers the AMS Public Policy Award.

First award, 2000: To William Frist, Joseph L. Lieberman, and Harold Varmus.

Second award, 2001: To Vernon Ehlers and Neal Lane.

Third award, 2002: To James T. Walsh and Barbara Mikulski.

Fourth award, 2003: To Sherwood L. Boehlert, Alan B. Mollohan, and Pete V. Domenici.

2004: No award made.

2005: No award made.

2006: No award made.

Waldemar J. Trjitzinsky Memorial Awards

The Society received a bequest from the estate of Waldemar J., Barbara G., and Juliet Trjitzinsky, the income from which is used to assist students who have declared a major in mathematics at a college or university that is an institutional member of the AMS. These funds help support students who lack adequate financial resources and who may be in danger of not completing the degree program in mathematics for financial reasons. Each year the Society selects a number of geographically distributed schools who in turn make one-time awards to beginning mathematical students to assist them in pursuit of careers in mathematics. The amount of each scholarship is currently US$3,000, and the number of scholarships awarded each year varies.

First award, 1991: Duke University (Robert Lane Bassett, Linie Yunwen Chang, Kara Lee Lavender), University of Scranton (Thomas A. Shimkus), Montana State University (Melissa Cockerill, Deborah Fagan, Sherry Heis), Howard Payne University (Pamela Jo Chaney).

Second award, 1992: Allegheny College (Julianne Stile), Memphis State University (Cassandra Burns), University of

California at Irvine (James Anthony Nunez), University of Puerto Rico (Juan Ramon Romero-Oliveras).

Third award, 1993: University of California at Los Angeles (Michelle L. Lanir), State University of New York at Geneseo (Jodi C. Wright), Eastern New Mexico University (Rebecca K. Moore), University of Virginia (Mikhail Krichman).

Fourth award, 1994: Boise State University (William Hudson and Margaret Norris), Illinois Institute of Technology (Guanghong Xu), Temple University (Coleen Clemetson), University of Maryland at College Park (Mikhail G. Konikov).

Fifth award, 1995: University of Arizona (Mark Robert Moseley), Arkansas State University (Donna J. Shepherd), Mississippi State University (Clayton T. Hester), Montclair State College (James R. Jarrell III).

Sixth award, 1996: Murray State University (Christie M. Safin), Stanford University (Andreea Nicoara), Union College (Allison Pacelli), Western Illinois University (Lorna Renee Sanders).

Seventh award, 1997: Georgetown University (Martin Akguc), Loyola Marymount University (Laura Steiner, Claudia Catalan, Elizabeth Madrigal), New York University (Emily Press), Southern Illinois University at Carbondale (Laura Wasser).

Eighth award, 1998: Stevens Institute of Technology (Kelly Cornish), Georgia State University (Kevin A. Wilson), Iowa State University (Matthew A. Halverson), University of Nevada at Las Vegas (Dumitru C. Tutuianu).

Ninth award, 1999: City University of New York (Hulya Cebeciouglu), Reed College (Jeremy Copeland), University of Texas at San Antonio (Danielle Lyles), Western Kentucky University (Marcia Jean Mercer).

Tenth award, 2000: California State University at Long Beach (Yen Hai Le), Case Western Reserve University (Alexander Statnikov), Clarkson University (Matthew Bartholomew), University of Houston (Alyssa Burns).

Eleventh award, 2001: Columbia University (Alexander Ivanov Sotirov), Florida Atlantic University (Gregory Nevil Leuchiali Maxwell), Henderson State University (Ann Smith), John Carroll University (Andrea C. Forney), Seattle University (Sinead Pollom), University of Texas at Austin (Virginia Roberts), University of Utah (Paul T. Watkins), Worcester Polytechnic Institute (Yakov Kronrod and Megan Lally).

Twelfth award, 2002: Stephen F. Austin State University (Marcus A. Arreguin), Bates College (Challis Kinnucan), Brigham Young University (Julie Brinton), The College of William and Mary (Suzanne L. Robertson), Furman University (Kevin L. Smith), University of Hartford (Aimee J. Groudas), University of Southern California (Peter Kirkpatrick), University of Texas at Dallas (Kevin R. Pond).

Thirteenth award, 2003: Bryn Mawr College (Thida S. Aye), Minnesota State University at Mankato (Andrew Richard Tackmann), University of Maryland at Baltimore County (Maria Christin Llewellyn), Colorado College (Rahbar Virk), California State University, Hayward (Sarah Deiwert and Angela Martinho), Lehigh University (Timothy P. Lewis), State University of New York at Potsdam (Bishal Thapa).

Fourteenth award, 2004: Beloit College (Laura Wolfram), Lafayette College (Prince Chidyagwai, Ekaterina Jager, Blerta Shtylla), Michigan State University (Antonio Veloz), University of Pennsylvania (Daniel Pomerleano), Portland State University (Kathryn Carr and Cass Bath), Santa Clara University (Olivia Gistand).

Fifteenth award, 2005: Abilene Christian University (Carissa Joy Strawn), Amherst College (Jennifer A. Roberge), Arizona State University (Yukiko Kozakai), University of Missouri, Kansas City (Melanie Marie Meyer), University of North Carolina at Greensboro (Christian Sykes), University of Rhode Island (Christopher Piecuch), Ohio State University (Sophia Leibman and Gabor Revesz).

Sixteenth award, 2006: California State University, San Bernardino (Lorena Pulido and Jennifer Renee Winter), University of Missouri, Rolla (Sean Michael Eagan), University of Central Missouri (Khadijah Shadeed), Boston College (Elizabeth Rini), Eckerd College (Elizabeth R. Morra), University of California, San Diego (John Roosevelt Quinn), Swarthmore College (Adam Joseph Lizzi).

Seventeenth award, 2007: Susan Christine Massey (University of Washington), Amy Streifel (Lewis and Clark College), Rosemary Holguin (SUNY at New Paltz), Emily Jean Ognacevic (Saint Louis University), Betsy Kay Barr (University of Tennessee Knoxville), Kayla Rose Boyle (University of Northern Iowa).

Eighteenth award, 2008: Aaron Peterson (Luther College), Faith L. Buell (Wright State University), Phillip David Lorren (Georgia Southern University), Daksha Shakya (Ithaca College), Joseph Zancocchio (College of Staten Island (CUNY)), Amanda J. Mueller (University of Wisconsin Milwaukee), Hans Parshall (Humboldt State University).

Next awards: Fall 2009.

Reciprocity Agreements

Africa

Egyptian Mathematical Society (ETMS)*

Apply to: M. H. Fahmy, Department of Mathematics, Faculty of Science, Al-Azhar University, Nasr City 11884, Cairo, Egypt; email: Secretary_etms@yahoo.com; http://www.etms-web.org.

Dues: U.S. $15, payable to Egyptian Mathematical Society at the above address.

Privileges: Receive a 60% discount on the prices of ETMS publications, a 50% discount on the publication charge per printed page in *ETMS Journal*, and reduced charge for participating at ETMS conferences.

Officers: A.-S. F. Obada (President), E. H. Doha (Vice-President), F. F. Ghaleb (Treasurer), M. H. Fahmy (Secretary).

Nigerian Mathematical Society

Address for mail: Department of Pure and Applied Mathematics, Ladoke Akintola University of Technology, Ogbomoso, Nigeria; email: ayeni_ro@yahoo.com; http://www.nigerianmathematicalsociety.com.

Apply to: Franic I. Njoku (Secretary), Nigerian Mathematical Society, Department of Mathematics, University of Nigeria, Nsukka, Nigeria

Dues: U.S. $60, payable to Samuel S. Okoya (Treasurer), Department of Mathematics, Obafemi Awolowo University, Ile-Ife, Nigeria.

Privileges: *Journal of the Nigerian Mathematical Society* and *Notices of Nigerian Mathematical Society*.

Officers: Reuben O. Ayeni (President), Michai O. Osilike (Vice-President), Samuel S. Okoya (Treasurer), Franic I. Njoku (Secretary).

South African Mathematical Society*

Address for mail: School of Mathematics, Witwatersrand University, Private Bag 3, Wits 2050, South Africa; email: clint.VanAlten@wits.ac.za.

Apply to: Erwin Brüning, School of Mathematical Sciences, Kwazulu-Natal University, Private Bag X54001, Durban 4000, South Africa.

Dues: R210.00 (Two hundred ten rands), payable to the South African Mathematical Society (SAMS), c/o Prof. Erwin Brüning (Treasurer) at the above address.

Privileges: The right to receive the *Notices of the SAMS* at no additional cost; reduced fees at SAMS meetings.

Officers: Nigel Bishop (President), Themba Dube (Vice-President), Erwin Brüning (Treasurer), Clint Van Alten (Secretary).

Tunisian Mathematical Society

Apply to: Khalifa Trimèche, Faculty of Sciences of Tunis, Department of Mathematics, CAMPUS 2092, Tunis, Tunisia; email: TMS@tms.rnu.tn; http://www.tms.rnu.tn.

Dues: $20, payable to Lotfi Kamoun at the above address.

Privileges: Obtain the publications of the Society, and possible partial financial support to attend the annual colloquium of the Society.

Officers: Khalifa Trimèche (President); Mohamed Sifi (Vice-President); Lotfi Kamoun (Treasurer); Abderrazek Karoui (Secretary).

The Americas

Canadian Mathematical Society

Apply to: Canadian Mathematical Society, 105-1785 Alta Vista Drive, Ottawa, Ontario, Canada K1G 3Y6; email: office@cms.math.ca; http://www.cms.math.ca/.

The American Mathematical Society has "reciprocity agreements" with a number of mathematical organizations around the world. A current list appears here.
These reciprocity agreements provide for reduced dues for members of these organizations who choose to join the AMS and who reside outside of the U.S. and Canada. Reciprocally, members of the AMS who reside in the U.S. or Canada may join these organizations at a reduced rate. Summaries of the privileges available to AMS members who join under the terms of reciprocity agreements are given on the following pages. Members of these organizations who join the AMS as reciprocity members enjoy all the privileges available to ordinary members of the Society. AMS dues for reciprocity members are $82 for 2009 and $84 for 2010. Each organization was asked to review and update its listing in the spring. An asterisk ($*$) after the name of an organization indicates that no response to this request had been received when the November *Notices* went to press.

Dues: 50% off applicable rate, payable in U.S. funds to the Canadian Mathematical Society at the above address.

Privileges: *CMS Notes*; access to members section on website; reductions on all CMS periodicals, publications, promotional items, and meeting registration.

Officers: Anthony To-Ming Lau (President); Michael Lamoureux, Kumar Murty, Cathy Baker, Pengfei Guan (Vice-Presidents); Jacques Hurtubise (President-Elect); David Rodgers (Treasurer); Johan Rudnik (Executive Director/Secretary).

Sociedad Colombiana de Matemáticas*

Address for mail: Apartado Aereo 2521, Bogotá, Colombia; email: `scm@scm.org.co`; `http://www.scm.org.co`.

Apply to: Carlos H. Montenegro E., Apartado Aereo 2521, Bogotá, Colombia.

Dues: U.S. $27, payable to Sociedad Colombiana de Matemáticas.

Privileges: Subscription to one of the publications of the Society (*Revista Colombiana de Matemáticas or Lecturas Matematicas*), discounts for participation in Society activities, and e-mail in the scm.org.co domain.

Officers: Carlos H. Montenegro E. (President), Jose Ricardo Arteaga (Vice-President).

Sociedad de Matemática de Chile*

Apply to: Sociedad de Matemática de Chile, María Luisa Santander 0363, Providencia, Santiago, Chile; email: `socmat@mat.puc.cl`; `http://www.socmachi.cl`.

Dues: U.S. $50, payable to Sociedad de Matemática de Chile.

Privileges: Receive *Gaceta de la Sociedad de Matemática*, *Notas de la Sociedad de Matemática de Chile.*

Officers: Rubí E. Rodríguez (President), Ana Cecilia De La Maza (Vice-President), Hernán Burgos (Treasurer), Andrés Navas (Secretary).

Sociedad Matemática de la República Dominicana*

Apply to: Isidro Rodríguez, Sociedad Matemática de la República Dominicana, Apartado 797-2, Santo Domingo, República Dominicana.

Dues: U.S. $10, payable to Amado Reyes at the above address.

Privileges: Right to receive *Notimat* (bimonthly newsletter) and *Revista Matemática Dominicana* (twice a year).

Officers: Isidro Rodríguez (President), Mariana Morales (Vice-President), Amado Reyes (Treasurer), Eliseo Cabrera (Secretary).

Sociedad Matemática Mexicana*

Apply to: Olivia Lazcano, Apartado Postal 70-450, México, D.F. 04510, México; email: `smm@smm.org.mx/`; `http://www.smm.org.mx/`.

Dues: U.S. $25, payable to Sociedad Matemática Mexicana.

Privileges: To be a regular member paying half of the regular fee for persons living outside of Mexico. Newsletter, *Bulletin of the Mexican Mathematical Society*, or *Miscelánea Matemática.*

Officers: Emilio Lluis-Puebla (President), Carlos Signoret (Vice-President), Eugenio Garnica (Treasurer), Pablo Padilla (General Secretary), Isidro Romero (Secretary), Lino Reséndiz and Silvia Morelos (Vocal).

Sociedad Uruguaya de Matemática y Estadística (SUME)*

Address for mail: J. Herrera y Reissig 565, CC 30, CP 11300, Fac. de Ingeniería, IMERL, Montevideo, Uruguay; email: `jlvb@fing.edu.uy`.

Apply to: José L. Vieitez (Presidente de SUME), at the above address.

Dues: U.S. $100, payable to Jorge Blanco at the above address.

Privileges: Receive PMU series and Predat series free.

Officers: José L. Vieitez (President), Jorge Blanco (Vice-President), Gonzalo Perera (Treasurer), F. Pelaez (Secretary).

Sociedade Brasileira de Matemática (SBM)

Address for mail: Estrada Dona Castorina–110, Rio de Janeiro-RJ, 22460-320 Brazil; email: `presidente@sbm.org.br`; `http://www.sbm.org.br`.

Apply to: Alexsandro Almeida Pinto; email: `alex@sbm.org.br`.

Dues: U.S. $50, payable to Walcy Santos; email: `atendimento@sbm.org.br`.

Privileges: *Revista Matématica Universitária* (free subscription) and 25% discount on SBM books.

Officers: Joao Lucas Barbosa (President), Hilario Alencar (Vice-President), Walcy Santos (Treasurer), Marco Antonio Teixeira (Secretary).

Sociedade Brasileira de Matemática Aplicada e Computacional*

Apply to: Andrea Alves Ribeiro, SBMAC/ICMC, Caixa Postal 668, Av. Trabalhador São Carlense, 400, 13560-970 São Carlos–SP, Brazil; email: `sbmac@icmc.usp.br`; `http://www.sbmac.org.br`.

Dues: U.S. $30, payable to Sociedade Brasileira de Matemática Aplicada e Computacional.

Privileges: *SBMAC Notices.*

Officers: Jose Alberto Cuminato (President), Alagacone Sri Ranga (Vice-President), Edson Wendland (Treasurer), Edson Luiz Cataldo Ferreira (Secretary).

Sociedade Paranaense de Matemática*

Apply to: C. Pereira da Silva, Sociedade Paranaense de Matemática, Caixa Postal 1261, 80001-970, Curitiba-PR, Brasil.

Dues: U.S. $12, payable to Sociedade Paranaense de Matemática.

Privileges: *Boletim da Sociedade Paranaense de Matemática* (two issues per year), *Monografias da Sociedade Paranaense de Matemática*.

Officers: C. Pereira da Silva (President), R. J. B. De Sampaio (Vice-President), E. Andretta (Treasurer), A. Moser (Secretary).

Unión Matemática Argentina*

Address for mail: Departamento de Matemática–Pabellon 1, Universidad de Buenos Aires–Ciudad Universitari, Intendente Güiraldes 2160, C1428EGA–Ciudad de Buenos Aires, Argentina; email: `uma@dm.uba.ar`; `http://www.union-matematica.org.ar`.

Apply to: Andrea Solotar, Dept. de Matemática–Facultad de Ciencia de Exactas, Ciudad Universitaria–Pabellon 1, 1428 Buenos Aires, Argentina.

Dues: U.S. $48, payable to Liliana Gysin at above address.

Privileges: Same privileges granted to UMA members.

Officers: Carlos Cabrelli (President), Hugo Aimar (Vice-President), Liliana Gysin (Treasurer), Andrea Solotar (Secretary).

Asia

Allahabad Mathematical Society

Apply to: Mona Khare, Secretary, Allahabad Mathematical Society, 10 C. S. P. Singh Marg, Allahabad-211001, India; email: `ams10marg@gmail.com`; email: `ams10@rediffmail.com`; `http://www.amsallahabad.org`.

Dues: U.S. $60 for annual members, payable to Allahabad Mathematical Society at the above address.

Privileges: All members can purchase publications of the Society at a discounted price.

Officers: D. P. Gupta (President), S. P. Singh and S. L. Singh (Vice-Presidents), S. Srivastava (Treasurer), M. Khare (Secretary).

Calcutta Mathematical Society*

Apply to: M. R. Adhikari, Secretary, Calcutta Mathematical Society, AE-374, Sector-1, Salt Lake City, Calcutta 700 064, India; telephone: (033) 2337-8882; Fax: (0091) 33-2337-6290; email: `cms@cal2.vsnl.net.in`.

Dues: U.S. $40, payable to Secretary, Calcutta Mathematical Society, at the above address.

Privileges: *Bulletin of the Calcutta Mathematical Society*; *News Bulletin of the Calcutta Mathematical Society*; *Review Bulletin of the Calcutta Mathematical Society*; library; seminars/symposia, summer and winter schools; workshops, popular lectures, etc.

Officers: K. Ramachandra (President), A. Chakraborty, N. D. Chakraborty, P. Muldowney, E. Trell, and H. M. Srivastava (Vice-Presidents), U. C. De (Treasurer), M. R. Adhikari (Secretary), H. P. Mazumdar (Editorial Secretary).

Indian Mathematical Society*

Apply to: Shashi Prabha Arya (Treasurer), 90, Saakshara Apts., A-3 Block, Paschim Vihar, New Delhi-110063, India; email: `shsh_ry@yahoo.co.in`; `http://www.indianmathsociety.org.in`.

Dues: U.S. $100 (annual) or $1000 (life), payable to Indian Mathematical Society, at the above address.

Privileges: Complimentary copy of the *The Mathematics Student*.

Officers: A. K. Agarwal (President), S. P. Arya (Treasurer), B. Nimse (Administrative Secretary), S. Deo (Academic Secretary), V. M. Shah (General Secretary).

Indonesian Mathematical Society (IndoMS)*

Apply to: Indonesian Mathematical Society, c/o Dr. Hilda Assiyatun, Department of Mathematics, Institut Teknologi Bandung (ITB), Jalan Ganesa 10 Bandung, Indonesia; `http://www.indoms-center.org`.

Dues: U.S. $15, payable to Dr. Hilda Assiyatun (Treasurer) at the above address.

Privileges: Reduced registration at conferences sponsored by The IndoMS and reduced price for any publications.

Officers: Edy Tri Baskoro (President), Widodo, Stevanus Budi Waluya, Angie Siti Anggari (Vice-Presidents), Hilda Assiyatun (Treasurer), Budi Nurani (Secretary).

Korean Mathematical Society

Apply to: Korean Mathematical Society, Korea Science and Technology Center 202, 635-4 Yeoksam-dong, Kangnam-ku, Seoul 135-703, Korea; email: `kms@kms.or.kr`; `http://www.kms.or.kr/`.

Dues: U.S. $40, payable to Korean Mathematical Society.

Privileges: Members will receive six volumes of *Journal of the KMS* and six volumes of *Bulletin of the KMS*.

Officers: Dohan Kim (President), Jong Hae Keum, Kil Hyun Kwon, Sun Young Jang (Vice-Presidents), Hye Sook Park (Treasurer), Dosang Joe (Secretary).

Mathematical Society of Japan

Apply to: Yihui Tang, Secretary, Mathematical Society of Japan, 34-8, Taito 1 chome, Taito-ku, Tokyo 110-0016, Japan; `http://wwwsoc.nii.ac.jp/msj6/math`.

Dues: Category I: 9,000 yen; Category II: 10,800 yen, payable to Mathematical Society of Japan at the above address.

Privileges: Category I: *Journal of the Mathematical Society of Japan*, *Sugaku-Tsusin* (2 issues); Category II: *Journal of the Mathematical Society of Japan*, *Sugaku* (in Japanese), *Sugaku-Tsushin* (4 issues).

Officers: Takash Tsuboi (President), Liang Zhang (Treasurer), Yihui Tang (Secretary).

Mathematical Society of the Philippines*

Address for mail: Mathematical Society of the Philippines, Institute of Mathematics, University of the Philippines, Diliman, Quezon City, Philippines 1101; email: `mathsoc@mathsocietyphil.org`; `http://www.mathsocietyphil.org`.

Apply to: Reginaldo Marcelo, Mathematics Department, Ateneo de Manila University, P.O. Box 154, Manila, Philippines.

Dues: U.S. $7, payable to Mathematical Society of the Philippines.

Privileges: Publications of the Mathematical Society of the Philippines; discount on conference fees.

Officers: Fidel Nemenzo (President), Jumela Sarmiento (Vice-President), Marian Roque (Treasurer), Ederlina Nocon (Secretary).

Mathematical Society of the Republic of China

Address for mail: c/o Department of Mathematics, National Taiwan University No. 1, Roosevelt Road Section 4, Taipei 10617, Taiwan; email: `tms@math.ntu.edu.tw`; `http://www.taiwanmathsoc.org.tw`.

Dues: U.S. $45, payable to Mathematical Society of the Republic of China at the above address.

Privileges: One-year free subscription to the *Taiwanese Journal of Mathematics*.

Officers: Fang-Bo Yeh (President), Ko-Wei Lih (Vice-President), Jenn-Nan Wang (Treasurer), Jung-Kai Chen (Secretary).

Mongolian Mathematical Society*

Apply to: A. Galtbayar, Mongolian Mathematical Society, P. O. Box 187, Post Office 46A, Ulaanbaatar, Mongolia; email: `galtbayar@yahoo.com`.

Dues: U.S. $20, payable to A. Galtbayar at the above address.

Privileges: Right to receive the *Mongolian Mathematical Journal* for free and to publish in the *MMJ* .

Officers: A. Mekei (President), B. Battsengel (Vice-President), A. Galtbayar and D. Purevsuren (Secretaries).

Nepal Mathematical Society

Apply to: Chet Raj Bhatta, Secretary, Nepal Mathematical Society, Central Department of Mathematics, Tribhuvan University, Kirtipur, Kathmandu, Nepal; email: `cdmath@wlink.com.np`.

Dues: U.S. $20, payable to Kabita Luitel (Treasurer) at the above address.

Privileges: All privileges enjoyed by an ordinary member, which includes purchasing NMS publications and participation in seminars at concessional rates.

Officers: Bhadra Man Tuladhar (President), Sharada Shrestha (Vice-President), Kabita Luitel (Treasurer), Chet Raj Bhatta (Secretary).

Persatuan Sains Matematik Malaysia*

Address for mail: Pusat Pengajian Sains Matematik, Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor, Malaysia; email: `maslina@pkrisc.cc.ukm.my`; `http://www.tmsk.uitm.edu.my/~persama`.

Apply to: Dr. Maslina at the above address.

Dues: U.S. $7.50, payable to Bendahari, PERSAMA, at the above address.

Privileges: *Warkah Berita PERSAMA* (two issues per year), *Bulletin of the Malaysian Mathematical Society* (two issues per year), *Menemui Matematik* (two issues per year).

Officers: Mohd Salmi Md Noorani (President), Husna Hassan and Arsmah Ibrahim (Vice-Presidents), Wan Rosmanira Ismail (Treasurer), Maslina Darus (Secretary).

Punjab Mathematical Society*

Address for mail: Department of Mathematics, University of the Punjab, Quaid-i-Azam Campus, Lahore, Pakistan; email: `mathdept@paknet.ptc.pk`.

Apply to: Zia ul Haq, Secretary, Punjab Mathematical Society, Department of Maths., University of the Punjab, Lahore, Pakistan.

Dues: U.S. $30 for life membership, payable to Umar Farooq Qureshi, Treasurer, P.M.S.

Officers: G. Mustafa Habibullah (President), Zia Ullah Randhawa and Munir Ahmad Ch. (Vice-Presidents), Umar Farooq Qureshi (Treasurer), Nawazish Ali Shah (Secretary).

Ramanujan Mathematical Society*

Apply to: Professor V. Thangaraj, Secretary, Ramanujan Institute for Advanced Study in Mathematics, University of Madras, Chennai-600005, India; email: `riasm@md3.vsnl.net.in`; `http://rms.enmail.com/`.

Dues: U.S. $20 (annual), U.S. $200 (life), payable to Professor V. Thangaraj at the above address.

Privileges: Complimentary copy of the *Journal of the Ramanujan Mathematical Society*.

Officers: Phoolan Prasad (President), S. Sri Bala (Vice-President), P. Paulraja (Treasurer), V. Thangaraj (Secretary).

Singapore Mathematical Society

Apply to: Lai Chee Chan, Singapore Mathematical Society, c/o Department of Mathematics, National University of

Singapore, 2 Science Drive 2, S 117543, Singapore; email: smsuser@math.nus.edu.sg; http://sms.math.nus.edu.sg.

Dues: 10 Singapore dollars, payable to Singapore Mathematical Society at the above address.

Privileges: Complimentary copy of *Mathematical Medley*, the Society's official magazine, and discounts on the Society's publications and activities.

Officers: Chengbo Zhu (President), Helmer Aslaksen (Vice-President), Seng Kee Chua (Treasurer), Victor Tan (Secretary).

Southeast Asian Mathematical Society

Apply to: c/o School of Mathematical Sciences, Universiti Sains Malaysia, 11800 USM Penang, Malaysia; email: rosihan@cs.usm.my; http://seams.math.nus.edu.sg.

Dues: None, membership by society of SEAMS only.

Officers: Rosihan M. Ali, Dato (President), Le Tuan Hoa and Fidel Nemenzo (Vice-Presidents), Saiful Hafizah Jaaman (Treasurer), Masllina Darus (Secretary).

Vietnam Mathematical Society

Address for mail: c/o 18 Hoang Quoc Viet Road, CauGiay District, 10307, Hanoi, Vietnam; email: vms@vms.org.vn; http://www.vms.org.vn.

Apply to: Phung Ho Hai at above address.

Dues: Hoi Toan Hoc Viet Nam, Account Number: 0491371684139 Vietcombank Thang Long, SWIFT: BFTVVNVX 049, 98 Hoang Quoc Viet, Cau Giay, Hanoi, Vietnam.

Privileges: Pay conference fees at the same rate as individual VMS members in any conferences organized or jointly organized by the VMS; buy (a) *Notices of the VMS* (in Vietnamese), 4 issues/year: U.S. $15 per year, or (b) *Vietnam Journal of Mathematics* (in English), 4 issues/year: U.S. $60 per year.

Officers: Le Tuan Hoa (President), Phung Ho Hai (Treasurer), Nguyen Huu Du (Secretary)

Vijnana Parishad of India*

Apply to: R. C. Singh Chandel, Secretary, Vijnana Parishad of India, D. V. Postgraduate College, Orai-285001, U.P., India; email: rc_chandel@yahoo.com.

Dues: U.S. $10, payable to Vijnana Parishad of India, D. V. Postgraduate College, Orai-285001, U.P., India.

Privileges: *Jñānābha* (an interdisciplinary mathematical journal currently published once a year); back volumes available at 25% discount.

Officers: V. P. Saxena (President), S. L. Singh, G. C. Sharma, and N. D. Samadhia (Vice-Presidents), R. C. Singh Chandel (Secretary-Treasurer), H. M. Srivastava (Foreign Secretary).

Europe

Azerbaijan Mathematical Society*

Apply to: A. Ali Novruzov, Department of Mechanics and Mathematics, Baku State University, Baku, Azerbaijan, 370145.

Dues: U.S. $10, payable to Azerbaijan Mathematical Society.

Privileges: All privileges of ordinary members plus 50% discount on all AzMS publications.

Officers: O. A. Veliev (President), F. A. Abdullaev (Treasurer), V. A. Gasimov (Secretary).

Balkan Society of Geometers

Apply to: Constantin Udriste, Treasurer, Department of Mathematics-Informatics, University Politehnica of Bucharest, Splaiul Independentei 313, Bucharest 060042, Romania; email: udriste@mathem.pub.ro; http://www.mathem.pub.ro.

Dues: 30 euros (except persons from countries with financial difficulties, 10 euros), payable to the Balkan Society of Geometers at the above address.

Privileges: Participation in meetings and all other privileges enjoyed by an ordinary member; discounts (at least 10%) on the prices of BSG publications.

Officers: Constantin Udriste (President), Mihai Anastasiei, Gabriel Pripoaie, Vladimir Balan (Vice-Presidents), Constantin Udriste (Treasurer), Vasile Iftode (Secretary).

Belgian Mathematical Society*

Apply to: Jan van Casteren, Secretary, University of Antwerp, Department of Mathematics, Middelheimlaan 1, B-2020 Antwerp, Belgium; email: bms@ulb.ac.be; email: jan.vancasteren@ua.ac.be; http://bms.ulb.ac.be.

Dues: 18 euros, payable to Belgian Mathematical Society, Campus Plaine, CP 218/01, Bld. du Triomphe, B-1050 Brussels, Belgium. Account number: 000-0641030-54 (IBAN : BE 42 0000 6410 3054, BIC : BPOTBEB1).

Privileges: Membership includes a subscription to *Bulletin of the Belgian Mathematical Society—Simon Stevin*; newsletter.

Officers: Cathérine Finet (President), Stefaan Caenepeel (Vice-President), Guy Van Steen (Treasurer), Jan van Casteren (Secretary).

Berliner Mathematische Gesellschaft e. V.

Apply to: B Wengel, Berliner Mathematische Gesellschaft, Schriftführer, Freie Universität Berlin, Institut für Mathematik, Sekretariat Frau B. Wengel, Arnimallee 3, 14195 Berlin, Germany; email: wolfgang.volk@berlin.de; http://www.BerlMathGes.de.

Dues: 10 euros, payable to Dr. Jörg Schmid-Kikuchi at the above address. IBAN : DE80 1002 00002530 873 400, BIC : BEBEDEBBXXX.

Privileges: *Sitzungsberichte der BMG* at reduced rate.

Officers: Rudolf Baierl (President), Gerhard Preuss (Vice-President), Jörg Schmid-Kikuchi (Treasurer), Wolfgang Volk (Secretary).

Croatian Mathematical Society

Apply to: Renata Svedrec, Secretary, HMD, Department of Mathematics, Bijenička 30, 10000 Zagreb, Croatia; email: hmd@math.hr; http://www.math.hr/hmd.

Dues: U.S. $10, payable to HMD, Zagrebačka banka d.d. Zagreb, 2500-03688780–IBAN: HR442360000-1101530802.

Privileges: *Vjesnik HMD* (in Croatian) and one of five journals edited by CMS free of charge. All publications of the CMS and all fees reduced by at least 25%.

Officers: Hrvoje Krayević (President), Ivica Gusić and Petar Mladinić (Vice-Presidents), Hrvoje Šikić (Treasurer), Renata Svedrec (Secretary).

Cyprus Mathematical Society*

Apply to: Gregory Makrides, 36 Stasinou Street, Suite 102, Strovolos 2003, Nicosia, Cyprus; email: cms@cms.org.cy.

Dues: U.S. $20, payable to Cyprus Mathematical Society at the above address.

Privileges: Receive the annual periodical *Mathematiko VEMA* in Greek. Invitations to conferences organized in Cyprus and the Annual Summer Math School organized in Cyprus at the end of June.

Officers: Gregory Makrides (President), Athanasios Gagatsis (Vice-President), Antreas Philippou (Treasurer), Savvas Antoniou (Secretary).

Dansk Matematisk Forening (Danish Mathematical Society)*

Address for mail: c/o President Vagn L. Hansen, Department of Mathematics, Building 303 S, Technical University of Denmark, DK-2800 Kongens Lyngby, Denmark; email: dmf@mathematics.dk/; http://www.mathematics.dk/.

Apply to: Please use the electronic form at http://www.mathematics.dk/.

Dues: DKK 155, payable to Carsten L. Petersen, Treasurer, Department of Science, NSM, Roskilde University (RUC), Building 27.2, Universitetsvej 1, Postbox 260, DK-4000 Roskilde, Denmark.

Privileges: *Mathematica Scandinavica* (750 DKK per year), *Nord. Mat. Tidss.* (*Normat*) (320 SEK per year). Members of the American Mathematical Society do not have to join Dansk Matematisk Forening to obtain the journals. Subscription orders should be sent directly to the journals: *Normat*, NCM Göteborgs Université, Box 160, SE-405 30 Gothenburg, Sweden; *Mathematica Scandinavica*, Matematisk Institut, Aarhus Universitet, 8000 Aarhus C, Denmark. Members of the American Mathematical Society who join the Danish Mathematical Society as reciprocity members will receive the newsletter *Matilde*.

Officers: Vagn Lundsgaard Hansen (President), Poul Hjorth (Vice-President), Carsten Lunde Peterson (Treasurer), Poul Hjorth (Secretary).

Deutsche Mathematiker-Vereinigung e.V. (DMV) (German Mathematical Society)

Apply to: Roswitha Jahnke, DMV-Office, c/o WIAS, Mohrenstr. 39, 10117 Berlin, Germany; email: dmv@wias-berlin.de; http://dmv.mathematik.de.

Dues: 50 euros, payable to Deutsche Mathematiker-Vereinigung e.V., Volksbank Freiburg, IBAN: DE 66 6809 0000 0006 9550 02, BIC: GENODE61FR1.

Privileges: Free subscription to: *Mitteilungen der DMV* and one of these publications: *Jahresbericht der DMV*, *Math. Semesterberichte* or *Journal für Mathematik-Didaktik*. Discounted registration rates at DMV meetings.

Officers: Wolfgang Lueck (President), Christian Baer (Vice-President), Juerg Kramer (Treasurer), Guenter Toerner (Secretary).

Edinburgh Mathematical Society

Apply to: A. D. Gilbert, Honorary Secretary, Edinburgh Mathematical Society, James Clerk Maxwell Building, King's Buildings, Mayfield Road, Edinburgh EH9 3JZ, Scotland; email: edmathsoc@ed.ac.uk; http://www.maths.ed.ac.uk.

Dues: U.S. $20 (£10 sterling) without Society's proceedings.

Privileges: The Society's proceedings are available at a concessionary rate directly from Cambridge University Press (journals@cambridge.org): Print only: U.S. $23 (£15 sterling); Print and online: U.S.$28 (£18 sterling).

Officers: P. J. Davies (President), R. J. Archbold (Vice-President), M. A. Youngson (Treasurer), A. D. Gilbert and T. H. Lenagan (Secretaries).

European Mathematical Society*

Apply to: Riitta Ulmanen, Department of Mathematics and Statistics, P.O. Box 68, University of Helsinki, F1-00014, Helsinki, Finland. email: ems-office@helsinki.fi; http://www.euro-math-soc.eu.

Dues: 44 euros, payable either via Web or to Riitta Ulmanen at the above address.

Privileges: An AMS member has a privilege to pay 44 euros instead of 88 euros and receive EMS Newsletter.

Officers: Ari Laptev (President), P. Exner and H. Holden (Vice-Presidents), Jouko Väänänen (Treasurer), Stephen Huggett (Secretary)

Gesellschaft für Angewandte Mathematik und Mechanik e.V. (GAMM)

Apply to: M. Kaliske, Institut für Statik und Dynamik der Tragwerke, Fakultät Bauingenieurwesen, Technische Universität Dresden, 01062 Dresden, Germany; email: gamm@mailbox.tu-dresden.de; http://www.gamm-eV.de.

Dues: 51 euros, payable to A. Frommer, Bergische Universität Wuppertal, Fachbereich C–Mathematik, 42097 Wuppertal, Germany.

Privileges: Regular publications of GAMM and participation in scientific meetings at a reduced rate.

Officers: Peter Wriggers (President), Rolf Jeltzsch (Vice-President), Michael Günther (Treasurer), Michael Kaliske (Secretary).

Glasgow Mathematical Association*

Apply to: Frances Goldman, Treasurer, Glasgow Mathematical Association, Department of Mathematics, University of Glasgow, Glasgow G12 8QW, United Kingdom; email: fhg@maths.gla.ac.uk; http://www.maths.gla.ac.uk/.

Dues: £7, payable to Glasgow Mathematical Association, at the above address.

Privileges: *Glasgow Mathematical Journal* at reduced rate (£45).

Officers: A. Craw (President), F. Goldman (Treasurer), L. Moon (Secretary).

Hellenic (Greek) Mathematical Society*

Apply to: Hellenic Mathematical Society, 34, Panepistimiou Street, 106 79 Athens, Greece; email: info@hms.gr; http://www.hms.gr/.

Dues: U.S. $20 payable to Hellenic Mathematical Society at the above address.

Privileges: The *Bulletin of HMS*, News-Bulletin (Enimerosi), discounts that are available to all members.

Officers: Nikolaos Alexandris (President), George Dimakos and Dionysios Anapolitanos (Vice-Presidents), Evaggelos Eustathiou (Treasurer), Ioannis Tyrlis (Secretary).

Icelandic Mathematical Society*

Address for mail: Icelandic Mathematical Society, Raunvisindastofnun Haskolans, Dunhaga 3, IS-107 Reykjavik, Iceland; email: kristjanj@simnet.is; http://www.vedur.is/is/.

Apply to: Dr. Kristjän Jonasson at the above address.

Dues: U.S. $12, payable to Dr. Hersir Sigurgeirsson at the above address.

Privileges: Reduced subscription rate on *Mathematica Scandinavia* and *Nordisk matematisk Tidskrift* (*Normat*); subscription orders should be sent directly to the journals.

Officers: Kristjän Jonasson (President), Hersir Sigurgeirsson (Treasurer), Fjola Run Björnsdóttir (Secretary).

Irish Mathematical Society

Address for mail: Shane O'Rourke, Department of Mathematics, Bishopstown Campus, Cork Intitute of Technology, Cork, Ireland; email: Shane.ORourke@cit.ie.

Apply to: Sinead Breen, St. Patrick's College, Drumcondra, Dublin 9, Ireland; email: sinead.breen@spd.dcu.ie. Membership application forms can be downloaded from http://www.maths.tcd.ie/pub/ims/imsapplicn.pdf.

Dues: U.S. $10 (2008), $15 (2009), payable to Irish Mathematical Society, Sinead Breen, RM. MOV30A, St. Patrick's College, Drumcondra, Dublin 9, Ireland.

Privileges: Free copy of the *Bulletin of the Irish Mathematical Society* (two times per year); free registration at IMS annual conference (September).

Officers: James Cruickshank (President), Stephen Wills (Vice-President), Sinéad Breen (Treasurer), Shane O'Rourke (Secretary).

János Bolyai Mathematical Society

Apply to: Ildikó Rákóczi, Executive Director, János Bolyai Mathematical Society, Fö utca 68, H-1027 Budapest, Hungary; email: bjmt@renyi.hu.

Dues: Are voluntary but should minimally cover duplication and mailing costs; for reciprocity members (residing outside Hungary) suggested fee is 1/8 of 1 percent of the member's net income, payable to Kereskedelmi ES Hitelbank P.T., Account Number 10200830-32310243. Sponsoring members pay at least U.S. $180 or equivalent per year.

Privileges: Upon request, *Matematikai Lapok* (twice a year), *Középiskolai Matematikai Lapok* (monthly). If sufficient interest is expressed, a bulletin in English will be available. In addition, the JBMS is negotiating to obtain discounts for its reciprocity and sponsoring members on several serial publications and periodicals appearing in Hungary. Contact the JBMS secretary for more information regarding this and other privileges of membership.

Officers: Gyula Katona (President), Ildikó Rákóczi (Executive Director), György Lippner (Treasurer), András Recski (Secretary General), Tibor Jordán (Vice Secretary General).

Jednota českých matematiků a fyziků (Union of Czech Mathematicians and Physicists)*

Apply to: Jan Kratochvíl, Union of Czech Mathematicians and Physicists, Žitná 25, 117 10 Praha 1, Czech Republic; email: jcmf@math.cas.cz; http://www.jcmf.cz.

Dues: U.S. $20, payable to Jan Obdržálek at the above address.

Privileges: (i) A discount of 20% in the conference fees for conferences, symposia, summer schools, and similar events organized (or coorganized) by the JČMF; (ii) newsletter.

Officers: Štefan Zajac (President), Eduard Fuchs and Oldřich Lepil (Vice-Presidents), Jan Obdržálek (Treasurer), Petr Řepa (Secretary).

Jednota slovenských matematikov a fyzikov (JSMF) (Union of Slovak Mathematicians and Physicists)*

Address for mail: Secretary of JSMF, FMFI UK Pavilon F1, Mlynská dolina, 842 48 Bratislava, Slovak Republic; email: `JSMF@CENTER.FMPH.UNIBA.SK`; `http://www.uniba.sk/~jsmf`.

Apply to: Hilda Draškovičová, FMFI UK, KATC, Mlynská dolina, 842 48 Bratislava, Slovak Republic.

Dues: U.S. $20, payable to Slovenská sporitel'ňa, Záhradnicka 93, 8000 Bratislava, Slovak Republic; č.u.: 101848-019/0900 IČO: 178705.

Privileges: A discount of 20% in conference fees for conferences, symposia, summer schools, and similar events organized by the JSMF.

Officers: Victor Bezak (President), Hilda Draškovičová (Vice-President), Edmund Dobročka (Treasurer), Imrich Morva (Secretary).

Koninklijk Wiskundig Genootschap*

Apply to: Rob van der Mei, CWI, P. O. Box 94079, 1090 GB Amsterdam, The Netherlands; email: `R.D.van.der.Mei@cwi.nl`; `http://www.wiskgenoot.nl`.

Dues: 50 euros.

Privileges: Free periodical *Nieuw Archief voor Wiskunde*.

Officers: H. W. Broer (President), G. Vegter (Vice-President), S. Bhulai (Treasurer), R. van der Mei (Secretary).

London Mathematical Society*

Apply to: Susan M. Oakes, London Mathematical Society, De Morgan House, 57–58 Russell Square, London WC1B 4HS, United Kingdom; email: `membership@lms.ac.uk`; `http://www.lms.ac.uk/`.

Dues: U.S. $43.50 payable to London Mathematical Society at the above address.

Privileges: *LMS Newsletter*; reduced rates for the *Bulletin*, *Journal*, and *Proceedings of the LMS*; *Nonlinearity*; LMS Lecture Notes; LMS Student Texts; LMS Monographs. (Please write to the LMS for complete details.)

Officers: E. B. Davies (President), D. G. Larman and F. A. Rogers (Vice-Presidents), N. M. J. Woodhouse (Treasurer), P. R. Cooper (Executive Secretary).

Mathematical Society of Serbia*

Apply to: Milica Babić, Mathematical Society of Serbia, Knez Mihailova 35/IV, p.p. 355, 11000 Belgrade, Serbia; email: `info@dms.org.yu`; `http://www.dms.org.yu`.

Dues: U.S. $12, payable to DRUŠTVO MATEMATIČARA SRBIJE Acct. No. 250-6498-06, NACIONALNA ŠTEDIONICA.

Privileges: *Matematički Vesnik*, *Teaching of Mathematics*.

Officers: Branislav Popović (President), Zoran Kadelburg (Vice-President), Milica Babić (Treasurer), Biljana Babić (Secretary).

Norsk Matematisk Forening (Norwegian Mathematical Society)

Apply to: Marius Irgens, Norsk Matematisk Forening, Department of Mathematical Sciences, NTNU, No-7491, Trondheim, Norway; email: `nmf@math.ntnu.no`; `http://www.matematikkforeningen.no`.

Dues: NOK 100, payable to Marius Irgens at the above address.

Privileges: All regular membership privileges, including the monthly newsletter *Infomat*.

Officers: Brynjulf Owren (President), Christian Skau (Vice-President), Marius Irgens (Treasurer and Secretary).

Österreichische Mathematische Gesellschaft (OMG)

Apply to: Robert F. Tichy, Institut für Mathematik, Technische Universität Graz, Steyrergasse 30, A-8010 Graz, Austria; email: `oemg@oemg.ac.at`; `http://www.oemg.ac.at/`.

Dues: 20 euros, payable to ÖMG, Wiedner Hauptstr. 8, A-1040 Wien, Bank Austria-Creditanstalt, IBAN: AT 83 12000229 10389200, BIC: BKAUATWW.

Privileges: *Internationale Mathematische Nachrichten* (IMN), reduction of fees at our congresses and meetings.

Officers: Robert F. Tichy (President), Michael Drmota (Vice-President), Helmut Pottmann (Treasurer), Michael Oberguggenberger (Secretary).

Polskie Towarzystwo Matematyczne*

Apply to: Maciej Czarnecki, ZG PTM, ul. Śniadeckich 8, 00-956 Warszawa, Poland; email: `zgptm@ptm.org.pl`; `http://www.ptm.org.pl`.

Dues: U.S. $22, payable to Polskie Towarzystwo Matematyczne, ul. Śniadeckich 8, 00-956 Warszawa, Poland, KREDYT BANK S.A., IBAN: PL 98 1500 1777 1217 7008 4349 0000, BIC: KRDBPL.

Privileges: Members receive one of the following five series of the publication *Annales Societatis Mathematicae Polonae*: *Commentationes Mathematicae*, *Wiadomości Matematyczne* (in Polish), *Matematyka Stosowana* (in Polish), *Didactica Mathematicae* (in Polish), *Antiquitates Mathematicae* (in Polish).

Officers: Stefan Jackowski (President), Bogusław Hajduk and Paweł Walczak (Vice-Presidents), Krystyna Jaworska (Treasurer), Maciej Czarnecki (Secretary).

Real Sociedad Matemática Española

Apply to: Ramón Esteban Romero, Secretaria de la Real Sociedad Matemática Española, Universidad Complutense de Madrid, Facultad de Matematicas, Despacho 525, 28040 Madrid, Spain; email: `secretaria@rsme.es`; `http://www.rsme.es`.

Dues: 25 euros, payable to Real Sociedad Matemática Española at the above address.

Privileges: *La Gaceta de la RSME* (Journal; paper and electronic access), 4 issues per year; *Boletín de la RSME* (weekly electronic newsletter).

Officers: Olga Gil-Medrano (President), Eduardo Godoy and Raúl Ibáñez (Vice-Presidents), Enrique Artal Bartolo (Treasurer), Ramón Esteban Romero (Secretary).

SEMA, Sociedad Española de Matemática Aplicada*

Apply to: Carlos Castro (Secretary), Despacho 520, Facultad de Matematicas, Universidad Complutense, 28040 Madrid, Spain; email: `info@sema.org.es`; `http://www.sema.org.es` .

Dues: 15 euros, payable to SEMA at the above address.

Privileges: Information concerning applied mathematics in Spain through *Boletín de la SEMA*, reduced inscription fee for activities sponsored by SEMA.

Officers: Carlos Vázquez (President), Rosa Donat (Vice-President), Iñigo Arregui (Treasurer), Carlos Castro (Secretary).

Sociedade Portuguesa de Matemática

Apply to: Filipe Oliveira, Sociedade Portuguesa de Matemática, Av. da República 45 3°, 1050-187 Lisboa, Portugal; email: `spm@spm.pt`; `http://www.spm.pt`.

Dues: 20 euros, payable to the Sociedade Portuguesa de Matemática, at the address above.

Privileges: Each member receives the following publication of our Society free of charge: *Boletim da Sociedade Portuguesa de Matemática* and *Gazeta de Matemática* and discounts on books.

Officers: Nuno Crato (President), Filipe Oliveira and Miguel Abreu (Vice-Presidents), Pedro J. Freitas (Treasurer).

Societat Catalana de Matemàtiques

Address for mail: Carrer del Carme 47, 08001, Barcelona, Spain; email: `scm@iec.cat`; `http://scm.iec.cat`.

Apply to: Secretary, Societat Catalana de Matemàtiques, at the address above.

Dues: 17 euros, payable to the Societat Catalana de Matemàtiques.

Privileges: *Butlletí de la Societat Catalana de Matemàtiques* (two times per year) plus *SCM/Notices* (two times per year).

Officers: Carles Perelló (President), Josep Lluis Solé (Vice-President), Teresa Martinez (Treasurer), Marianna Bosch (Secretary).

Societatea Matematicienilor din Romania*

Apply to: Horia I. Ene, Calea Grivitei 21, P. O. Box 1-764, 70700 Bucvharest, Romania.

Dues: U.S. $10, payable to Societatea Matematicienilor din Romania at the address above.

Privileges: Reduced rates for participation in scientific conferences organized by SMR, *Bulletin Mathématiques* (four times per year) free.

Officers: Horia I. Ene (President), Nicolae Popa (Vice-President), Serban Barcanescu (Treasurer), Radu Purice (Secretary).

Societatea de Ştiinţe Matematice din România*

Apply to: Radu Gologan, President, Str. Academiei, NR. 14, Sector 1, 010014, Bucureşti, Rômania; email: `office@rms.unibuc.ro`; `http://www.rms.unibuc.ro`.

Dues: U.S. $15/$30 (see privileges below), payable to Societatea de Ştiinţe Matematice din România, Account R008 RNCB 0076 0043 5732 0002, Banca Comerciala Romana, Filiala Sector 5, Bucuresti, Romania.

Privileges: For membership dues of U.S. $30, free subscription to one of the Society's journals. When participating in the annual meetings of the Society, all AMS members are exempt from taxes.

Officers: Radu Gologan (President), Doru Stefanescu (Vice-President), Cristina Luţu (Treasurer), Mircea Trifu (Secretary).

Société Mathématique de France

Apply to: Société Mathématique de France, Attn. Claire Ropartz, Institut Henri Poincaré, 11 Rue Pierre et Marie Curie, F-75231 Paris cedex 05, France; email: `smf@dma.ens.fr`; `http://smf.emath.fr/`.

Dues: U. S. $49, payable to the American Mathematical Society or SMF.

Privileges: *Bulletin*, U.S. $174; *Memoires*, U.S. $137; *Bulletin* and *Mémoires*, U.S. $310; *Bulletin* (version électronique seule), U.S. $133; *Astérisque*, U.S. $550; *Histoire des Mathématiques*, U.S. $83; *Histoire des Mathématiques* (version électronique seule), U.S. $63; *Panoramas et Synthèses*, U.S. $99; *Annales scientifiques de l'ENS*, U.S. $525.

Officers: St. Jaffard (President), E. Russ, F. Germinet, M. Granger (Vice-Presidents), M. Vigue (Treasurer), P. Loidreau (Adjoint Treasurer) B. Helffer (Secretary).

Société Mathématique du Luxembourg*

Apply to: Norbert Poncin, Société Mathématique du Luxembourg, Université du Luxembourg, Campus Limpertsberg, 162A, Avenue de la Faïencerie, L-1511 Luxembourg, Luxembourg; email: norbert.poncin@uni.lu; http://math.uni.lu/sml.

Dues: 20 euros (less discount), payable to Société Mathématique du Luxembourg at the above address.

Privileges: Discount on membership dues (same percent as for AMS); information concerning activities of the SML.

Officers: Norbert Poncin (President), Martin Schlichenmaier (Vice-President), Jean Schiltz (Treasurer), Jean-Luc Marichal (Secretary).

Société de Mathématiques Appliquées et Industrielles (SMAI)*

Apply to: Société de Mathématiques Appliquées et Industrielles (SMAI), Institut Henri Poincaré, 11 rue Pierre et Marie Curie, 75231 Paris cedex 05, France; email: smai@emath.fr; http://smai.emath.fr/.

Dues: 40 euros, payable to Société de Mathématiques Appliquées et Industrielles at the above address.

Privileges: Free subscription to the Society's bulletin, *Matapli* (magazine); lettre SMAI-INFO (regular electronic newsletter).

Officers: Denis Talay (President), Patrick Lascaux (Vice-Presidents), Robert Eymard (Treasurer), Serge Piperno (Secretary).

Society of Associations of Mathematicians and Computer Scientists of Macedonia*

Apply to: Boro Piperevski, President SAMCSM, Pirinska B.B., 91000 Skopje, Macedonia.

Dues: $5, payable to SDMI na MAKEDONIA, acct. 40120-678-10217, Pirinska B.B., 91000 Skopje, Macedonia.

Privileges: Receiving the *Bulletin of SAMCSM* and taking part in SAMCSM activities.

Officers: Boro Piperevski (President), Borko Ilievski (Vice-President), Kosta Miševski (Treasurer), Vasile Marčevski (Secretary).

Society of Mathematicians, Physicists, and Astronomers of Slovenia*

Address for mail: DMFA, P.P. 2964, 1000 Ljubljana, Slovenia; email: tomaz.pisanski@fmf.uni-lj.si; http://www.dmfa.si/.

Apply to: Tomaž Pisanski at the above address.

Dues: SKB Banka D. D., Ajdovscina 4, SWIFT (BIC): SKBASI2X, IBAN: SI56 0310 0100 0018 78

Privileges: Subscription to *Obzornik za matematiko in fiziko* (surface mail).

Officers: Zvonko Trontelj (President), Nada Razpet (Vice-President), Andreja Jaklič (Treasurer), Janez Krušič (Secretary).

Suomen matemaattinen yhdistys (Finnish Mathematical Society)

Address for mail: Department of Mathematics and Statistics, P. O. Box 68 (Gustaf Hällströmin katu 2b), 00014 University of Helsinki, Finland; email: tadeas.priklopil@helsinki.fi; http://www.math.helsinki.fi/~smy/english/.

Apply to: Tadeas Priklopil, Secretary, at the above address.

Dues: 15 euros, payable to Jari Taskinen, Treasurer, at the above address.

Privileges: *Arkhimedes* (six issues per year) and *Eukleides* (newsletter), *Mathematica Scandinavica* at reduced price.

Officers: Mats Gyllenberg (President), Maarit Järvenpää (Vice-President), Jari Taskinen (Treasurer), Tadeas Priklopil (Secretary).

Svenska Matematikersamfundet (Swedish Mathematical Society)

Address for mail: Nils Dencker, Matematikcentrum, Lund University, Box 118, SE-221 00 Lund, Sweden; email: dencker@math.lth.se; http://www.matematikersamfundet.org.se.

Apply to: Milagros Izquierdo Barrios, MAI, Linköping University, SE-581 83 Linköping, Sweden.

Dues: 100 Swedish crowns, payable to Milagros Izquierdo Barrios at above address.

Privileges: *Mathematica Scandinavia* and *Nordisk Matematisk Tidskrift* at reduced rates. Newsletter (*Utskicket*) about the activities and meetings of the Society.

Officers: Nils Dencker (President), Tobias Ekholm (Vice-President), Milagros Izquierdo Barrios (Treasurer), Pavel Kurasov (Secretary).

Swiss Mathematical Society

Address for mail: Swiss Mathematical Society, Department of Mathematics, University of Fribourg, Chemin du musee 23, CH-1700 Fribourg, Switzerland; email: viktor.schroeder@math.uzh.ch; http://www.math.ch.

Apply to: Norbert Hungerbühler at the above address.

Dues: 25 CHF or 17 EUR, if residing outside Switzerland, payable by check to SMS, Louise Wolf, P. O. Box 300, CH-1723 Marli, Switzerland or by bank transfer to "Credit Suisse (Switzerland) IBAN: 35 0483 5026 5892 0000 0, BIC: CRESCHZZ80A.

Privileges: *Commentarii Mathematici Helvetici* (special price), *Elemente der Mathematik* (special price), Electronic Newsletter (free).

Officers: Viktor Schroeder (President), Bruno Colbois (Vice-President), Christine Riedtmann (Secretary-Treasurer).

Ukrainian Mathematical Society*

Apply to: A. S. Serdyuk, Institute of Mathematics, National Academy of Sciences, Ukraine, Tereschenkivskaja str., 3, 01601 Kyiv-4, Ukraine; email: sam@imath.kiev.ua.

Dues: U.S. $30, payable to N. A. Nazarenko at the above address.

Privileges: All privileges of a normal individual UMS member.

Officers: A. M. Samoilenko (President), M. L. Gorbachuk (Vice-President), N. A. Nazarenko (Treasurer), A. S. Serdyuk (Secretary).

Union of Bulgarian Mathematicians*

Apply to: Sava Ivanov Grozdev, Secretary, Union of Bulgarian Mathematicians, Acad. G. Bonchev Str., Block 8, BG-1113 Sofia, Bulgaria.

Dues: 20 USD, payable to Union of Bulgarian Mathematicians, Account #1100366612, BULBANK AD Central office, code 62196214.

Privileges: The right to attend all events organized by the UBM at reduced rate and to present papers at them, the right to attend other events in Bulgaria at a reduced rate, and the right to purchase all UMB editions at a reduced rate.

Officers: St. Dodunekov (President), I. Tonov, O. Mushkarov, R. Nikolaev (Vice Presidents).

Unione Matematica Italiana

Apply to: Giuseppe Anichini, Segreteria dell'Unione Matematica Italiana, Dipartimento di Matematica, Piazza Porta S. Donato, 5, 40126 Bologna, Italy; email: umi@dm.unibo.it; http://umi.dm.unibo.it/.

Dues: 50 euros, payable to Unione Matematica Italiana.

Privileges: Free *Notiziario dell'UMI* (10 issues a year), *Rivista la Matematica nella Societa e nella cultura* (ex Sez. A).

Officers: Franco Brezzi (President), Graziano Gentili (Vice-President), Barbara Lazzari (Treasurer), Giuseppe Anichini (Secretary).

Middle East

Iranian Mathematical Society*

Apply to: M. Shokouhi, Iranian Mathematical Society, P.O. Box 13145-418, Tehran, Iran; email: iranmath@ims.ir; http://www.ims.ir.

Dues: U.S. $45 payable to Iranian Mathematical Society at the above address.

Privileges: *Bulletin of the Iranian Mathematical Society* (two issues per year in English), *Farhang va Andisheh Riazi* (two issues per year in Persian), *Khabarnameh* and *Gozaresh* (8 issues per year in Persian), and reduced rate for participation in the conferences and seminars organized by IMS.

Officers: A. R. Medghalchi (President), M. J. Mamayhani (Treasurer).

Israel Mathematical Union (IMU)

Address for mail: Israel Mathematical Union, Faculty of Mathematics and Computer Science, The Weizmann Institute of Science, POB 26, Rehovot 76100 Israel; email: imu@imu.org.il; http://www.imu.org.il/membership.txt

Apply to: Vered Rom-Kedar, Secretary, at the above address.

Dues: 50 Israeli shekels for two years.

Privileges: Participation in meetings and all other privileges enjoyed by an ordinary member.

Officers: Harry Dym (President), Robert Krauthgamer (Treasurer), Vered Rom-Kedar (Secretary).

Palestinian Society for Mathematical Sciences*

Address for mail: Mathematics Department, Birzeit University, P. O. Box 14, West Bank, Palestine.

Apply to: Fawzi Yagoub, Department of Mathematics and Computer Science, SUNY College at Fredonia, Fredonia, NY 14063.

Dues: U.S. $30, payable to Fawzi Yagoub; see address above.

Privileges: Free issues of the *PSMS Newsletter*, 50% reduction on all PSMS conference fees, 50% reduction on all PSMS publications.

Officers: Mohammad Al-Amleh (President); Mohammad Saleh, Tahseen Mughrabi (Vice-Presidents); Raghib Abu Saris, Nur edden Rabei, Mohammad El-Atrash, Taha Abu Kaf, Saber Elaydi (Members).

Saudi Association for Mathematical Sciences*

Apply to: M. A. Alabdullatif, President, King Saud University, College of Science, P. O. Box 2455, Riyadh 11451, Saudi Arabia.

Dues: U.S. $30, payable to Saudi Association for Mathematical Sciences at the above address.

Privileges: Reduction in membership fee from U.S. $40 to U.S. $30; proceedings of conferences, symposia, and seminars arranged by the Association.

Officers: M. A. Alabdullatif (President), A. Alshihah (Vice-President), M. A. Aseerj (Treasurer), M. S. Qutaifan (Secretary).

South Pacific

Australian Mathematical Society Inc.

Address for mail: AustMS Business Office, Department of Mathematics, Australian National University, Canberra, ACT 0200, Australia; email: Secretary@austms.org.au; http://www.austms.org.au/.

Apply to: The Business Manager at the above address.

Dues: $AUD 55 (in 2009), payable to the Australian Mathematical Society, c/o The Business Manager, at the above address.

Privileges: Complimentary issues of *The Gazette* (five issues in 2009), *Journal AustMS–Pure Mathematics and Statistics* ($AUD 70), *ANZIAM Journal* ($AUD 60), *Bulletin of AustMS* ($AUD 66). Reduced price for volumes in Lecture Series and reduced registration at conferences sponsored by AustMS.

Officers: N. Joshi (President), P. G. Howlett and S. O. Warnaar (Vice-Presidents), A. Howe (Treasurer), E. J. Billington (Secretary).

New Zealand Mathematical Society

Address for mail: New Zealand Mathematical Society, c/o Dr. Winston Sweatman (NZMS Secretary), Institute of Information and Mathematical Sciences, Massey University at Albany, Private Bag 102904, North Shore 0745, Auckland, New Zealand; email: w.sweatman@massey.ac.nz; http://www.math.waikato.ac.nz/NZMS/NZMS.html.

Apply to: John Shanks, Department of Mathematics and Statistics, University of Otago, P.O. Box 56, Dunedin, New Zealand.

Dues: NZ$22.50 payable to John Shanks at above address.

Privileges: *Newsletter of the NZMS* (three per year).

Officers: Robert McLachlan (President), Charles Semple (Vice-President), Peter Donelan (Treasurer), Winston Sweatman (Secretary).

Mathematics Calendar

Please submit conference information for the Mathematics Calendar through the Mathematics Calendar submission form at http://www.ams.org/cgi-bin/mathcal-submit.pl.

The most comprehensive and up-to-date Mathematics Calendar information is available on the AMS website at http://www.ams.org/mathcal/.

November 2009

* 4–5 **Symposium on interdisciplinary approaches to calcium and secretory dynamics in cells: Mathematical models and experiments**, Universidad de Cantabria, Santander(Spain).
Description: The principal aim of the symposium is to promote the exchange of ideas among researchers, experimentalists and theoreticians, interested in the field of calcium and secretory dynamics in cells. Our goal is to cover secretory cell prototypes with very different time scales: from panchreatic cells (alpha, beta), as example of slow secretory cells, to presynaptic terminals. Our idea is, on one hand, to show similarities and differences regarding the basic mechanisms responsibles of triggering secretion in these cells; on the other hand, we plan to analyse the framework of the mathematical models describing these cellular processes.
Information: http://www.camath.unican.es/.

* 23–27 **Progress in Dynamics**, Institut Henri Poincaré, Paris, France.
Description: The conference will emphasize specific problems in dynamical systems, smooth ergodic theory, and related topics, including differential geometry, group theory and number theory, that have seen much progress, but where significant problems vital to the field remain open. Specific examples are the Katok entropy rigidity conjecture for geodesic flows of negatively curved manifolds, the Boltzmann ergodic hypothesis, Liouvillean phenomena, the construction of metrics with ergodic geodesic flow, smooth rigidity of actions of abelian groups of higher rank. The conference will provide a venue for established scholars to interact not only with each other, but also with the junior scholars who will play an essential role now and in the years to come. Limited support for participants is expected to be available. Recent recipients of doctoral degrees, women, and members of traditionally underrepresented groups are particularly encouraged to apply.
Information: http://www.math.psu.edu/katok_s/AK65/home.html.

December 2009

* 8–11 **Operators and Operator Algebras in Edinburgh**, University of Edinburgh, Scotland, U.K.
Confirmed speakers: C. Anantharaman-Delaroche (Orleans), W. Arendt (Ulm), E. Berkson (Illinois Champaign-Urbana), O. Blasco (Valencia), G. Brown (Royal Institution of Australia), M-J. Carro (Universitat de Barcelona), E. Christensen (Copenhagen), M. Cowling (Birmingham), A. M. Davie (Edinburgh), U. Haagerup (Odense), M. Junge (Illinois Champaign-Urbana), N. Kalton (Columbia, Missouri), N. Ozawa (Tokyo and UCLA), J. Parcet (CSIC & UA Madrid), J. Peterson (Vanderbilt), G. Pisier (Texas A&M and Paris VI), W. Ricker (KU Eichstaett), R. Smith (Texas A&M), J-L. Torrea (UA Madrid), S. Vaes (KU Leuven), A. Volberg (Michigan State), S. White (Glasgow).
Honorary Organisers: Alastair Gillespie and Allan. M. Sinclair.
Organisers: Tony Carbery, Ian Doust, Sandra Pott, Stuart White and Jim Wright
Information: http://www.maths.gla.ac.uk/~saw/ooae/.

This section contains announcements of meetings and conferences of interest to some segment of the mathematical public, including ad hoc, local, or regional meetings, and meetings and symposia devoted to specialized topics, as well as announcements of regularly scheduled meetings of national or international mathematical organizations. A complete list of meetings of the Society can be found on the last page of each issue.

An announcement will be published in the *Notices* if it contains a call for papers and specifies the place, date, subject (when applicable), and the speakers; a second announcement will be published only if there are changes or necessary additional information. Once an announcement has appeared, the event will be briefly noted in every third issue until it has been held and a reference will be given in parentheses to the month, year, and page of the issue in which the complete information appeared. Asterisks (*) mark those announcements containing new or revised information.

In general, announcements of meetings and conferences carry only the date, title of meeting, place of meeting, names of speakers (or sometimes a general statement on the program), deadlines for abstracts or contributed papers, and source of further information. If there is any application deadline with respect to participation in the meeting, this fact should be noted. All communications on meetings and conferences in the mathematical sciences should be sent to the Editor of the *Notices* in care of the American Mathematical Society in Providence or electronically to notices@ams.org or mathcal@ams.org.

In order to allow participants to arrange their travel plans, organizers of meetings are urged to submit information for these listings early enough to allow them to appear in more than one issue of the *Notices* prior to the meeting in question. To achieve this, listings should be received in Providence **eight months** prior to the scheduled date of the meeting.

The complete listing of the Mathematics Calendar will be published only in the September issue of the *Notices*. The March, June/July, and December issues will include, along with new announcements, references to any previously announced meetings and conferences occurring within the twelve-month period following the month of those issues. New information about meetings and conferences that will occur later than the twelve-month period will be announced once in full and will not be repeated until the date of the conference or meeting falls within the twelve-month period.

The Mathematics Calendar, as well as Meetings and Conferences of the AMS, is now available electronically through the AMS website on the World Wide Web. To access the AMS website, use the URL: http://www.ams.org/.

* 10–19 **International Workshop on Harmonic Mappings and Hyperbolic Metrics**, Indian Institute of Technology Madras, Chennai-600036, India
Description: The workshop aims to foster international cooperation in the area of Harmonic Mappings and Hyperbolic Metrics, and to motivate further interaction among Indian researchers with a wide range of function theorists from various other countries. The primary emphasis of the workshop will be on promoting collaborative research work involving all the potential participants. In the workshop the theme Harmonic Mappings and Hyperbolic Metrics will be introduced to participants through a series of lectures on this topic by globally renowned experts. There will be limited paper presentation sessions by participants and the accepted original papers will be considered for possible publication in the forthcoming volume of the Journal of Analysis.
Information: Visit: http://sites.google.com/site/iwhmhm09.

* 14–18 **Cycles and Special Values of L-series**, Centre de Recerca Matemàtica, UAB E-08193 Bellaterra, Barcelona, Spain.
Description: An interrelated web of conjectures, due, in rough chronological order, to Birch–Swinnerton-Dyer, Tate, Bloch–Beilinson, and Bloch–Kato, connects the arithmetic properties of algebraic cycles (taken modulo some relation, such as rational or algebraic equivalence) with the analytic properties of associated L-functions. The varieties for which we have the most explicit information are those that can be related to automorphic forms: Shimura varieties and their relatives. Studying these examples and exploiting their rich underlying structure has led to a fruitful interaction between arithmetic algebraic geometry and representation theory whose intensity shows no sign of abating.
Information: http://www.crm.cat/Activitats/Activitats/2009-2010/wklseries/web-wklseries/default.htm.

February 2010

* 26–28 **Texas Geometry and Topology Conference**, Texas Christian University, Fort Worth, TX.
Description: The Texas Geometry and Topology Conference (TGTC) has run twice a year since its inception in 1989. It currently rotates among six Texas universities, each conference featuring a broad array of internationally acclaimed speakers. More general details on the TGTC and its history can be found at http://www.math.tamu.edu/~tgtc/archive/. For details concerning the Spring 2010 conference, please visit our web site at http://faculty.tcu.edu/epark/TGTC.

* 22–March 5 **Arithmetic Geometry for Function Fields of Positive Characteristic**, Centre de Recerca Matemàtica, UAB, E-08193 Bellaterra, Barcelona, Spain.
Scientific Committee: Francesc Bars (Universitat Autònoma de Barcelona), Gebhard Böckle (Universität Duisburg-Essen), David Burns (King's College London), David Goss (Ohio State University at Columbus), Ignazio Longhi (National Taiwan University), Fabien Trihan (University of Nottingham), Xavier Xarles (Universitat Autònoma de Barcelona), Douglas Ulmer (University of Arizona).
Speakers: 1) Gebhard Böckle Universitaet Duisburg-Essen, Germany; 2) Douglas Ulmer University of Arizona, USA.
Information: http://www.crm.cat/Activitats/Activitats/2009-2010/acarithff/web-acarithff/default.asp.

March 2010

* 9–12 **Model and Data Hierarchies for Simulating and Understanding Climate: Tutorials**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, CA
Organizing Committee: Amy Braverman (Jet Propulsion Laboratory), Rupert Klein (Freie Universität Berlin, Mathematics), Bjorn Stevens (Max-Planck-Institut für Meteorologie).
Overview: Tutorials provide an introduction to the problems and concepts from mathematics, physics, atmospheric sciences, computer science, and other disciplines. The goal is to familiarize participants with the techniques, and to create a common language among researchers coming from different fields. The tutorials cover: Equation Hierarchies, Numerical Hierarchies, Simulation Hierarchies, Data Hierarchies.
Application/Registration: An application and registration form is available at http://www.ipam.ucla.edu/programs/cltut. Applications received by Jan. 11, 2010, will receive fullest consideration. Encouraging the careers of women and minority mathematicians and scientists is an important component of IPAM's mission and we welcome their applications. You may also simply register and attend without IPAM funding.

* 17–26 **Second International School on Geometry and Physics. Geometric Langlands and Gauge Theory**, Centre de Recerca Matemàtica, UAB, E-08193 Bellaterra, Barcelona,Spain.
Description: The geometric Langlands correspondence lies at the core of one of the most significant current interactions between geometry and physics, integrating far-reaching discoveries and conjectures originating in physics, geometry, representation theory and arithmetic. This advanced school is designed to deliver training on this interdisciplinary topic. It is targeted at graduate students, postdocs and researchers working in geometry and physics at an international level.
Information: http://www.crm.cat/Activitats/Activitats/2009-2010/aclanglands/web-aclanglands/.

April 2010

* 12–16 **Computer Security and Cryptography**, Centre de recherches mathématiques, Université de Montréal, Pavillon André-Aisenstadt, 2920, Chemin de la tour, room 5357, Montréal (Québec) H3T 1J4, Canada.
Description: Among the exciting new directions in cryptography that this one-week workshop will attempt to touch upon are the following: proliferating hardness assumptions and protocols in pairing-based cryptography; provable security and the random oracle model in theory and practice; design and selection of new cryptographic hash functions; new security models for deterministic encryption and searchable encryption; new number theoretic constructs in cryptography such as expander graphs, lattice-based systems, elliptic divisibility sequences, etc.; the trade-off between security and privacy in emerging applications such as cloud storage; new applications of pairings to areas such as e-cash and Attribute Based Encryption.
Information: http://www.crm.umontreal.ca/Crypto10/index_e.php.

* 14–18 **International Conference on Fundamental Structures of Algebra in honor of the 70th birthday of Professor Şerban Basarab**, Faculty of Mathematics and Computer Science, Ovidius University, Constanta, Romania.
Description: The Faculty of Mathematics and Computer Science from Ovidius University, Constantza, in cooperation with the Institute of Mathematics of the Romanian Academy (Bucharest) and the Romanian Mathematical Society will organize an International Conference on Fundamental Structures of Algebra to honor the 70th birthday of Professor Şerban Basarab, from the Romanian Institute of Mathematics. There will be talks from Thursday, April 15, through Saturday, April 17. Accommodation expenses will be covered by the local organizers for the invited speakers. We intend to have proceedings of the conference as well which will be published in our journal Analele Ştiinţifice ale Universităţii Ovidius, Seria Matematica (http://www.anstuocmath.ro/). For Registration please send an e-mail to Viviana Ene (vivian_ro@yahoo.com).
Last date for registration: March 10, 2010.
Conference fee: will be announced.
Information: http://www.univ-ovidius.ro/math/conference/70/index.htm.

May 2010

* 17–21 **AIM Workshop: Supercharacters and combinatorial Hopf algebras**, American Institute of Mathematics, Palo Alto, CA.

Description: This workshop, sponsored by AIM and the NSF, will bring together experts in the emerging area of supercharacter theory and experts in Hopf algebras.

Information: `http://aimath.org/ARCC/workshops/supercharacters.html`.

* 17–22 **Frobenius splitting in algebraic geometry, commutative algebra, and representation theory**, University of Michigan, Ann Arbor, MI.

Description: The goal of this conference is to bring together researchers working with different aspects of Frobenius splittings and their applications, and to facilitate communication and interaction between them. We plan to have a number of survey talks, introducing the various points of view on Frobenius splitting, followed by research talks. Most of the talks will be suitable for graduate students and young researchers.

Information: `http://sites.google.com/site/frobeniussplitting/`.

* 26–28 **International Conference on Computational Mathematics (ICCM) 2010 Workshop on Advances in Numerical Partial Differential Equations**, Holiday Inn Tobu Narita 320-1 TOKKO, CHIBA NARITA, CHIBA, 286-0106 JAPAN.

Description: International Conference on Computational Mathematics (ICCM), 2010 Workshop on Advances on Numerical PDEs May 26–28, 2010, Holiday Inn Tobu Narita, Tokyo, Japan

Organizer: Dr. Mohammad Siddique, Fayetteville State University, NC, USA. `http://faculty.uncfsu.edu/msiddiqu`.

Keynote Speakers: 1. Professor Chi-Wang Shu, Brown University, USA 2. Professor A. Q. M. Khaliq, Middle Tennessee State University, USA 3. Professor Vinod Arya, Fayetteville State University, USA 4. Professor Weizhu Bao, National University of Singapore, Singapore.

Information: `http://www.waset.org/conferences/2010/tokyo/iccm/`.

* 26–28 **Workshop in ICCM 2010 on Advances in Numerical Partial Differential Equations (NPDEs)**, Holiday Inn Tobu Narita 320-1 TOKKO, CHIBA NARITA, CHIBA, 286-0106 JAPAN.

Organizer: Dr. Mohammad Siddique, Department of Mathematics and Computer Science, Fayetteville State University, 1200 Murchison Road, Fayetteville, NC. 28301, USA

Information: `msiddiqu@uncfsu.edu` `http://faculty.uncfsu.edu/msiddiqu`.

For details please visit: 1. `http://www.waset.org/conferences/2010/tokyo/iccm/`; 2. `http://www.waset.org/conferences/2010/tokyo/iccm/npdes.pdf`.

* 27–28 **From A=B to Z=60, A Conference in Honor of Doron Zeilberger's 60th Birthday**, Rutgers University, Piscataway, New Jersey.

Description: On the occasion of Doron Zeilberger's 60th birthday we will honor his extraordinary research accomplishments and longstanding influence in mathematics. This international conference will be co-hosted by the Mathematics Department and the DIMACS Center at Rutgers University. In keeping with the breadth of Zeilberger's work, there will be speakers from a wide variety of fields that have been influenced and continue to be impacted by the power of his methods; to wit, Enumerative Combinatorics, Algebraic Combinatorics, and Algorithmic Proof Theory. We anticipate an exciting gathering of former and current students, collaborators, colleagues, and friends.

Information: `http://math.rutgers.edu/events/Z60/`.

June 2010

* 7–11 **AIM Workshop: Low-dimensional structures in dynamical systems with variable time lags**, American Institute of Mathematics, Palo Alto, CA.

Description: This workshop, sponsored by AIM and the NSF, will focus on low-(Hausdorff) dimensional structures in differential delay equations with state dependent time lags.

Information: `http://www.aimath.org/ARCC/workshops/variabletimelag.html`.

* 13–18 **48th International Symposium on Functional Equations**, Batz-sur-Mer , France.

Topics: Functional equations and inequalities, mean values, functional equations on algebraic structures, Hyers-Ulam stability, regularity properties of solutions, conditional functional equations, functional-differential equations, iteration theory; applications of the above, in particular to the natural, social, and behavioral sciences.

Local Organizer: Nicole Brillouët-Belluot, Département d'Informatique et de Mathématiques, Ecole Centrale de Nantes, 1 rue de la Noë, B.P. 92101, 44 321 Nantes-Cedex 3, France.

Information: `nicole.belluot@ec-nantes.fr`.

Scientific Committee: J. Aczél (Honorary Chair; Waterloo, ON, Canada), W. Benz (Honorary Member, Hamburg, Germany), Z. Daroczy (Honorary Member, Debrecen, Hungary), R. Ger (Chair; Katowice, Poland), Zs. Pales (Debrecen, Hungary), J. Rätz (Bern, Switzerland), L. Reich (Graz, Austria), and A. Sklar (Chicago, IL, USA).

Information: Participation at these annual meetings is by invitation only. Those wishing to be invited to this or one of the following meetings send details of their interest and, preferably, publications (paper copies) and/or manuscripts with their postal and e-mail address to: Roman Ger, Institute of Mathematics, Silesian University, Bankowa 14, PL-40-007 Katowice, Poland (`romanger@us.edu.pl`) before December 15, 2009.

* 16–23 **Budapest Semesters in Mathematics 25th Anniversary Reunion and Conference**, Budapest, Hungary.

Description: In celebration of its twenty-fifth year, Budapest Semesters in Mathematics will host a gala reunion and mathematics conference in Budapest for BSM alumni, mathematicians who wrote letters of recommendation for them, and those people who have supported the program over the past quarter century.

Information: `http://www.bsmath.hu/`.

July 2010

* 6–8 **Conference on Industrial and Applied Mathematics**, Bandung Institute of Technology, Bandung, Indonesia

Description: The conference is focused on the areas mostly covered in industrial and applied mathematics, such as Financial Mathematics, Optimization, Applied Probability, Control Theory and Its Application, Biological, Physical Modeling and Application of Mathematics in Sciences, Fluid Dynamics, Numerical Methods and Scientific Computing.

Information: `http://www.math.itb.ac.id/`.

August 2010

* 2–6 **Formal Power Series and Algebraic Combinatorics 2010**, San Francisco State University, San Francisco, CA, USA.

Description: The 22nd International Conference on Formal Power Series and Algebraic Combinatorics (FPSAC'10) will take place at San Francisco State University, August 2-6, 2010. Topics include all aspects of combinatorics and its connections with other areas of mathematics, physics, computer science, and biology. The conference will feature invited lectures, contributed presentations, a poster session, and software demonstrations. As usual, there will be no parallel sessions. The official languages of the conference are English, French, and Spanish. %For more information, please visit:

Information: `http://math.sfsu.edu/fpsac`.

* 14–17 **Satellite Conference of ICM 2010 on Mathematics in Science and Technology**, India Habitat Centre, Lodhi Road, New-Delhi, India.

Description: The conference will focus on emerging areas of mathematics applied to solve problems of Science and Technology. Representatives of 30 societies of the world which are members of the ICIAM have consented to attend and interact with the participants of the conference. This provides an ample opportunity for young scientists and engineers to meet and disscuss with world-class experts.

Information: `http://www.siam-india.org,www.icm2010.co.cc`.

* 16–19 **SIAM Conference on Nonlinear Waves and Coherent Structures (NW10)**, Sheraton Society Hill Hotel, Philadelphia, Pennsylvania.
Description: This conference is sponsored by the SIAM Activity Group on Nonlinear Waves and Coherent Structures.
Information: `http://www.siam.org/meetings/nw10/`.

September 2010

* 13–December 17 **Modern Trends in Optimization and Its Application**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles,CA.
Organizing Committee: Stephen Boyd (Stanford), Emmanuel Candes (Stanford), Masakazu Kojima (Tokyo Institute of Technology), Monique Laurent (CWI), Arkadi Nemirovski (Georgia Tech), Yurii Nesterov (Université Catholique de Louvain), Bernd Sturmfels (UC Berkeley), Michael Todd (Cornell), Lieven Vandenberghe (UCLA).
Overview: Developments in convex optimization problem, robust optimization, algorithms and more have expanded the scale and complexity of optimization problems, and are leading to a wider adoption of optimization techniques in many science and engineering fields. This program will focus on the development and application of these trends.
Application: An application form is available at: `http://www.ipam.ucla.edu/programs/op2010`. Applications for individual workshops will be posted on individual workshop home pages. Encouraging the careers of women and minority mathematicians and scientists is an important component of IPAM's mission and we welcome their applications.

The following new announcements will not be repeated until the criteria in the next to the last paragraph at the bottom of the first page of this section are met.

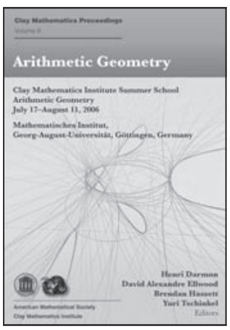
December 2010

* 29–31 **ICCAM 2010: "International Conference on Computational and Applied Mathematics", Symposium Partial Differential Equations: Modeling, Analysis and Numerical Methods**, First Hotel Bangkong, 2 Soi Somprasong 1, Petchaburi Road, Tanonphayathai, Rajthavee, Bangkok 10400 Thailand.
Description: The International Conference on Computational and Applied Mathematics aims to bring together academic scientists, leading engineers, industry researchers and scholar students to exchange and share their experiences and research results about all aspects of Computational and Applied Mathematics, and discuss the practical challenges encountered and the solutions adopted. SYMPOSIUM PARTIAL DIFFERENTIAL EQUATIONS (PDEs): MODELING, ANALYSIS AND NUMERICAL METHODS
Organizer: Dr. Mohammad Siddique, Department of Mathematics and Computer Science, Fayetteville State University, 1200 Murchison Road, Fayetteville, NC. 28301, USA. `e-mail: msiddiqu@uncfsu.edu`; `http://faculty.uncfsu.edu/msiddiqu`.
Important Dates Paper submission: August 31, 2010. Notification of acceptance: September 30, 2010.
Final paper submission & authors' registration: October 31, 2010
Conference Dates: December 29–31, 2010.
Information: `http://www.waset.org/conferences/2010/bangkok/iccam/`.

New Publications Offered by the AMS

To subscribe to email notification of new AMS publications, please go to http://www.ams.org/bookstore-email.

Algebra and Algebraic Geometry



Arithmetic Geometry

Henri Darmon, *McGill University, Montreal, Quebec, Canada*, **David Alexandre Ellwood**, *Clay Mathematics Institute, Cambridge, MA*, **Brendan Hassett**, *Rice University, Houston, TX*, and **Yuri Tschinkel**, *Courant Institute of Mathematical Sciences, New York University, NY*, Editors

This book is based on survey lectures given at the 2006 Clay Summer School on Arithmetic Geometry at the Mathematics Institute of the University of Göttingen. Intended for graduate students and recent Ph.D.'s, this volume will introduce readers to modern techniques and outstanding conjectures at the interface of number theory and algebraic geometry.

The main focus is rational points on algebraic varieties over non-algebraically closed fields. Do they exist? If not, can this be proven efficiently and algorithmically? When rational points do exist, are they finite in number and can they be found effectively? When there are infinitely many rational points, how are they distributed?

For curves, a cohesive theory addressing these questions has emerged in the last few decades. Highlights include Faltings' finiteness theorem and Wiles's proof of Fermat's Last Theorem. Key techniques are drawn from the theory of elliptic curves, including modular curves and parametrizations, Heegner points, and heights.

The arithmetic of higher-dimensional varieties is equally rich, offering a complex interplay of techniques including Shimura varieties, the minimal model program, moduli spaces of curves and maps, deformation theory, Galois cohomology, harmonic analysis, and automorphic functions. However, many foundational questions about the structure of rational points remain open, and research tends to focus on properties of specific classes of varieties.

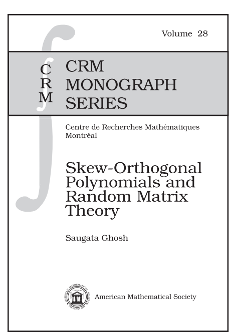
This item will also be of interest to those working in number theory.

Titles in this series are co-published with the Clay Mathematics Institute (Cambridge, MA).

Contents: **N. Elkies**, About the cover: Rational curves on a K3 surface; *Curves:* **H. Darmon**, Rational points on curves; **H. Chapdelaine**, Non-abelian descent and the generalized Fermat equation; **M. Rebolledo**, Merel's theorem on the boundedness of the torsion of elliptic curves; **P. Charollois**, Generalized Fermat equations (d'après Halberstadt-Kraus); **S. Dasgupta** and **J. Voight**, Heegner points and Sylvester's conjecture; **J. Voight**, Shimura curve computations; **M. Greenberg**, Computing Heegner points arising from Shimura curve parametrizations; **M. Greenberg**, The arithmetic of elliptic curves over imaginary quadratic fields and Stark-Heegner points; **Y. I. Manin**, Lectures on modular symbols; *Surfaces:* **B. Hassett**, Rational surfaces over nonclosed fields; **D. Harari**, Non-abelian descent; **B. G. Vioreanu**, Mordell-Weil problem for cubic surfaces, numerical evidence; *Higher-dimensional varieties:* **Y. Tschinkel**, Algebraic varieties with many rational points; **D. Abramovich**, Birational geometry for number theorists; **J. M. Starr**, Arithmetic over function fields; **N. Ratazzi** and **E. Ullmo**, Galois + Équidistribution = Manin-Mumford; **E. Ullmo** and **A. Yafaev**, The André-Oort conjecture for products of modular curves; **C.-L. Chai** and **F. Oort**, Moduli of abelian varieties and p-divisible groups; **D. Kaledin**, Cartier isomorphism and Hodge theory in the non-commutative case.

Clay Mathematics Proceedings, Volume 8

November 2009, 562 pages, Softcover, ISBN: 978-0-8218-4476-2, LC 2009027374, 2000 *Mathematics Subject Classification:* 14E30, 14G05, 14D10, **AMS members US$95**, List US$119, Order code CMIP/8



Skew-Orthogonal Polynomials and Random Matrix Theory

Saugata Ghosh, *Gurgaon, India*

Orthogonal polynomials satisfy a three-term recursion relation irrespective of the weight function with respect to which they are defined. This gives a simple formula for the kernel function, known in the literature as the Christoffel–Darboux sum. The availability of asymptotic results of orthogonal polynomials and the simple structure of the Christoffel–Darboux sum make the study of unitary ensembles of random matrices relatively straightforward.

In this book, the author develops the theory of skew-orthogonal polynomials and obtains recursion relations which, unlike orthogonal polynomials, depend on weight functions. After deriving reduced expressions, called the generalized Christoffel–Darboux formulas (GCD), he obtains universal correlation functions and non-universal level densities for a wide class of random matrix ensembles using the GCD.

The author also shows that once questions about higher order effects are considered (questions that are relevant in different branches of physics and mathematics) the use of the GCD promises to be efficient.

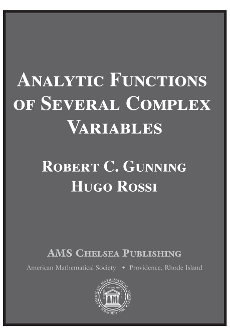
Titles in this series are co-published with the Centre de Recherches Mathématiques.

Contents: Introduction; Level density and correlation functions; The $S_{\mathbb{N}}^{(\beta)}(x,y)$ kernel and Christoffel–Darboux formulas; Mapping; Unitary ensembles; Orthogonal ensembles (even dimension); Orthogonal ensembles (odd dimension); Symplectic ensembles; Skew-orthogonal polynomials and differential systems; Matrix integral representations and zeros of polynomials; Duality; Conclusion; Appendix A. Proofs of (5.7), (5.12), and (5.19); Appendix B. Associated Laguerre and Gaussian results as limiting cases of Jacobi skew-orthogonal polynomials; Appendix C. Proofs of (10.2)–(10.9); Bibliography.

CRM Monograph Series, Volume 28

October 2009, 127 pages, Hardcover, ISBN: 978-0-8218-4878-4, LC 2009029006, 2000 *Mathematics Subject Classification:* 33-XX, 11Cxx, 26Cxx, 15-XX, **AMS members US$41**, List US$51, Order code CRMM/28

Analysis



Analytic Functions of Several Complex Variables

Robert C. Gunning, *Princeton University, NJ*, and **Hugo Rossi**, *University of Utah, Salt Lake City, UT*

The theory of analytic functions of several complex variables enjoyed a period of remarkable development in the middle part of the twentieth century. After initial successes by Poincaré and others in the late 19th and early 20th centuries, the theory encountered obstacles that prevented it from growing quickly into an analogue of the theory for functions of one complex variable. Beginning in the 1930s, initially through the work of Oka, then H. Cartan, and continuing with the work of Grauert, Remmert, and others, new tools were introduced into the theory of several complex variables that resolved many of the open problems and fundamentally changed the landscape of the subject. These tools included a central role for sheaf theory and increased uses of topology and algebra. The book by Gunning and Rossi was the first of the modern era of the theory of several complex variables, which is distinguished by the use of these methods.

The intention of Gunning and Rossi's book is to provide an extensive introduction to the Oka-Cartan theory and some of its applications, and to the general theory of analytic spaces. Fundamental concepts and techniques are discussed as early as possible. The first chapter covers material suitable for a one-semester graduate course, presenting many of the central problems and techniques, often in special cases. The later chapters give more detailed expositions of sheaf theory for analytic functions and the theory of complex analytic spaces.

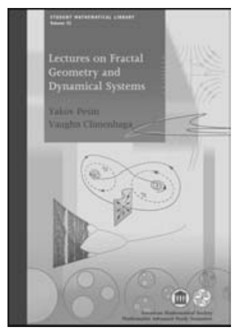
Since its original publication, this book has become a classic resource for the modern approach to functions of several complex variables and the theory of analytic spaces.

This item will also be of interest to those working in geometry and topology.

Contents: Holomorphic functions; Local rings of holomorphic functions; Varieties; Analytic sheaves; Analytic spaces; Cohomology theory; Stein spaces, geometric theory; Stein spaces, sheaf theory; Pseudoconvexity; Partitions of unity; The theorem of Schwartz on Frechet spaces; References; Bibliography; Index.

AMS Chelsea Publishing, Volume 368

December 2009, 317 pages, Hardcover, ISBN: 978-0-8218-2165-7, LC 2009025418, 2000 *Mathematics Subject Classification:* 32C15, 32C22, 32C35, 32Exx, 32Q28, **AMS members US$45**, List US$50, Order code CHEL/368.H



Lectures on Fractal Geometry and Dynamical Systems

Yakov Pesin and **Vaughn Climenhaga**, *Pennsylvania State University, University Park, PA*

Both fractal geometry and dynamical systems have a long history of development and have provided fertile ground for many great mathematicians and much deep and important mathematics. These two areas interact with each other and with the theory of chaos in a fundamental way: many dynamical systems (even some very simple ones) produce fractal sets, which are in turn a source of irregular "chaotic" motions in the system. This book is an introduction to these two fields, with an emphasis on the relationship between them.

The first half of the book introduces some of the key ideas in fractal geometry and dimension theory—Cantor sets, Hausdorff dimension, box dimension—using dynamical notions whenever possible, particularly one-dimensional Markov maps and symbolic dynamics. Various techniques for computing Hausdorff dimension are shown, leading to a discussion of Bernoulli and Markov measures and of the relationship between dimension, entropy, and Lyapunov exponents.

In the second half of the book some examples of dynamical systems are considered and various phenomena of chaotic behaviour are discussed, including bifurcations, hyperbolicity, attractors, horseshoes, and intermittent and persistent chaos. These phenomena are naturally revealed in the course of our study of two real models from science—the FitzHugh–Nagumo model and the Lorenz system of differential equations.

This book is accessible to undergraduate students and requires only standard knowledge in calculus, linear algebra, and differential equations. Elements of point set topology and measure theory are introduced as needed.

This book is a result of the MASS course in analysis at Penn State University in the fall semester of 2008.

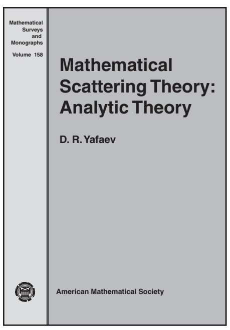
This item will also be of interest to those working in differential equations.

This volume is published in cooperation with the Mathematics Advanced Study Semesters.

Contents: Basic concepts and examples; Fundamentals of dimension theory; Measures: definitions and examples; Measures and dimensions; Discrete-time systems: the FitzHugh–Nagumo model; The bifurcation diagram for the logistic map; Chaotic attractors and persistent chaos; Horseshoes and intermittent chaos; Continuous-time systems: the Lorenz model; Appendix; Hints to selected exercises; Suggested reading; Bibliography; Index.

Student Mathematical Library, Volume 52

December 2009, approximately 324 pages, Softcover, ISBN: 978-0-8218-4889-0, LC 2009028324, 2000 *Mathematics Subject Classification:* 37-01, 37C45; 37B10, 37D20, 37E05, **AMS members US$41**, List US$51, Order code STML/52



Mathematical Scattering Theory
Analytic Theory

D. R. Yafaev, *Université Rennes 1, France*

The main subject of this book is applications of methods of scattering theory to differential operators, primarily the Schrödinger operator.

There are two different trends in scattering theory for differential operators. The first one relies on the abstract scattering theory. The second one is almost independent of it. In this approach the abstract theory is replaced by a concrete investigation of the corresponding differential equation. In this book both of these trends are presented. The first half of this book begins with the summary of the main results of the general scattering theory of the previous book by the author, *Mathematical Scattering Theory: General Theory*, American Mathematical Society, 1992. The next three chapters illustrate basic theorems of abstract scattering theory, presenting, in particular, their applications to scattering theory of perturbations of differential operators with constant coefficients and to the analysis of the trace class method.

In the second half of the book direct methods of scattering theory for differential operators are presented. After considering the one-dimensional case, the author returns to the multi-dimensional problem and discusses various analytical methods and tools appropriate for the analysis of differential operators, including, among others, high- and low-energy asymptotics of the Green function, the scattering matrix, ray and eikonal expansions.

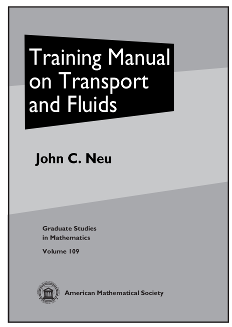
The book is based on graduate courses taught by the author at Saint-Petersburg (Russia) and Rennes (France) Universities and is oriented towards a reader interested in studying deep aspects of scattering theory (for example, a graduate student in mathematical physics).

Contents: Basic notation; Introduction; Basic concepts; Smooth theory. The Schrödinger operator; Smooth theory. General differential operators; Scattering for perturbations of trace class type; Scattering on the half-line; One-dimensional scattering; The limiting absorption principle (LAP), the radiation conditions and the expansion theorem; High- and lower-energy asymptotics; The scattering matrix (SM) and the scattering cross section; The spectral shift function and trace formulas; The Schrödinger operator with a long-range potential; The LAP and radiation estimates revisited; Review of the literature; Bibliography; Index.

Mathematical Surveys and Monographs, Volume 158

December 2009, approximately 445 pages, Hardcover, ISBN: 978-0-8218-0331-8, LC 2009027382, 2000 *Mathematics Subject Classification:* 34L25, 35-02, 35P10, 35P25, 47A40, 81U05, **AMS members US$88**, List US$110, Order code SURV/158

Applications



Training Manual on Transport and Fluids

John C. Neu, *University of California, Berkeley, CA*

I have learned a lot from John Neu over the past years, and his book reflects very well his sense of style and purpose.

*—**Walter Craig, McMaster University, Hamilton, Ontario, Canada and Fields Institute for Research in Mathematical Sciences, Toronto, Ontario, Canada***

This book presents elementary models of transport in continuous media and a corresponding body of mathematical technique. Physical topics include convection and diffusion as the simplest models of transport; local conservation laws with sources as the general framework of continuum mechanics; ideal fluid as the simplest model of a medium with mass; momentum and energy transport; and finally, free surface waves, in particular, shallow water theory.

There is a strong emphasis on dimensional analysis and scaling. Some topics, such as physical similarity and similarity solutions, are traditional. In addition, there are reductions based on scaling, such as incompressible flow as a limit of compressible flow, and shallow water theory derived asymptotically from the full equations of free surface waves. More and deeper examples are presented as problems, including a series of problems that model a tsunami approaching the shore.

The problems form an embedded subtext to the book. Each problem is followed by a detailed solution emphasizing process and craftsmanship. The problems express the practice of applied mathematics as the examination and re-examination of simple but essential ideas in many interrelated examples.

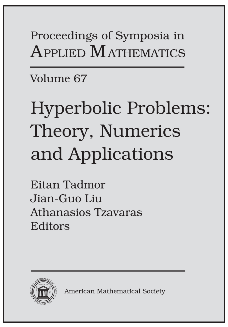
This item will also be of interest to those working in differential equations.

Contents: *Transport processes: The basic prototypes:* Convection; Diffusion; Local conservation laws; *Superposition:* Superposition of point source solutions; δ-functions; *Scaling-based reductions in* *basic fluid mechanics:* Ideal fluid mechanics; Free surface waves; Solution of the shallow water equations; Bibliography; Index.

Graduate Studies in Mathematics, Volume 109

January 2010, approximately 269 pages, Hardcover, ISBN: 978-0-8218-4083-2, 2000 *Mathematics Subject Classification:* 35-XX, 44-XX, 76-XX, **AMS members US$47**, List US$59, Order code GSM/109

Differential Equations



Hyperbolic Problems: Theory, Numerics and Applications

Eitan Tadmor, *University of Maryland, College Park, MD*, **Jian-Guo Liu**, *Duke University, Durham, NC, and University of Maryland, College Park, MD*, and **Athanasios E. Tzavaras**, *University of Maryland, College Park, MD, and University of Crete, Heraklion, Greece*, Editors

The International Conference on Hyperbolic Problems: Theory, Numerics and Applications, "HYP2008", was held at the University of Maryland from June 9–14, 2008. This was the twelfth meeting in the bi-annual international series of HYP conferences which originated in 1986 at Saint-Etienne, France, and over the last twenty years has become one of the highest quality and most successful conference series in Applied Mathematics.

The articles in this two-part volume are written by leading researchers as well as promising young scientists and cover a diverse range of multi-disciplinary topics addressing theoretical, modeling and computational issues arising under the umbrella of "hyperbolic PDEs".

This volume will bring readers to the forefront of research in this most active and important area in applied mathematics.

This item will also be of interest to those working in applications.

Contents: Part I: *List of plenary talks:* **S. Benzoni-Gavage** and **J.-F. Coulombel**, Multidimensional shock waves and surface waves; **G.-Q. Chen** and **M. Feldman**, Shock reflection-diffraction phenomena and multidimensional conservation laws; **S. Chen**, Study on Mach reflection and Mach configuration; **F. Golse**, Nonlinear regularizing effect for conservation laws; **S. Jin**, Numerical methods for hyperbolic systems with singular coefficients: Well-balanced scheme, Hamiltonian preservation, and beyond; **A. Kiselev**, Some recent results on the critical surface quasi-geostrophic equation: A review; **B. Perthame**, Why hyperbolic and kinetic models for cell populations self-organization?; **B. Piccoli**, Flows on networks and complicated domains; *Invited talks:* **D. Amadori** and **A. Corli**, Global solutions for a hyperbolic model of multiphase flow; **F. Ancona** and **A. Marson**, On the convergence rate for the Glimm scheme; **W. Bao** and **F. Y. Lim**, Analysis and computation for the semiclassical limits of the ground and excited states of the Gross-Pitaevskii equation; **G.-Q. Chen**, **M. Slemrod**, and **D. Wang**, Conservation laws: Transonic flow and differential geometry; **C. Christoforou**, A survey on the L^1 comparison of entropy weak solutions to Euler equations in the large with respect to physical parameters; **P. D'Ancona**, **D. Foschi**, and **S. Selberg**, Low regularity solutions of the Maxwell-Dirac system; **A. Dedner** and **R. Klöfkorn**, Stabilization for discontinuous Galerkin methods applied to systems of conservation laws; **C. De Lellis**, Ill-posedness for bounded admissible solutions of the 2-dimensional p-system; **D. Donatelli** and **P. Marcati**, Applications of dispersive estimates to the acoustic pressure waves for incompressible fluid problems; **P. G. LeFloch**, Stability in the L^1 norm via a linearization method for nonlinear hyperbolic systems; **S. Nishibata** and **M. Suzuki**, A review of semiconductor models: Global solvability and hierarchy; Index; **Part II:** *Contributed talks:* **G. Alberti**, **S. Bianchini**, and **G. Crippa**, Two-dimensional transport equation with Hamiltonian vector fields; **A. C. Alvarez**, **G. Hime**, and **D. Marchesin**, Analytic regularization of an inverse problem for a system of conservation laws; **P. Antonelli** and **P. Marcati**, On the finite weak solutions to a system in quantum fluid dynamics; **K. C. Assi** and **M. Laforest**, Accuracy of modeling error estimates for discrete velocity models; **A. V. Azevedo**, **A. P. de Souza**, **F. Furtado**, and **D. Marchesin**, The Riemann solution for three-phase flow in a porous medium; **J. Balbás** and **X. Qian**, Non-oscillatory central schemes for 3D hyperbolic conservation laws; **J. Benz**, **A. Meister**, and **P. A. Zardo**, A conservative, positivity preserving scheme for advection-diffusion-reaction equations in biochemical applications; **S. Berres** and **T. Voitovich**, On the spectrum of a rank two modification of a diagonal matrix for linearized fluxes modelling polydisperse sedimentation; **S. Bianchini** and **L. V. Spinolo**, Invariant manifolds for viscous profiles of a class of mixed hyperbolic-parabolic systems; **P. Birken** and **A. Jameson**, Nonlinear iterative solvers for unsteady Navier-Stokes equations; **F. Bouchut**, **C. Klingenberg**, and **K. Waagan**, An approximate Riemann solver for ideal MHD based on relaxation; **R. Bürger**, **A. Coronel**, and **M. Sepúlveda**, Numerical solution of an inverse problem for a scalar conservation law modelling sedimentation; **R. Bürger**, **K. H. Karlsen**, and **J. D. Towers**, A conservation law with discontinuous flux modelling traffic flow with abruptly changing road surface conditions; **M. J. Castro-Diaz**, **P. G. LeFloch**, **M. L. Muñoz-Ruiz**, and **C. 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Hattori**, Viscous conservation laws with discontinuous initial data; **G. Hime** and **V. Matos**, Parallel computation of large amplitude shocks for a system of conservation laws with small data; **H. Holden**, **N. H. Risebro**, and **H. Sande**, Convergence of front tracking and the Glimm scheme for a model of the flow of immiscible gases; **X. Hu** and **D. Wang**, Global existence and incompressible limit of weak solutions to the multi-dimensional compressible magnetohydrodynamics; **H. K. Jenssen** and **I. A. Kogan**, Construction of conservative systems; **E. A. Johnson** and **J. A. Rossmanith**, Collisionless magnetic reconnection in a five-moment two-fluid electron-positron plasma; **M. Jradeh**, Finite difference scheme for a nonlinear damped wave equation derived from brain modulation; **K. H. Karlsen** and **T. K. Karper**, Convergent finite element methods for compressible barotropic Stokes systems; **S. Karni** and **G. Hernández-Dueñas**, A hybrid scheme for flows in porous media; **F. Kemm**, Discrete involutions, resonance, and the divergence problem in MHD; **J. Kim** and **R. J. LeVeque**, Two-layer shallow water system and its applications; **W. J. Lambert** and **D. Marchesin**, Asymptotic rarefaction waves for balance laws with stiff sources; **R. Liska**, **R. Loubère**, **P.-H. Maire**, **J. Briel**, **S. Galera**, and **P. Váchal**, Comparison of staggered and cell-centered Lagrangian and ALE hydrodynamical methods; **M. Lukáčová-Medviďová** and **E. Tadmor**, On the entropy stability of Roe-type finite volume methods; **A. Madrane** and **E. Tadmor**, Entropy stability of Roe-type upwind finite volume methods on unstructured grids; **F. Marche** and **C. Berthon**, A robust high order VFRoe scheme for shallow water equations; **S. Mishra** and **E. Tadmor**, Vorticity preserving schemes using potential-based fluxes for the system wave equation; **T. Nakamura** and **S. 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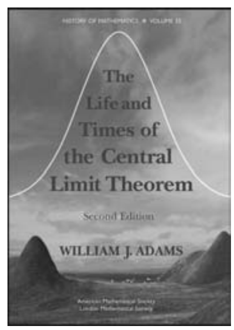
Proceedings of Symposia in Applied Mathematics, Volume 67

Part 1: December 2009, approximately 351 pages, Hardcover, ISBN: 978-0-8218-4729-9, LC 2009023286, 2000 *Mathematics Subject Classification:* 35Lxx, 35M10, 35Q30, 35Q60, 35R35, 65Mxx, 65Nxx, 65Txx, 65Yxx, 65Z05, 74B20, 74Jxx, 76Rxx, 76Txx, 80A32, 80Mxx, 83F05, **AMS members US$71**, List US$89, Order code PSAPM/67.1

Part 2: December 2009, approximately 671 pages, Hardcover, ISBN: 978-0-8218-4730-5, LC 2009023286, 2000 *Mathematics Subject Classification:* 35Lxx, 35M10, 35Q30, 35Q60, 35R35, 65Mxx, 65Nxx, 65Txx, 65Yxx, 65Z05, 74B20, 74Jxx, 76Rxx, 76Txx, 80A32, 80Mxx, 83F05, **AMS members US$127**, List US$159, Order code PSAPM/67.2

Set: December 2009, approximately 1022 pages, Hardcover, ISBN: 978-0-8218-4728-2, LC 2009023286, 2000 *Mathematics Subject Classification:* 35Lxx, 35M10, 35Q30, 35Q60, 35R35, 65Mxx, 65Nxx, 65Txx, 65Yxx, 65Z05, 74B20, 74Jxx, 76Rxx, 76Txx, 80A32, 80Mxx, 83F05, **AMS members US$178**, List US$223, Order code PSAPM/67

General and Interdisciplinary



The Life and Times of the Central Limit Theorem

Second Edition

William J. Adams, *Pace University, New York, NY*

About the First Edition:

The study of any topic becomes more meaningful if one also studies the historical development that resulted in the final theorem. …This is an excellent book on mathematics in the making.

—Philip Peak, ***The Mathematics Teacher***, May, 1975

I find the book very interesting. It contains valuable information and useful references. It can be recommended not only to historians of science and mathematics but also to students of probability and statistics.

—Wei-Ching Chang, ***Historica Mathematica***, August, 1976

In the months since I wrote…I have read it from cover to cover at least once and perused it here and there a number of times. I still find it a very interesting and worthwhile contribution to the history of probability and statistics.

—Churchill Eisenhart, past president of the American Statistical Association, in a letter to the author, February 3, 1975

The name *Central Limit Theorem* covers a wide variety of results involving the determination of necessary and sufficient conditions under which sums of independent random variables, suitably standardized, have cumulative distribution functions close to the Gaussian distribution. As the name Central Limit Theorem suggests, it is a centerpiece of probability theory which also carries over to statistics.

Part One of *The Life and Times of the Central Limit Theorem, Second Edition* traces its fascinating history from seeds sown by Jacob Bernoulli to use of integrals of $\exp(x^2)$ as an approximation tool, the development of the theory of errors of observation, problems in mathematical astronomy, the emergence of the hypothesis of elementary errors, the fundamental work of Laplace, and the emergence of an abstract Central Limit Theorem through the work of Chebyshev, Markov and Lyapunov. This closes the classical period of the life of the Central Limit Theorem, 1713–1901.

The second part of the book includes papers by Feller and Le Cam, as well as comments by Doob, Trotter, and Pollard, describing the modern history of the Central Limit Theorem (1920–1937), in particular through contributions of Lindeberg, Cramér, Lévy, and Feller.

The Appendix to the book contains four fundamental papers by Lyapunov on the Central Limit Theorem, made available in English for the first time.

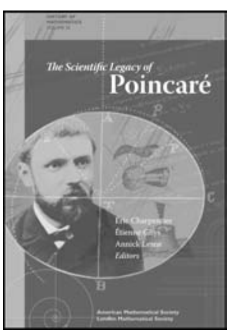
This item will also be of interest to those working in probability.

Co-published with the London Mathematical Society beginning with Volume 4. Members of the LMS may order directly from the AMS at the AMS member price. The LMS is registered with the Charity Commissioners.

Contents: *Early life and middle years:* A seed is sown; Approximation by integrals of e^{-x^2}; Impetus provided by the theory of errors of observation; Impetus provided by mathematical astronomy; The flowering of the central limit theorem begins; The development of the hypothesis of elementary errors; The emergence of an abstract central limit theorem; Chebyshev's pupils: A. A. Markov and A. M. Lyapunov; Bibliography; *The modern era:* W. Feller, The fundamental limit theorems in probability; L. Le Cam, The central limit theorem around 1935; H. F. Trotter, J. L. Doob, David Pollard, and L. Le Cam, Comments and rejoinder; *Appendix:* A. M. Lyapunov, On a theorem in probability theory; A. M. Lyapunov, On a theorem in probability theory; A. M. Lyapunov, A general proposition in probability theory; A. M. Lyapunov, A new form of a theorem on the limit of a probability; Index.

History of Mathematics, Volume 35

November 2009, approximately 195 pages, Hardcover, ISBN: 978-0-8218-4899-9, LC 2009022932, 2000 *Mathematics Subject Classification:* 60-03; 01A50, 01A55, 01A60, 60F05, **AMS members US$42**, List US$53, Order code HMATH/35



The Scientific Legacy of Poincaré

Éric Charpentier, *Université Bordeaux 1, Talence, France*, **Étienne Ghys**, *École Normale Supérieure de Lyon, France*, and **Annick Lesne**, *Université Pierre et Marie Curie, Paris, France*, Editors

Translated by Joshua Bowman

Henri Poincaré (1854–1912) was one of the greatest scientists of his time, perhaps the last one to have mastered and expanded almost all areas in mathematics and theoretical physics. He created new mathematical branches, such as algebraic topology, dynamical systems, and automorphic functions, and he opened the way to complex analysis with several variables and to the modern approach to asymptotic expansions. He revolutionized celestial mechanics, discovering deterministic chaos. In physics, he is one of the fathers of special relativity, and his work in the philosophy of sciences is illuminating.

For this book, about twenty world experts were asked to present one part of Poincaré's extraordinary work. Each chapter treats one theme, presenting Poincaré's approach, and achievements, along with examples of recent applications and some current prospects. Their contributions emphasize the power and modernity of the work of Poincaré, an inexhaustible source of inspiration for researchers, as illustrated by the Fields Medal awarded in 2006 to Grigori Perelman for his proof of the Poincaré conjecture stated a century before.

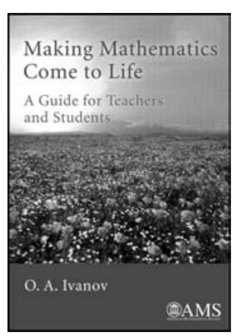
This book can be read by anyone with a master's (even a bachelor's) degree in mathematics, or physics, or more generally by anyone who likes mathematical and physical ideas. Rather than presenting detailed proofs, the main ideas are explained, and a bibliography is provided for those who wish to understand the technical details.

Co-published with the London Mathematical Society beginning with Volume 4. Members of the LMS may order directly from the AMS at the AMS member price. The LMS is registered with the Charity Commissioners.

Contents: E. Ghys, Poincaré and his disk; **N. Bergeron**, Differential equations with algebraic coefficients over arithmetic manifolds; **E. Kowalski**, Poincaré and analytic number theory; **J.-P. Françoise**, The theory of limit cycles; **D. Cerveau**, Singular points of differential equations: On a theorem of Poincaré; **M. Nauenberg**, Periodic orbits of the three body problem: Early history, contributions of Hill and Poincaré, and some recent developments; **N. Anantharaman**, On the existence of closed geodesics; **F. Béguin**, Poincaré's memoir for the Prize of King Oscar II: Celestial harmony entangled in homoclinic intersections; **E. Ghys**, Variations on Poincaré's recurrence theorem; **G. Boffetta**, **G. Lacorata**, and **A. Vulpiani**, Low-dimensional chaos and asymptotic time behavior in the mechanics of fluids; **A. Yger**, The concept of "residue" after Poincaré: Cutting across all of mathematics; **L. Bessières**, **G. Besson**, and **M. Boileau**, The proof of the Poincaré conjecture, according to Perelman; **J. Mawhin**, Henri Poincaré and the partial differential equations of mathematical physics; **P. Cartier**, Poincaré's *calculus of probabilities*; **M. M. France**, Poincaré and geometric probability; **P.-P. Grivel**, Poincaré and Lie's third theorem; **M. Le Bellac**, The Poincaré group; **Y. Pomeau**, Henri Poincaré as an applied mathematician; **G. Heinzmann**, Henri Poincaré and his thoughts on the philosophy of science.

History of Mathematics, Volume 36

January 2010, approximately 396 pages, Hardcover, ISBN: 978-0-8218-4718-3, LC 2009027575, 2000 *Mathematics Subject Classification:* 30F35, 34C07, 37N05, 53C22, 32A27, 57M40, 16S30, 83A05, 00A30, 35J05, 01A60, **AMS members US$71**, List US$89, Order code HMATH/36



Making Mathematics Come to Life

A Guide for Teachers and Students

O. A. Ivanov, *Steklov Institute of Mathematics, St. Petersburg, Russia*

"It is difficult to define the genre of the book. It is not a problem book, nor a textbook, nor a 'book for reading about mathematics'. It is most of all reminiscent of a good lecture course, from which a thoughtful student comes away with more than was actually spoken about in the lectures."

—from the Preface by A. S. Merkurjev

If you are acquainted with mathematics at least to the extent of a standard high school curriculum and like it enough to want to learn more, and if, in addition, you are prepared to do some serious work, then you should start studying this book.

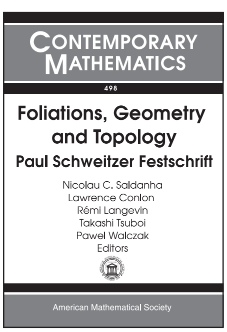
An understanding of the material of the book requires neither a developed ability to reason abstractly nor skill in using the refined techniques of mathematical analysis. In each chapter elementary problems are considered, accompanied by theoretical material directly related to them. There are over 300 problems in the book, most of which are intended to be solved by the reader. In those places in the book where it is natural to introduce concepts outside the high school syllabus, the corresponding definitions are given with examples. And in order to bring out the meaning of such concepts clearly, appropriate (but not too many) theorems are proved concerning them.

Unfortunately, what is sometimes studied at school under the name "mathematics" resembles real mathematics not any closer than a plucked flower gathering dust in a herbarium or pressed between the pages of a book resembles that same flower in the meadow besprinkled with dewdrops sparkling in the light of the rising sun.

Contents: Introduction; Induction; Combinatorics; The whole numbers; Geometric transformations; Inequalities; Graphs; The pigeonhole principle; Complex numbers and polynomials; Rational approximations; Mathematics and the computer; Instead of a conclusion: teaching how to look for solutions of problems, or fantasy in the manner of Pólya; Solutions of the supplementary problems.

December 2009, approximately 326 pages, Hardcover, ISBN: 978-0-8218-4808-1, LC 2009025419, 2000 *Mathematics Subject Classification:* 00A05; 00A35, **AMS members US$55**, List US$69, Order code MBK/61

Geometry and Topology



Foliations, Geometry, and Topology

Paul Schweitzer Festschrift

Nicolau C. Saldanha, *Pontificia Universidade Catolica, Rio de Janeiro, Brazil*, **Lawrence Conlon**, *Washington University, St. Louis, MO*, **Rémi Langevin**, *Université de Bourgogne, Dijon, France*, **Takashi Tsuboi**, *University of Tokyo, Japan*, and **Paweł Walczak**, *University of Lodz, Poland*, Editors

This volume represents the proceedings of the conference on Foliations, Geometry, and Topology, held August 6–10, 2007, in Rio de Janeiro, Brazil, in honor of the 70th birthday of Paul Schweitzer. The papers concentrate on the theory of foliations and related areas such as dynamical systems, group actions on low dimensional manifolds, and geometry of hypersurfaces.

There are survey papers on classification of foliations and their dynamical properties, including codimension one foliations with Bott–Morse singularities. Other papers involve the relationship of foliations with characteristic classes, contact structures, and Eliashberg–Mishachev wrinkled mappings.

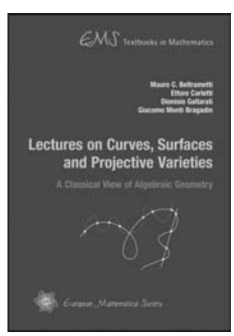
Contents: S. Hurder, Classifying foliations; **T. Tsuboi**, Classifying spaces for groupoid structures; **B. Scárdua** and **J. Seade**, Compact foliations with Bott-Morse singularities; **G. Hector** and **M. A. Chaouch**, Dynamiques Source-Puits et Flots transversalement affines; **J. L. Arraut** and **C. Maquera**, Structurally stable singular actions of $\mathbb{R}^2$ having a first integral; **S. Matsumoto**, The parameter rigid flows on orientable 3-manifolds; **D. Calegari**, The Euler class of planar groups; **Y. Matsuda**, Global fixed points for groups of homeomorphisms of the circle; **P. G. Walczak**, Orthogonal total foliations: Godbillon-Vey forms via local conformal invariants; **F. J. Andrade**, **J. L. M. Barbosa**, and **J. H. S. de Lira**, Prescribed mean curvature hypersurfaces in warped products; **H. Kodama**, **Y. Mitsumatsu**, **S. Miyoshi**, and **A. Mori**, On Thurston's inequality for spinnable foliations; **S. Miyoshi** and **A. Mori**, Reeb components and Thurston's inequality; **Y. M. Eliashberg** and **N. M. Mishachev**, Wrinkled embeddings.

Contemporary Mathematics, Volume 498

November 2009, 232 pages, Softcover, ISBN: 978-0-8218-4628-5, LC 2009018764, 2000 *Mathematics Subject Classification:* 57R30, 53C12, **AMS members US$63**, List US$79, Order code CONM/498

New AMS-Distributed Publications

Algebra and Algebraic Geometry



Lectures on Curves, Surfaces and Projective Varieties

A Classical View of Algebraic Geometry

Mauro C. Beltrametti, **Ettore Carletti**, **Dionisio Gallarati**, and **Giacomo Monti Bragadin**, *University of Genova, Italy*

Translated from the Italian by Francis Sullivan

This book offers a wide-ranging introduction to algebraic geometry along classical lines. It consists of lectures on topics in classical algebraic geometry, including the basic properties of projective algebraic varieties, linear systems of hypersurfaces, algebraic curves (with special emphasis on rational curves), linear series on algebraic curves, Cremona transformations, rational surfaces, and notable examples of special varieties like the Segre, Grassmann, and Veronese varieties. An integral part and special feature of the presentation is the inclusion of many exercises, not easy to find in the literature and almost all with complete solutions.

The text is aimed at students in the last two years of an undergraduate program in mathematics. It contains some rather advanced topics suitable for specialized courses at the advanced undergraduate or beginning graduate level, as well as interesting topics for a senior thesis. The prerequisites have been deliberately limited to basic elements of projective geometry and abstract algebra. Thus, for example, some knowledge of the geometry of subspaces and properties of fields is assumed.

The book will be welcomed by teachers and students of algebraic geometry who are seeking a clear and panoramic path leading from the basic facts about linear subspaces, conics and quadrics to a systematic discussion of classical algebraic varieties and the tools needed to study them. The text provides a solid foundation for approaching more advanced and abstract literature.

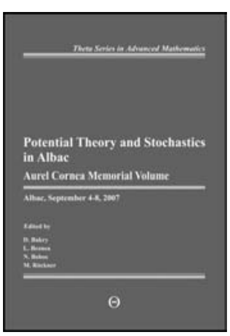
A publication of the European Mathematical Society (EMS). Distributed within the Americas by the American Mathematical Society.

Contents: Prerequisites; Algebraic sets, morphisms, and rational maps; Geometric properties of algebraic varieties; Rudiments of elimination theory; Hypersurfaces in projective space; Linear systems; Algebraic curves; Linear series on algebraic curves; Cremona transformations; Rational surfaces; Segre varieties; Grassmann varieties; Supplementary exercises; Bibliography; Index.

EMS Textbooks in Mathematics, Volume 9

August 2009, 506 pages, Hardcover, ISBN: 978-3-03719-064-7, 2000 *Mathematics Subject Classification:* 14-01, 14E05, 14E07, 14H50, 14J26, 14J70, 14M99, 14N05, **AMS members US$62**, List US$78, Order code EMSTEXT/9

Analysis



Potential Theory and Stochastics in Albac

Aurel Cornea Memorial Volume

Dominique Bakry, *Université Paul Sabatier, Toulouse, France*, **Lucian Beznea**, *Romanian Academy, Institute of Mathematics, Bucharest, Romania*, **Nicu Boboc**, *University of Bucharest, Romania*, and **Michael Röckner**, *Bielefeld University, Germany*, Editors

This volume contains the proceedings of the Potential Theory and Stochastics Conference, which was held in Albac, Romania, from September 4 to 8, 2007. It is also intended as a memorial volume for Aurel Cornea. Besides a presentation of the life and work of Aurel Cornea, it includes twenty refereed papers of the participants, covering the main topics of the conference: geometric aspects in potential theory, Dirichlet structures and stochastic analysis, potential theoretical methods for the analysis of infinite dimensional processes, stochastic partial differential equations, non-linear partial differential equations and potential theory.

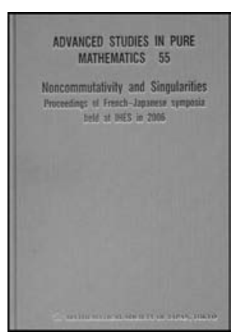
This item will also be of interest to those working in probability.

A publication of the Theta Foundation. Distributed worldwide, except in Romania, by the AMS.

Contents: D. Bakry, **F. Baudoin**, **M. Bonnefont**, and **B. Qian**, Subelliptic Li–Yau estimates on three dimensional spaces; **V. Barbu**, **P. Blanchard**, **G. Da Prato**, and **M. Röckner**, Self-organized criticality via stochastic partial differential equations; **K. Ben Ali** and **M. Bezzarga**, On a nonhomogenous quasilinear problem in Sobolev spaces with variable exponent; **M. Biroli**, Γ-convergence for strongly local Dirichlet forms in open sets with holes; **H.-P. Blatt**, Divergence of rational approximants to non-analytic functions; **N. Boboc** and **G. Bucur**, Non-symmtetric resistance forms; **S.-L. Eriksson** and **H. Leutwiler**, Hyperbolic harmonic functions and their function theory; **M. Fukushima**, On extended Dirichlet spaces and the space of BL functions; **S. J. Gardiner** and **T. Sjödin**, Partial balayage and the exterior inverse problem of potential theory; **M. Ghergu** and **V. Rădulescu**, The influence of the distance function in some singular elliptic problems; **K. GowriSankaran**, A Fatou type theorem for multiply superharmonic functions; **Z.-C. Hu**, **Z.-M. Ma**, and **W. Sun**, Some remarks on representations of non-symmetric local Dirichlet forms; **N. Jacob**, **A. Potrykus**, and **M. Schicks**, Operators associated with multi-parameter families of probability measures; **K. Kuwae**, Jensen's inequality over CAT(κ)-space with small diameter; **P. A. Loeb**, Rich measure spaces; **Y. Mizuta**, **T. Ohno**, and **T. Shimomura**, Integrability of maximal functions for generalized Lebesgue spaces $L^{p(\cdot)}(\log L)^{q(\cdot)}$; **M. N. Pascu**, Probabilistic approaches to monotonicity and maximum principles; **E. Popa**, Polyinvariant elements in a semi-dynamical system; **W. Stannat**, Lipschitz continuity of the pseudo resolvent of the stochastic Burgers equation; **C. Udrea**, Excessive functions with respect to Monge–Ampére resolvents and concave functions.

International Book Series of Mathematical Texts

June 2009, 246 pages, Hardcover, ISBN: 978-973-87899-5-1, 2000 *Mathematics Subject Classification:* 00B25, 31-06, 60-06, **AMS members US$46**, List US$57, Order code THETA/14



Noncommutativity and Singularities

Proceedings of French–Japanese Symposia Held at IHÈS in 2006

Jean-Pierre Bourguignon, *Institut des Hautes Ètudes Scientifiques, Bures-sur-Yvette, France*, **Motoko Kotani**, *Tohoku University, Sendai, Japan*, **Yoshiaki Maeda**, *Keio University, Kohoku, Japan*, and **Nobuyuki Tose**, *Keio University, Japan*, Editors

The two symposia, the Hayashibara Forum and the MSJ/IHÈS Joint Workshop, were held at the Institute des Hautes Ètudes Scientifiques (IHÈS) in November 2006. The Hayashibara Forum focused on singularity theory, which has been one of the research areas that has over the years been well represented at IHÈS. The MSJ/IHÈS Joint Workshop focused on the broad area of noncommutativity, with an emphasis on noncommutative geometry as one of the fundamental themes of 21st century mathematics.

This volume contains papers presented at the symposia in the form of invited lectures and contributed talks by young researchers. The scope of this volume reflects a new development for singularity theory and a new direction in mathematics through noncommutativity. This volume aims to inspire not only the specialists in these fields but also a wider audience of mathematicians.

This item will also be of interest to those working in algebra and algebraic geometry.

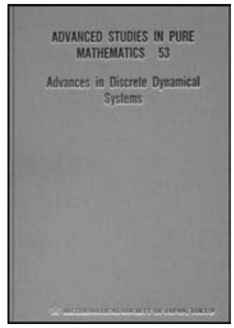
Published for the Mathematical Society of Japan by Kinokuniya, Tokyo, and distributed worldwide, except in Japan, by the AMS.

Contents: *Plenary Lectures:* **P. Biane**, From Pitman's theorem to crystals; **T. Harada**, Singularities and self-similarity in gravitational collapse; **S. Izumiya**, Horospherical geometry in the hyperbolic space; **H. Kanno**, Instanton counting and the chiral ring relations in supersymmetric gauge theories; **Y. Kawahigashi**, Superconformal field theory and operator algebras; **P. Popescu-Pampu**, Iterating the Hessian: A dynamical system on the moduli space of elliptic curves and dessins d'enfants; **S. V. Ngọc**, Quantum Birkhoff normal forms and semiclassical analysis; **K.-i. Sugiyama**, On geometric analogues of Iwasawa main conjecture for a hyperbolic threefold; **Y. Sugiyama**, Partial regularity and its application to the blow-up asymptotics of parabolic systems modelling chemotaxis with porous medium diffusion; **T. Yamaguchi**, Upper curvature bounds and singularities; **Y. Yomdin** and **G. Zahavi**, High-order processing of singular data; *Research Articles:* **S. Echterhoff**, **R. Nest**, and **H. Oyono-Oyono**, An analogue of Serre fibrations for C^*-algebra bundles; **K. Fujiwara**, **H. Itoyama**, and **M. Sakaguchi**, Spontaneous partial breaking of $\mathcal{N} = 2$ supersymmetry and the $U(N)$ gauge model; **K. Gomi**, An analogue of the space of conformal blocks in $(4k + 2)$-dimensions; **M. Kasatani** and **Y. Takeyama**, The quantum Knizhnik–Zamolodchikov equation and non-symmetric Macdonald polynomials; **Y. Konishi**, Local Gromov–Witten invariants of cubic surfaces; **S. Minabe**, Flop invariance of the topological vertex; **H. Moriuchi**, A table of θ-curves and handcuff graphs with up to seven crossings; **H. Nagoya**, A quantization of the sixth Painlevé equation; **Y. Nohara**, Lagrangian fibrations and theta functions; **Y. Ogawa**, Generalized Q-functions and UC hierarchy of B-type; **M. Pichot**, The space of triangle buildings; **M. Watanabe**, Ends of metric measure spaces with nonnegative Ricci curvature; **S. Yamagata**, On ideal boundaries of some Coxeter groups; **T. Yoshida**, On manifolds which are locally modeled on the standard representation of a torus.

Advanced Studies in Pure Mathematics, Volume 55

July 2009, 363 pages, Hardcover, ISBN: 978-4-931469-54-9, 2000 *Mathematics Subject Classification:* 58-06; 58B34, **AMS members US$65**, List US$81, Order code ASPM/55

Differential Equations



Advances in Discrete Dynamical Systems

Saber Elaydi, *Trinity University, San Antonio, TX*, **Kazuo Nishimura** and **Mitsuhiro Shishikura**, *Kyoto University, Japan*, and **Nobuyuki Tose**, *Keio University, Japan*, Editors

This volume contains the proceedings of talks presented at the 11th International Conference on Difference Equations and Applications (ICDEA 2006). ICDEA 2006 was held on July 2006 in Kyoto at the 15th MSJ International Research Institute.

These proceedings comprise new results at the leading edge of many areas in difference equations and discrete dynamical systems and their various applications to the sciences, engineering, physics, and economics.

Published for the Mathematical Society of Japan by Kinokuniya, Tokyo, and distributed worldwide, except in Japan, by the AMS.

Contents: **J. Ferreira Alves**, On periodic points of 2-periodic dynamical systems; **J. A. D. Appleby** and **C. Swords**, Asymptotic behaviour of a nonlinear stochastic difference equation modelling an inefficient financial market; **J. Diblík** and **I. Hlavičková**, Asymptotic properties of solutions of the discrete analogue of the Emden–Fowler equation; **M. Cecchi**, **Z. Došlá**, and **M. Marino**, Intermediate solutions for nonlinear difference equations with p-Laplacian; **O. Došlý**, Oscillation theory of symplectic difference systems; **T. Furumochi** and **M. Muraoka**, Periodic solutions of periodic difference equations; **Y. Hamaya**, On the existence of almost periodic solutions to a nonlinear Volterra difference equation; **K. Hori**, Indeterminacy in a monetary economy with heterogeneous agents; **S. Iwamoto** and **M. Yasuda**, Golden optimal path in discrete-time dynamic optimization processes; **S. R. Jang**, Cannibalism in a discrete predator-prey model with an age structure in the prey; **T. Kohda**, 3-dimensional i.i.d. binary random vectors governed by Jacobian elliptic space curve dynamics; **A. Kondo**, Inefficacy of temporary policy in Neumeyer–Yano's monetary model; **C. Correia Ramos**, **N. Martins**, **J. Sousa Ramos**, and **R. Severino**, Discrete potential theory for iterated maps of the interval; **M. Inoue** and **H. Matsunaga**, Global behavior of a two-dimensional monotone difference system; **F. Kawahigashi** and **H. Matsunaga**, Asymptotic stability conditions for a delay difference system; **M. Matsuo** and **T. Sakagami**, Characterization of equilibrium paths in the two-sector model with sector specific externality; **D. Mendes**, **V. M. Mendes**, **J. Sousa Ramos**, and **O. Gomes**, Computing topological entropy in asymmetric Cournot duopoly games with homogeneous expectations; **A. Mizushima**, Equilibrium dynamics in an overlapping generations economy with endogenous labor supply; **S. Murakami**, Stabilities with respect to a weight function in Volterra difference equations; **P. Niamsup**, A note on asymptotic stability condition for delay difference equations; **N. Nishimura**, **H. Takahashi**, and **A. Venditti**, Global externalities, endogenous growth and sunspot fluctuations; **L. Erbe** and **A. Peterson**, Some oscillation results for second order linear delay dynamic equations; **N. Pop**, Analysis of an evolutionary variational inequality arising in elasticity quasi-static contact problems; **C. Pötzsche**, Dissipative delay endomorphisms and asymptotic equivalence; **P. Řehák**, A Willett type criterion with the best possible constant for linear dynamic equations; **J. A. D. Appleby**, **M. Riedle**, and **A. Rodkina**, On asymptotic stability of linear stochastic Volterra difference equations with respect to a fading perturbation; **W. Hernandez-Padilla** and **L.-I. Roeger**, Local stability of a discrete competition model derived from a nonstandard numerical method; **S. Saito**, Eventual stability criterion for periodic points of Michio Morishima's example; **T. Sauer**, Detection of periodic driving in nonautonomous difference equations; **H. Sedaghat**, Periodic and chaotic behavior in a class of second order difference equations; **J. F. Selgrade** and **J. H. Roberds**, Uniqueness of polymorphism for a discrete, selection-migration model with genetic dominance; **W. Sizer**, Periodicity in the May's host parasitoid equation; **P. Stehlík**, On variational methods for second order discrete periodic problems; **Y. Takahashi**, Time evolution with and without remote past; **Y. Aoki** and **Y. Tomoda**, The Friedman rule under habit formation; **A. Vanderbauwhede**, Subharmonic bifurcation from relative equilibria in reversible systems with rotation symmetry; **C. L. Wesley**, **L. J. S. Allen**, **C. B. Jonsson**, **Y.-K. Chu**, and **R. D. Owen**, A discrete-time rodent-hantavirus model structured by infection and developmental stages.

Advanced Studies in Pure Mathematics, Volume 53

June 2009, 398 pages, Hardcover, ISBN: 978-4-931469-49-5, 2000 *Mathematics Subject Classification:* 39A05; 37N25, 37N40, 39A11, **AMS members US$52**, List US$65, Order code ASPM/53

Geometry and Topology

Geometry, Analysis, and Algebraic Geometry (Surveys in Differential Geometry, Volume XIII)

Forty Years of the Journal of Differential Geometry

Huai-Dong Cao, *Lehigh University, Bethlehem, PA*, and **Shing-Tung Yau**, *Harvard University, Cambridge, MA*, Editors

The editors of the highly esteemed *Journal of Differential Geometry* (published by International Press) each year present a new volume of Surveys in Differential Geometry, a collection of original contributions on a specially chosen topic pertaining to differential geometry and related topics. The series presents an overview of recent trends while making predictions and suggestions for future research.

Each invited contributor is a prominent specialist in the field of algebraic geometry, mathematical physics, or related areas. Contributors to Surveys tend to transcend classical frameworks within their field.

Once every three years, Lehigh University and Harvard University, in conjunction with the editors of the JDG, sponsor a conference whose purpose is to survey the general field of differential geometry and related subjects. Speakers at the conference are likewise selected for their prominence in a given field and for their innovative contributions to it. Hence every third volume of Surveys is a publication of those presented talks.

The Surveys in Differential Geometry series is a beneficial collection for experts and non-experts alike, and, in particular, for those independent of the mainstream of activity in the field of geometry.

This item will also be of interest to those working in analysis.

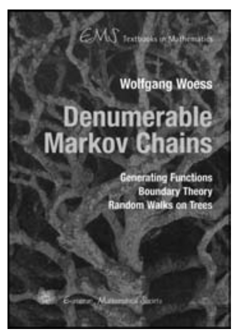
A publication of International Press. Distributed worldwide by the American Mathematical Society.

Contents: **D. Auroux**, Special Lagrangian fibrations, wall-crossing, and mirror symmetry; **S. Brendle** and **R. Schoen**, Sphere theorems in geometry; **R. Donagi** and **T. Pantev**, Geometric Langlands and non-Abelian Hodge theory; **K. Grove**, Developments around positive sectional curvature; **C. LeBrun**, Einstein metrics, four-manifolds, and conformally Kähler geometry; **F. Hang**, **F. Lin**, and **Y. Yang**, Existence of Faddeev knots; **F. Bogomolov** and **Y. Tschinkel**, Milnor K_2 and field homomorphisms; **E. Viehweg**, Arakelov inequalities; **S.-T. Yau**, A survey of Calabi-Yau manifolds.

International Press

August 2009, 318 pages, Hardcover, ISBN: 978-1-57146-138-4, 2000 *Mathematics Subject Classification:* 53C44, **AMS members US$68**, List US$85, Order code INPR/83

Probability



Denumerable Markov Chains

Generating Functions, Boundary Theory, Random Walks on Trees

Wolfgang Woess, *Graz University of Technology, Austria*

Markov chains are among the basic and most important examples of random processes. This book is about time-homogeneous Markov chains that evolve with discrete time steps on a countable state space.

A specific feature is the systematic use, on a relatively elementary level, of generating functions associated with transition probabilities for analyzing Markov chains. Basic definitions and facts include the construction of the trajectory space and are followed by ample material concerning recurrence and transience, the convergence and ergodic theorems for positive recurrent chains. There is a side-trip to the Perron–Frobenius theorem. Special attention is given to reversible Markov chains and to basic mathematical models of population evolution such as birth-and-death chains, Galton–Watson process and branching Markov chains.

A good part of the second half is devoted to the introduction of the basic language and elements of the potential theory of transient Markov chains. Here the construction and properties of the Martin boundary for describing positive harmonic functions are crucial. In the long final chapter on nearest neighbor random walks on (typically infinite) trees the reader can harvest from the seed of methods laid out so far, in order to obtain a rather detailed understanding of a specific, broad class of Markov chains.

The level varies from basic to more advanced, addressing an audience from master's degree students to researchers in mathematics, and persons who want to teach the subject on a medium or advanced level. Measure theory is not avoided; careful and complete proofs are provided. A specific characteristic of the book is the rich source of classroom-tested exercises with solutions.

A publication of the European Mathematical Society (EMS). Distributed within the Americas by the American Mathematical Society.

Contents: Preliminaries and basic facts; Irreducible classes; Recurrence and transience, convergence, and the ergodic theorem; Reversible Markov chains; Models of population evolution; Elements of the potential theory of transient Markov chains; The Martin boundary of transient Markov chains; Minimal harmonic functions on Euclidean lattices; Nearest neighbour random walks on trees; Solutions of all exercises; Bibliography; List of symbols and notation; Index.

EMS Textbooks in Mathematics, Volume 10

August 2009, 386 pages, Hardcover, ISBN: 978-3-03719-071-5, 2000 *Mathematics Subject Classification:* 60-01, 60J10, 60J50, 60J80, 60G50, 05C05, 94C05, 15A48, **AMS members US$54**, List US$68, Order code EMSTEXT/10

Classified Advertisements

Positions available, items for sale, services available, and more

CALIFORNIA

CALIFORNIA INSTITUTE OF TECHNOLOGY
Harry Bateman Research Instructorships in Mathematics

Description: Appointments are for two years. The academic year runs from approximately October 1 to June 1. Instructors typically are expected to teach one course per quarter for the full academic year and to devote the rest of their time to research. During the summer months there are no duties except research.

Eligibility: Open to persons who have recently received their doctorates in mathematics.

Deadline: January 1, 2010.

Application information: Please apply online at `mathjobs.org`. You can also find information about this position at `http://www.math.caltech.edu/positions.html`. To avoid duplication of paperwork, your application may also be considered for an Olga Taussky and John Todd Instructorship. Caltech is an Affirmative Action/Equal Opportunity Employer. Women, minorities, veterans, and disabled persons are encouraged to apply.

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CALIFORNIA INSTITUTE OF TECHNOLOGY
Olga Taussky and John Todd Instructorships in Mathematics

Description: Appointments are for three years. There are three terms in the Caltech academic year, and instructors typically are expected to teach one course in all but two terms of the total appointment. These two terms will be devoted to research. During the summer months there are no duties except research.

Eligibility: Offered to persons within three years of having received the Ph.D. who show strong research promise in one of the areas in which Caltech's mathematics faculty is currently active.

Deadline: January 1, 2010.

Application information: Please apply online at `mathjobs.org`. You can also find information about this position at `http://www.math.caltech.edu/positions.html`. To avoid duplication of paperwork, your application may also be considered for a Harry Bateman Research Instructorship. Caltech is an Affirmative Action/Equal Opportunity Employer. Women, minorities, veterans, and disabled persons are encouraged to apply.

000080

CALIFORNIA INSTITUTE OF TECHNOLOGY
Scott Russell Johnson Senior Postdoctoral Scholar in Mathematics

Description: There are three terms in the Caltech academic year. The fellow is typically expected to teach one course in two terms each year, and is expected to be in residence even during terms when not teaching. The initial appointment is for three years with an additional three-year terminal extension expected.

Eligibility: Offered to a candidate within six years of having received the Ph.D. who shows strong research promise in one of the areas in which Caltech's mathematics faculty is currently active.

Deadline: January 1, 2010.

Application information: Please apply online at `mathjobs.org`. You can also find information about this position at `http://www.math.caltech.edu/positions.html`. To avoid duplication of paperwork, your application may also be considered for an Olga Taussky and John Todd or a Harry Bateman Instructorship. Caltech is an Affirmative Action/Equal Opportunity Employer. Women, minorities, veterans, and disabled persons are encouraged to apply.

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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 anonymously. 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.

Upcoming deadlines for classified advertising are as follows: December 2009 issue–September 28, 2009; January 2010 issue–October 28, 2009; February 2010 issue–November 25, 2009; March 2010 issue–December 28, 2009; April 2010 issue–January 28, 2010; May 2010 issue–February 26, 2010.

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. cannot be published unless they are accompanied by a statement that the institution does not discriminate on these grounds whether or not it is subject to U.S. laws. Details and specific wording may be found on page 1373 (vol. 44).

Situations wanted advertisements from involuntarily unemployed mathematicians are accepted under certain conditions for free publication. Call toll-free 800-321-4AMS (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 `classads@ams.org`. AMS location for express delivery packages is 201 Charles Street, Providence, Rhode Island 20904. Advertisers will be billed upon publication.

CALIFORNIA INSTITUTE OF TECHNOLOGY
Tenure-Track Position

The Division of Physics, Mathematics, and Astronomy at the California Institute of Technology invites applications for a tenure-track position at the assistant professor level in mathematics. We are especially interested in the following research areas: topology/geometry and analysis, but other fields may be considered. The term of the initial appointment is normally four years and appointment is contingent upon completion of the Ph.D. Exceptionally well-qualified applicants may also be considered at the associate or full professor level. We are seeking highly qualified applicants who are committed to a career in research and teaching.

Application Information: Please apply online at `mathjobs.org`. You can also find information about this position at `http://www.math.caltech.edu/positions.html`. Caltech is an Affirmative Action/Equal Opportunity Employer. Women, minorities, veterans, and disabled persons are encouraged to apply.

000081

MATHEMATICAL SCIENCES RESEARCH INSTITUTE
Berkeley, CA

MSRI invites applications for 40 Research Professors, 200 Research Members, and 30 semester-long Post-Doctoral Fellows in the following programs: Random Matrix Theory, Interacting Particle Systems and Integrable Systems (August 16, 2010, to December 17, 2010), Inverse Problems and Applications (August 16, 2010, to December 17, 2010), Free Boundary Problems, Theory and Applications (January 10, 2011, to May 20, 2011), and Arithmetic Statistics (January 10, 2011, to May 20, 2011). A very small number of positions that are unaffiliated with these four programs may be available as part of our Complementary Program. Research professorships are intended for senior researchers who will be making key contributions to a program, including the mentoring of postdoctoral fellows, and who will be in residence for three or more months. Research memberships are intended for researchers who will be making contributions to a program and who will be in residence for one or more months. Post-doctoral fellowships are intended for recent Ph.D.s. Interested individuals should carefully describe the purpose of their proposed visit, and indicate why a residency at MSRI will advance their research program. To receive full consideration, application must be complete, including all letters of support. Application deadlines: Research Professorships, October 1, 2009; Research Memberships, December 1, 2009; Post-doctoral Fellowships, December 1, 2009. Application information: `http://www.msri.org/propapps/applications/application_material`. The Institute is committed to the principles of Equal Opportunity and Affirmative Action.

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UNIVERSITY OF CALIFORNIA, LOS ANGELES
Department of Mathematics
Faculty Positions Academic Year 2010–2011

The Department of Mathematics, subject to administrative approval, will consider tenure-track/tenure appointments in a wide range of possible fields with emphasis on applied mathematics. We also plan to make temporary and visiting appointments in the following categories 2–5. Depending on the level, candidates must give evidence of potential or demonstrated distinction in scholarship and teaching.

(1) Tenure-Track/Tenured Faculty Positions. Salary is commensurate with level of experience.

(2) E. R. Hedrick Assistant Professorships. Salary is $61,200 and appointments are for three years. The teaching load is four quarter courses per year.

(3) Computational and Applied Mathematics (CAM) Assistant Professorships. Salary is $61,200, and appointments are for three years. The teaching load is normally reduced to two or three quarter courses per year by research funding as available.

(4) Program in Computing (PIC) Assistant Adjunct Professorships. Salary is $65,500. Applicants for these positions must show very strong promise in teaching and research in an area related to computing. The teaching load is four one-quarter programming courses each year and one seminar every two years. Initial appointments are for one year and possibly longer, up to a maximum service of four years.

(5) Assistant Adjunct Professorships and Research Postdocs. Normally appointments are for one year, with the possibility of renewal. Strong research and teaching background required. The salary range is $53,200–$59,500. The teaching load for adjuncts is six quarter courses per year.

If you wish to be considered for any of these positions you must submit an application and supporting documentation electronically via `http://www.mathjobs.org`.

For fullest consideration, all application materials should be submitted on or before December 9, 2009. Ph.D. is required for all positions.

UCLA and the Department of Mathematics have a strong commitment to the achievement of excellence in teaching and research and diversity among its faculty and staff. The University of California is an Equal Opportunity/Affirmative Action Employer. The University of California asks that applicants complete the Equal Opportunity Employer survey for Letters and Science at the following URL: `http://cis.ucla.edu/facultysurvey`. Under Federal law, the University of California may employ only individuals who are legally authorized to work in the United States as established by providing documents specified in the Immigration Reform and Control Act of 1986.

000038

UNIVERSITY OF CALIFORNIA, DAVIS
Post-Doc Positions in Mathematics

The Department of Mathematics at the University of California, Davis, is soliciting applications for a few postdoctoral positions starting July 1, 2010. The areas of specialization are open.

To be considered for the Arthur J. Krener Assistant Professor position, the department seeks applicants with excellent research potential in areas of faculty interest and effective teaching skills. Applicants are required to have completed their Ph.D. by the time of their appointment, but no earlier than July 1, 2006. The annual salary of this position is $52,350. The typical teaching load is 3 to 4 quarter-long courses. Arthur J. Krener appointments are renewable for a total of up to three years, assuming satisfactory performance in research and teaching.

Applicants for the VIGRE Fellow position must be U.S. citizens, nationals, or permanent residents and have received their Ph.D. no earlier than January 1, 2009. Applicants in all research areas are encouraged to apply. The current annual salary for VIGRE Fellows is $59,456. The typical teaching load is 2 to 3 quarter-long courses. VIGRE Fellow appointments are renewable for a total of up to three years, assuming satisfactory performance in research and teaching.

Additional information about the department may be found at `http://math.ucdavis.edu`. Our postal address is Department of Mathematics, University of California, One Shields Avenue, Davis, CA 95616-8633.

Applications will be accepted until the positions are filled. To guarantee full consideration, the application should be received by November 30, 2009. To apply: submit the AMS Cover Sheet and supporting documentation electronically through `http://www.mathjobs.org`.

UC Davis is an Affirmative Action/Equal Employment Opportunity Employer and is dedicated to recruiting a diverse faculty community. We welcome all qualified applicants to apply, including women, minorities, individuals with disabilities, and veterans.

000077

CONNECTICUT

YALE UNIVERSITY
Assistant Professors Tenure-Track

The Mathematics Department at Yale University intends to make one or more tenure-track assistant professor appointments beginning July 1, 2010. Positions will be open to all fields of mathematics. Evidence of strong promise of leadership in research and excellence in teaching required. Yale is an Affirmative Action/ Equal Opportunity Employer. Qualified women and members of minority groups are encouraged to apply.

Applications should be submitted through `http://www.mathjobs.org`, inquiries should be submitted to `tenuretrack.math@yale.edu`. Review of applications will begin on December 15, 2009.

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YALE UNIVERSITY
J. Willard Gibbs Assistant Professorships in Mathematics 2010-11

The Gibbs Assistant Professorships are intended primarily for men and women who received the Ph.D. degree and show definite promise in research in pure or applied mathematics. Appointments are for three years. The salary will be at least $69,000. Each recipient of a Gibbs Assistant Professorship will be given a moving allowance based on the distance to be moved.

The teaching load for Gibbs Assistant Professors will be kept light, so as to allow ample time for research. This will consist of three one-semester courses per year. Part of the duties may consist of a one-semester course at the graduate level in the general area of the instructor's research. Yale is an Affirmative Action/ Equal Opportunity Employer. Qualified women and members of minority groups are encouraged to apply. Submit applications and supporting material through `mathjobs.org` by January 1, 2010. Submit inquiries to `gibbs.committee@yale.edu`. Offers expected to be made in early February 2010.

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GEORGIA

GEORGIA INSTITUTE OF TECHNOLOGY
School of Mathematics

The School of Mathematics at Georgia Tech is continuing an ambitious faculty recruitment program begun several years ago. Building on past successes, this recruiting effort is intended to make rapid advances in the scope and quality of our research and graduate education programs. Candidates will be considered at all ranks, with priority given to those candidates who: (1) show the potential to carry out research of exceptional quality at Georgia Tech; (2) complement existing strengths in the School of Mathematics; (3) reinforce bridges to programs in engineering and the physical, computing, and life sciences; (4) have strong potential for external funding; and (5) have a demonstrated commitment to high quality teaching at both the undergraduate and graduate levels. Consistent with these priorities, candidates will be considered in all areas of pure and applied mathematics and statistics. Applications should consist of a curriculum vitae, including a list of publications, summary of future research plans, and at least three letters of reference. Applications should also include evidence of teaching interest and abilities. Candidates for associate and full professor positions should submit a statement outlining their vision for service as a senior faculty member at Georgia Tech. Applications should be submitted directly to `http://www.mathjobs.org`. If a candidate cannot submit an application electronically, then it may be sent to the Hiring Committee, School of Mathematics, Georgia Institute of Technology, Atlanta, GA, 30332-0160, USA. Review of applications will begin in October 2009, and the roster of candidates being considered will be updated on a continual basis. Georgia Tech, an institution of the University System of Georgia, is an Equal Opportunity/ Affirmative Action Employer.

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ILLINOIS

NORTHWESTERN UNIVERSITY
Department of Mathematics

Applications are invited for job-ad-2009-2 tenured or tenure-track positions starting September 2010. Priority will be given to exceptionally promising research mathematicians. We invite applications from qualified mathematicians in all fields.

Applications should be made electronically at `http://www.mathjobs.org` and should include (1) the American Mathematical Society Cover Sheet for Academic Employment, (2) a curriculum vitae, (3) a research statement, (4) a teaching statement, and (5) three letters of recommendation, one of which discusses the candidate's teaching qualifications. Inquiries may be sent to: `hiring@math.northwestern.edu`.

Applications received by November 1st will be given priority. AA/EOE. Women and minority candidates are especially encouraged to apply.

000062

UNIVERSITY OF CHICAGO
Department of Mathematics

The University of Chicago Department of Mathematics invites applications for the following positions:

1. L. E. Dickson Instructor: This is open to mathematicians who have recently completed or will soon complete a doctorate in mathematics or a closely related field, and whose work shows remarkable promise in mathematical research and teaching. The appointment typically is for two years, with the possibility of renewal for a third year. The teaching obligation is up to four one-quarter courses per year.

2. Assistant Professor: This is open to mathematicians who are further along in their careers, typically two or three years past the doctorate. These positions are intended for mathematicians whose work has been of outstandingly high caliber. Appointees are expected to have the potential to become leading figures in their fields. The appointment is generally for three years, with a teaching obligation of three one-quarter courses per year.

Applicants will be considered for any of the positions above which seem appropriate. Complete applications consist of (a) a cover letter, (b) a curriculum vitae, (c) three or more letters of reference, at least one of which addresses teaching ability, and (d) a description of previous research and plans for future mathematical research. Applicants are strongly encouraged to include information related to their teaching experience, such as a teaching statement or evaluations from courses previously taught, as well as an AMS cover sheet. If you have applied for an NSF Mathematical Sciences Postdoctoral Fellowship, please include that information in your application, and let us know how you plan to use it if awarded.

Applications must be submitted online through `www.mathjobs.org`. Questions may be directed to `apptsec@math.uchicago.edu`. We will begin screening applications on December 1, 2009. Screening will continue until all available positions are filled. The University of Chicago is an Equal Opportunity/Affirmative Action Employer.

000042

UNIVERSITY OF ILLINOIS AT CHICAGO
Department of Mathematics, Statistics, and Computer Science

The department has active research programs in a broad spectrum of centrally important areas of pure mathematics, computational and applied mathematics, combinatorics, mathematical computer science and scientific computing, probability and statistics, and mathematics education. See `http://www.math.uic.edu` for more information.

Applications are invited for tenure-track assistant professor or tenured associate professor positions, effective August 16,

2010. Preference will be given to applicants in statistics and related areas, but outstanding applicants in all specialties will be considered. Final authorization of the position is subject to the availability of state funding.

Applicants must have a Ph.D. or equivalent degree in mathematics, computer science, statistics, mathematics education, or related field; an outstanding research record; and evidence of strong teaching ability. The salary is negotiable.

Send vita and at least three (3) letters of recommendation, clearly indicating the position being applied for, to: Appointments Committee; Dept. of Mathematics, Statistics, and Computer Science; University of Illinois at Chicago; 851 S. Morgan (m/c 249); Box T; Chicago, IL 60607. Applications through `mathjobs.org` are encouraged. No email applications will be accepted. To ensure full consideration, materials must be received by November 16, 2009. However, we will continue considering candidates until all positions have been filled. Minorities, persons with disabilities, and women are particularly encouraged to apply. UIC is an AA/EOE.

000065

UNIVERSITY OF ILLINOIS AT CHICAGO
Department of Mathematics, Statistics, and Computer Science

The department has active research programs in a broad spectrum of centrally important areas of pure mathematics, computational and applied mathematics, combinatorics, mathematical computer science and scientific computing, probability and statistics, and mathematics education. See `http://www.math.uic.edu` for more information.

Applications are invited for the following position, effective August 16, 2010. Final authorization of the position is subject to the availability of state funding.

Research Assistant Professorship. This is a non-tenure-track position, normally renewable annually to a maximum of three years. This position carries a teaching responsibility of three courses per year, and the expectation that the incumbent play a significant role in the research life of the department. The salary for AY 2009-2010 for this position is $54,500. Applicants must have a Ph.D. or equivalent degree in mathematics, computer science, statistics, mathematics education, or related field, and evidence of outstanding research potential. Preference will be given to candidates in areas related to number theory or dynamical systems.

Send vita and at least three (3) letters of recommendation, clearly indicating the position being applied for, to: Appointments Committee; Dept. of Mathematics, Statistics, and Computer Science; University of Illinois at Chicago; 851 S. Morgan (m/c 249); Box R; Chicago, IL 60607. Applications through `mathjobs.org` are encouraged. No email applications will be accepted. To ensure full consideration, materials must be received by December 31, 2009. However, we will continue considering candidates until all positions have been filled. Minorities, persons with disabilities, and women are particularly encouraged to apply. UIC is an AA/EOE.

000066

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN
Department of Mathematics
Assistant/Associate Professor Positions

Applications are invited for one or more full-time faculty positions to commence approximately on August 16, 2010, at either the assistant professor or associate professor levels. Appointees will be expected to have an outstanding research program and to teach both graduate and undergraduate students. The department welcomes applications in all areas of mathematics. The salary and teaching load are competitive.

Applicants must have a Ph.D. (or equivalent) in hand or show clear evidence of completion by the time the appointment begins. They are expected to present evidence of excellence in research and teaching, and those applying at the associate professor level should have demonstrated evidence of leadership in the field. Applications should be submitted electronically through `http://mathjobs.org` and must include the AMS Standard Cover Sheet for Academic Employment, curriculum vitae including email address, a publication list, a research statement, and for assistant professor applicants at least three letters of reference, including one letter addressing the candidate's teaching. Reference letter writers should submit their letters online through `http://mathjobs.org`. If they are unable to do so, they may send their letters to the following address: Search, Department of Mathematics, University of Illinois at Urbana-Champaign, 1409 West Green Street, Urbana, IL 61801, USA; tel: (217) 333-3352; `search@math.uiuc.edu`. Applicants for an associate professorship must provide the names and addresses of exactly four references. The department will solicit letters of reference for the finalists for associate professor positions.

For full consideration, complete applications, including letters of reference for assistant professor positions, must be received by November 13, 2009. Applicants may be interviewed before the closing date; however, no hiring decision will be made until after the closing date.

The University of Illinois is an Affirmative Action, Equal Opportunity Employer.

000087

INDIANA

INDIANA UNIVERSITY-PURDUE UNIVERSITY INDIANAPOLIS
Searching for Assistant, Associate, or Full Professor in Applied Mathematics

The Department of Mathematical Sciences at IUPUI invites applications for two or more tenure-track faculty positions in applied and computational mathematics, with rank open, to begin August 1, 2010. These appointments will be made in support of Indiana University's Life Sciences Initiative and the newly established Center for Mathematical Biosciences, in the department. Applicants must have an earned doctorate in the mathematical sciences or related areas, a strong research program and be able to teach effectively at the undergraduate and graduate levels. Applicants at the associate or full professor level must have a record of significant research accomplishments and external funding. Tenure may be offered to a successful senior candidate, depending on the candidate's qualifications and accomplishments. A complete application must include: a letter of interest, curriculum vitae, statements on research plans and teaching philosophy, and three letters of recommendation. Applications should be submitted electronically to: `mathjobs.org`. Screening of completed applications will begin on November 1, 2009, and will continue until all approved positions are filled. IUPUI is an EEO/AA Employer, M/F/D.

000086

KENTUCKY

UNIVERSITY OF LOUISVILLE
Department of Mathematics

The Department of Mathematics at the University of Louisville invites applications for two tenure-track positions at the assistant professor level beginning Fall 2010. Preference will be given to applicants in applied or computational areas of combinatorics and probability, but qualified applicants in other areas enhancing the department's Ph.D. program in applied and industrial mathematics and complementing existing strengths, will be considered. The typical teaching load in the department is two courses per semester.

Minimum qualifications for these positions include a Ph.D. degree, or its equivalent, in the mathematical sciences. Applicants with demonstrated strengths in research and teaching are encouraged to apply. The expectations include that the successful applicant will contribute fully to research and both undergraduate and graduate instruction, including courses for STEM majors, as well as mathematics courses for prospective elementary, middle, and high school teachers.

Review of applications will begin November 1, 2009. Applicants must apply online at `http://www.louisville.edu/jobs`. For the combinatorics position use Job ID# 24408, for the probability position use Job ID #24411 and submit your CV electronically. The following items need to be mailed in a hardcopy to the address below: (1) cover letter that clearly indicates the position name or the job ID number, summary of research interest and statement of teaching interests; (2) the AMS Standard Coversheet; and (3) curriculum vitae. Please have mailed directly at least four letters of recommendation which discuss at length your research and teaching qualifications to:

Search Committee
Department of Mathematics
University of Louisville
Louisville, KY 40292.

The University of Louisville is an Affirmative Action, Equal Opportunity, Americans with Disabilities Employer, committed to diversity and in that spirit, seeks applications from a broad variety of candidates.

For more information about the position or institution please see: `http://www.math.louisville.edu/`.

000083

MARYLAND

JOHNS HOPKINS UNIVERSITY
Department of Mathematics

The Department of Mathematics invites applications for one or more positions at the associate professor or full professor level beginning fall 2010 or later. Candidates in all areas of pure mathematics are encouraged to apply.

To submit your applications go to: `http://www.mathjobs.org/jobs/jhu`. Applicants are strongly advised to submit their other materials electronically at this site.

Submit the AMS cover sheet, a curriculum vitae, a list of publications, and the names and addresses of three references. Applicants should indicate whether they are applying for an associate professor or a full professor position. The department will assume responsibility to solicit letters of evaluation and will provide evaluators with a copy of the summary of policies on confidentiality of letters of evaluation. If you do not have computer access, you may mail your application to: Appointments Committee, Department of Mathematics, Johns Hopkins University, 404 Krieger Hall, Baltimore, MD 21218. Write to: `http://www.mathjobs.org/jobs/JHU/cpoole??jhu.edu`; email: `cpoole@jhu.edu` for questions concerning these positions.

Applications received by December 1, 2009, will be given priority. The Johns Hopkins University is an Affirmative Action/Equal Opportunity Employer. Minorities and women candidates are encouraged to apply.

Deadline for Applications: No deadline given.

For more information about the position or institution/company: `http://www.mathematics.jhu.edu/new/jobs.htm`.

000060

JOHNS HOPKINS UNIVERSITY
Non-Tenure-Track J. J. Sylvester Assistant Professor

Subject to availability of resources and administrative approval, the Department of Mathematics solicits applications for non-tenure-track assistant professor positions beginning fall 2010.

The J. J. Sylvester Assistant Professorship is a three-year position offered to recent Ph.D.'s with outstanding research potential. Candidates in all areas of pure mathematics, including analysis, mathematical physics, geometric analysis, complex and algebraic geometry, number theory, and topology are encouraged to apply. The teaching load is three courses per academic year.

To submit your applications go to `http://www.mathjobs.org/jobs/jhu`. Applicants are strongly advised to submit their other materials electronically at this site.

If you do not have computer access, you may mail your application to: Appointments Committee, Department of Mathematics, Johns Hopkins University, 404 Krieger Hall, Baltimore, MD 21218. Application should include a vita, at least four letters of recommendation of which one specifically comments on teaching, and a description of current and planned research. Write to `cpoole@jhu.edu` for questions concerning these positions. Applications received by December 1, 2009, will be given priority. The Johns Hopkins University is an Affirmative Action/Equal Opportunity Employer. Minorities and women candidates are encouraged to apply.

Deadline for Applications: No deadline given. For more information about the position or institution/company: `http://www.mathematics.jhu.edu/new/jobs.htm`

000061

MASSACHUSETTS

BOSTON COLLEGE
Department of Mathematics
Postdoctoral Position

The Department of Mathematics at Boston College invites applications for a postdoctoral position beginning September 2010. This position is intended for a new or recent Ph.D. with outstanding potential in research and excellent teaching. This is a 3-year Visiting Assistant Professor position, and carries a 2-1 annual teaching load. Research interests should lie within geometry and topology or related areas. Candidates should expect to receive their Ph.D. prior to the start of the position and have received the Ph.D. no earlier than spring 2009.

Applications must include a cover letter, description of research plans, curriculum vitae, and four letters of recommendation, with one addressing the candidate's teaching qualifications. Applications received no later than January 1, 2010, will be assured our fullest consideration. Please submit all application materials through `http://mathjobs.org`.

Boston College will start a Ph.D. program in mathematics beginning fall 2010. Applicants may learn more about the department, its faculty and its programs at `http://www.bc.edu/math`. Electronic inquiries concerning this position may be directed to `postdoc-search@bc.edu`. Boston College is an Affirmative Action/Equal Opportunity Employer. Applications from women, minorities, and individuals with disabilities are encouraged.

000050

BOSTON COLLEGE
Department of Mathematics
Tenure-Track Positions

The Department of Mathematics at Boston College invites applications for two tenure-track positions at the level of assistant professor beginning in September 2010, one in number theory or related areas, including algebraic geometry and representation theory; and the second in either geometry/topology or number theory or related areas. In exceptional cases, a higher-level appointment may be considered. The teaching load for each position is three semester courses per year.

Requirements include a Ph.D. or equivalent in mathematics awarded in 2008 or earlier, a record of strong research combined with outstanding research potential, and demonstrated excellence in teaching mathematics.

A completed application should contain a cover letter, a description of research plans, a statement of teaching philosophy, curriculum vitae, and at least four letters of recommendation. One or more of the letters of recommendation should directly comment on the candidate's teaching credentials.

Applications completed no later than December 1, 2009, will be assured our fullest consideration. Please submit all application materials through `http://mathjobs.org`.

Boston College will start a Ph.D. program in mathematics beginning fall 2010. Applicants may learn more about the department, its faculty, and its programs at `http://www.bc.edu/math`. Electronic inquiries concerning these positions may be directed to math-search@bc.edu. Boston College is an Affirmative Action/ Equal Opportunity Employer. Applications from women, minorities, and individuals with disabilities are encouraged.

000049

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Department of Mathematics
Positions for Faculty and Instructors

The Mathematics Department at MIT is seeking to fill positions in pure and applied mathematics and statistics, at the level of instructor, assistant professor and higher, beginning September 2010. Appointments are based primarily on exceptional research qualifications. Appointees will be expected to fulfill teaching duties and to pursue their own research program. Ph.D. is required by the employment start date.

For more information, and to apply, please visit http://www.mathjobs.org.

To receive full consideration, please submit applications by December 1, 2009. Recommendations should be submitted through mathjobs.org but may also be sent as PDF attachments to hiring@math.mit.edu, or as paper copies mailed to: Mathematics Search Committee, Room 2-345, Department of Mathematics, MIT, 77 Massachusetts Ave., Cambridge, MA 02139-4307.

Please do not mail or email duplicates of items already submitted via mathjobs.

MIT is an Equal Opportunity, Affirmative Action Employer.

000048

MICHIGAN

MICHIGAN TECHNOLOGICAL UNIVERSITY
Department of Mathematical Sciences
Tenure-track Position in Statistics

Applications are invited for a tenure-track assistant professorship in statistics. Candidates with research interests in statistical genetics and related areas, such as biostatistics and computational statistics, are especially encouraged to apply.

The Department of Mathematical Sciences offers BS, MS, and Ph.D. programs. Current faculty have expertise in statistical genetics, wildlife statistics, probability, applied mathematics, discrete mathematics, commutative algebra, and mathematics education. Faculty are expected to have an active research program, seek external funding, and provide excellent teaching. Teaching loads are very competitive.

The position starts 16 August 2010, and candidates must complete all requirements for the Ph.D. in statistics or a related field by that date. Review of applications will begin 16 November 2009; candidates applying by that date are assured full consideration. Interested candidates should send a vita, three letters of recommendation (at least one of which addresses teaching), a description of proposed research program, and a statement of teaching interests to:

Search Committee Statistics Position, Department of Mathematical Sciences, Michigan Technological University, 1400 Townsend Drive, Houghton, MI 49931-1295.

Michigan Tech is an ADVANCE institution, one of a limited number of universities in receipt of NSF funds in support of our commitment to increase diversity and the participation and advancement of women in STEM. We also have a Dual Career Assistance Program (DCAP), which facilitates the hiring of partners of strategic hires. The website for our DCAP is: http://www.dual.mtu.edu.

Michigan Technological University is an Equal Opportunity Educational Institution/Equal Opportunity Employer/ Affirmative Action Employer.

000076

NEW HAMPSHIRE

DARTMOUTH COLLEGE
John Wesley Young Research Instructorship

The John Wesley Young Instructorship is a postdoctoral, two- to three-year appointment intended for promising Ph.D. graduates with strong interests in both research and teaching and whose research interests overlap a department member's. Current research areas include applied mathematics, combinatorics, geometry, logic, non-commutative geometry, number theory, operator algebras, probability, set theory, and topology. Instructors teach four ten-week courses distributed over three terms, though one of these terms in residence may be free of teaching. The assignments normally include introductory, advanced undergraduate, and graduate courses. Instructors usually teach at least one course in their own specialty. This appointment is for 26 months with a monthly salary of $4,833 and a possible 12-month renewal. Salary includes two-month research stipend for instructors in residence during two of the three summer months. To be eligible for a 2010–2013 instructorship, candidate must be able to complete all requirements for the Ph.D. degree before September, 2010. Applications may be obtained at http://www.math.dartmouth.edu/recruiting/ or http://www.mathjobs.org—Position ID:JWY # 1717. General inquiries can be directed to Annette Luce, Department of Mathematics, Dartmouth College, 6188 Kemeny Hall, Hanover, New Hampshire 03755-3551. At least one referee should comment on applicant's teaching ability; at least two referees should write about applicant's research ability. Applications received by January 5, 2010, receive first consideration; applications will be accepted until position is filled. Dartmouth College is committed to diversity and strongly encourages applications from women and minorities.

000058

NEW JERSEY

INSTITUTE FOR ADVANCED STUDY, SCHOOL OF MATHEMATICS

The School of Mathematics has a limited number of memberships, some with financial support for research in mathematics and computer science at the institute during the 2010-11 academic year. Candidates must have given evidence of ability in research comparable at least with that expected for the Ph.D. degree.

During the academic year of 2010-11 Richard Taylor of Harvard University will lead a program on Galois Representations and Automorphic Forms. The program will embrace all aspects of the conjectural relationship between automorphic forms and Galois representations: functoriality and Langlands' conjectures, analytic approaches (in particular the trace formula) algebraic approaches (those growing out of Wiles's work on Fermat's Last Theorem), p-adic Hodge theory (in particular the so called p-adic Langlands' Program and applications to other problems in number theory). There will be a weekly seminar and a week-long workshop highlighting recent developments connected with the program.

Recently the school established the von Neumann Fellowships, and up to six of these fellowships will be available for the 2010-11 year. To be eligible for a von Neumann Fellowship, applicants should be at least five, but no more than fifteen, years following the receipt of their Ph.D.

The Veblen Research Instructorship is a three-year position which the School of Mathematics and the Department of Mathematics at Princeton University established in 1998. Three-year instructorships will be offered each year to candidates in pure and applied mathematics who have received their Ph.D. within the last three years. The first and third year of the instructorship will be spent at Princeton University and will carry regular teaching responsibilities. The second year will be spent at the institute and dedicated to independent research of the instructor's choice.

Applications materials may be requested from Applications, School of Mathematics, Institute for Advanced Study, Einstein Drive, Princeton, NJ 08540; email: applications@math.ias.edu. Application forms may be downloaded via a

Web connection to: http://www.math.ias.edu.

Application deadline is December 1.

The Institute for Advanced Study is committed to diversity and strongly encourages applications from women and minorities.

000041

RUTGERS UNIVERSITY
Department of Mathematics and Computer Science

The Department of Mathematics and Computer Science at Rutgers University-Newark is soliciting applications for an anticipated tenure-track assistant professor position to start in the fall 2010 semester. A qualified applicant must have a Ph.D. and be engaged in a promising research program related to one of the areas represented in the department:

· representation theory, number theory, algebra

· low-dimensional topology, geometric group theory, Kleinian groups

· geometry, analysis, partial differential equations

Duties will include research and teaching. Applications must be made via http://www.mathjobs.org. Review of applications will begin November 16, 2009, and will continue until the position is filled.

Rutgers University is an EEO/AA employer and strongly encourages applications from women and underrepresented groups.

000059

NEW YORK

CLARKSON UNIVERSITY
Department of Mathematics

The Department of Mathematics (www.clarkson.edu/math) invites applications for two tenure-track positions starting in August 2010: one in applied mathematics and one in statistics. The applied mathematics position will be filled at the assistant professor level, and the statistics position will be filled at the assistant or associate professor level.

We are especially interested in candidates with expertise in computational areas of applied mathematics, including statistics or dynamical systems, but all areas of applied mathematics will be considered. Responsibilities will include teaching undergraduate and graduate level mathematics courses, and directing graduate students. Minimum requirements are a Ph.D. in mathematics by the date of appointment, demonstrated excellence in both research potential and teaching ability, and fluency in English. In addition, the candidate should be able to interact with other faculty in the department and the university.

Applications including vita and three reference letters should be submitted to Prof. C. A. Lynch, Department of Mathematics, Clarkson University, Potsdam, NY 13699-5815. Completed applications will be reviewed starting immediately. Women and minorities are urged to apply. Clarkson University is an AA/EOE Employer. (Pos. #128-08 statistics and #127-08 applied math)

000057

NORTH CAROLINA

NORTH CAROLINA STATE UNIVERSITY
Department of Mathematics

The Mathematics Department at North Carolina State University invites applications for a tenure-track position beginning fall 2010, depending on the availability of funding. We are seeking an exceptionally well-qualified individual with research interests compatible with those in the department. All areas of pure and applied mathematics will be considered, but we are especially interested in candidates in the general area of analysis. Candidates must have a Ph.D. in the mathematical sciences, an outstanding research program, a commitment to effective teaching at the undergraduate and graduate levels, and demonstrated potential for excellence in both research and teaching. She or he will likely have had successful postdoctoral experience. The Department of Mathematics has strong research programs in both pure and applied mathematics. Many members of the department participate in interdisciplinary programs and research groups on campus and in the broader Research Triangle community. More information about the department can be found at http://www.math.ncsu.edu.

To submit your application materials, go to http://www.mathjobs.org/jobs/ncsu. Include a vita, at least three letters of recommendation, and a description of current and planned research. You will then be given instructions to go to http://jobs.ncsu.edu/applicants/Central?quickFind=84158 and complete a Faculty Profile for the position.

Write to math-jobs@math.ncsu.edu for questions concerning this position.

NC State University is an Equal Opportunity and Affirmative Action Employer. In addition, NC State welcomes all persons without regard to sexual orientation. The College of Physical and Mathematical Sciences welcomes the opportunity to work with candidates to identify suitable employment opportunities for spouses or partners. For ADA accommodations, please contact Frankie Stephenson by email at Frankie_stephenson@ncsu.edu or by calling (919) 513-2294. Applications received by December 15, 2009, will be given priority.

000082

OHIO

THE OHIO STATE UNIVERSITY
College of Mathematical and Physical Sciences
Department of Mathematics

The Department of Mathematics in the College of Mathematical and Physical Sciences at The Ohio State University anticipates having tenure-track positions available, effective autumn quarter 2010. We are interested in all areas of pure and applied math, including financial mathematics. Candidates are expected to have a Ph.D. in mathematics (or related area) and to present evidence of excellence in teaching and research. Further information about the department can be found at http://www.math.ohio-state.edu.

Applications should be submitted online at http://www.mathjobs.org. If you cannot apply online, please contact facultysearch@math.ohio-state.edu or write to: Hiring Committee, Department of Mathematics, The Ohio State University, 231 W. 18th Avenue, Columbus, OH 43210.

Applications will be considered on a continuing basis, but the annual review process begins November 16, 2009.

To build a diverse workforce, Ohio State encourages applications from minorities, veterans, women, and individuals with disabilities. EEO/AA Employer.

000054

OKLAHOMA

THE UNIVERSITY OF OKLAHOMA
Department of Mathematics

Applications are invited for one full-time, tenure-track position in mathematics beginning 16 August 2010. The position is initially budgeted at the assistant professor level, but an appointment at the associate professor level may be possible for an exceptional candidate with qualifications and experience appropriate to that rank. Normal duties consist of teaching two courses per semester, conducting research, and rendering service to the department, university, and profession at a level appropriate to the faculty member's experience. The position requires an earned doctorate and research interests that are compatible with those of the existing faculty; preference will be given to applicants with potential or demonstrated excellence in research and prior successful undergraduate teaching experience. Salary and benefits are competitive. For full consideration, applicants should send a completed AMS cover sheet, curriculum vitae, a description of current and planned research, and have three letters of recommendation (at least one of which must address the applicant's teaching experience and proficiency) sent to:

Search Committee
Department of Mathematics
The University of Oklahoma
601 Elm, PHSC 423
Norman, OK 73019-0315
Phone: 405-325-6711
FAX: 405-325-7484
Email: search@math.ou.edu

*Applications may also be submitted online through http://mathjobs.org.

Screening of applications will begin on November 15, 2009, and will continue until the position(s) is filled.

The University of Oklahoma is an Equal Opportunity/Affirmative Action Employer. Women and minorities are encouraged to apply.

000085

PENNSYLVANIA

PENN STATE UNIVERSITY
Assistant Professor of Math Education

Penn State Lehigh Valley invites applications for an Assistant Professor of Math Education (tenure-track). Teach math methods course for elementary education majors and lower level math courses for education majors using traditional and hybrid delivery modes. Prefer ability to teach higher-level math course for engineering and science students. Assignments may include day, evening, and Saturday classes. Research and service expected. Ph.D./Ed.D. in mathematics, math education, or a related field (will consider ABD candidates), and teaching experience at the preschool, elementary, or middle school level is required. Evidence of potential for excellent teaching, research, and publication in high-quality journals, and professional growth is expected. To learn more about the campus and Penn State, visit http://www.psu.edu/ur/cmpcoll.html. To learn more about the position and how to apply, visit http://www.psu.jobs/Search/Opportunities.html and follow the "Faculty" link. AA/EOE.

000064

RHODE ISLAND

BROWN UNIVERSITY
J. D. Tamarkin Assistant Professorship

One three-year non-tenured non-renewable appointment, beginning July 1, 2010. The teaching load is one course one semester, and two courses the other semester and consists of courses of more than routine interest. Candidates are required to have received a Ph.D. degree or equivalent by the start of their appointment, and they may have up to three years of prior academic and/or postdoctoral research experience.

Applicants should have strong research potential and a commitment to teaching. Field of research should be consonant with the current research interests of the department.

For full consideration, applicants must submit a curriculum vitae, an AMS Standard Cover Sheet, and three letters of recommendation by December 1, 2009. Please submit all application materials online at http://www.mathjobs.org.

If necessary, inquiries and materials can be addressed to: Junior Search Committee, Department of Mathematics, Box 1917, Brown University, Providence, RI 02912. Email inquiries should be addressed to juniorsearch@math.brown.edu.

Brown University is an Equal Opportunity/Affirmative Action Employer and encourages applications from women and minorities.

000067

SOUTH CAROLINA

COLLEGE OF CHARLESTON
School of Sciences and Mathematics
DEAN

For full details find the link for the position on http://ssm.cofc.edu/.

000084

UNIVERSITY OF SOUTH CAROLINA
Department of Mathematics

Applications are invited for a tenured full professor position in applied and computational mathematics for research related to modeling and computation of soft materials, especially, biomaterials and function of manufactured biological tissues.

The individual should have sufficient background in mathematical modeling, mathematical/numerical analysis, simulation, and/or visualization of soft materials to direct a vigorous interdisciplinary research program and to interact effectively with researchers at the Advanced Tissue Biofabrication Center at the Medical University of South Carolina (in Charleston, SC) towards in silico fabrication of tissues and viable branched vascular trees. The position is part of a statewide initiative to build strength in biofabrication technology.

The successful candidate is expected to play an active role in the Interdisciplinary Mathematics Institute at USC and to have a firm commitment to excellence in teaching at both the graduate and undergraduate levels. The beginning date for the position is August 16, 2010, or possibly as early as January 1, 2010, for qualified candidates.

For full consideration, all supporting material should be submitted electronically through http://www.mathjobs.org by November 30, 2009. The supporting material should include a detailed vita with a summary of research accomplishments and goals, a completed AMS Standard Cover Sheet, and four letters of recommendation. One letter should appraise the applicant's teaching abilities. In addition, a cover letter should be submitted through mathjobs.org addressed to: Hiring Committee, Department of Mathematics, University of South Carolina, Columbia, SC 29208. The email address hiring@math.sc.edu can be used for further inquiries. Information about the department can be found on the Web at http://www.math.sc.edu.

The University of South Carolina is an Affirmative Action, Equal Opportunity Employer. Women and minorities are encouraged to apply. The University of South Carolina does not discriminate in educational or employment opportunities or decisions for qualified persons on the basis of race, color, religion, sex, national origin, age, disability, sexual orientation, or veteran status.

000072

TENNESSEE

UNIVERSITY OF TENNESSEE AT KNOXVILLE
Department of Mathematics

The Mathematics Department at The University of Tennessee at Knoxville seeks to fill a postdoctoral position in any of the following fields: applied mathematics, computational mathematics, geometry, topology, probability, or differential equations. Candidates should have had their Ph.D.s for no more than four years by September, 2009. Primary consideration will be given to candidates whose interests overlap with existing faculty. The position is a 9 month academic year appointment for three years, beginning August 1, 2010, and may not be extended. The teaching load for this position will be two courses per semester. The salary will be $50,000 per year. Evidence of potential for excellence in research and high-quality teaching is required. Review of applications will begin January 1, 2010, and continue until the position is filled. The Knoxville campus of the University of Tennessee is seeking candidates who have the ability to contribute in meaningful ways to the diversity and intercultural goals of the university.

Candidates should submit a curriculum vita, a description of their research accomplishments and plans, and a teaching statement. These documents as well as three letters of recommendation, at least one of which should address teaching, can be submitted any of the following ways: (1) by mail to Postdoctoral Search Committee, Department of Mathematics, University of Tennessee, Knoxville, TN 37996-0612, (2) by email to bmorgan@math.utk.edu, or (3) electronically at http://www.mathjobs.org/jobs (preferred).

The University of Tennessee is an EEO/AA/Title VI/Title IX/Section 504/ADA/ADEA institution in the provision of its education and employment programs and services. All qualified applicants will receive equal consideration for employment without regard to race, color, national origin, religion, sex, pregnancy, marital status, sexual orientation, gender identity, age, physical or mental disability, or covered veteran status.

000075

VANDERBILT UNIVERSITY
Non-Tenure-Track Assistant Professor Positions

We invite applications for several visiting and non-tenure-track assistant professor positions in the research areas of the Mathematics Department beginning fall 2010. These positions will have variable terms and teaching loads. We anticipate two special non-tenure-track assistant professorships which will be three-year appointments with a 1-1 teaching load and a stipend to support research.

We are looking for individuals with outstanding research potential and a strong commitment to excellence in teaching. Preference will be given to recent doctorates. Submit your application and supporting materials electronically through the AMS website mathjobs.org via the URL http://www.mathjobs.org/jobs.

Alternatively, application materials may be sent to: NTT Appointments Committee, Vanderbilt University, Department of Mathematics, 1326 Stevenson Center, Nashville, TN 37240.

These materials should include a letter of application, a curriculum vitae, a publication list, a research statement, four letters of recommendation, and the AMS Cover Sheet. One of the letters must discuss the applicant's teaching qualifications. Reference letter writers should be asked to submit their letters online through mathjobs.org. Evaluation of the applications will commence on December 1, 2009, and continue until the positions are filled.

For information about the Department of Mathematics at Vanderbilt University, please consult the web at http://www.math.vanderbilt.edu/.

Vanderbilt is an Equal Employment Opportunity/Affirmative Action employer. Women and minorities are especially invited to apply.

000063

TEXAS

SOUTHERN METHODIST UNIVERSITY
Rank/Title Assistant Professor (Position Number 00050290)

Applications are invited for one tenure-track assistant professor position, to begin in the fall semester of 2010. While preference will be given to applicants in computational and applied mathematics, applicants in other related areas are encouraged. Applicants must have a Ph.D., provide evidence of outstanding research, and have a strong commitment to teaching at all levels. The Department of Mathematics offers an active doctoral program in computational and applied mathematics. Applicants can visit http://www.smu.edu/math for more information about the department.

Applicants should send a letter of application with a curriculum vitae, a list of publications, research and teaching statements, and three letters of recommendation to: Faculty Search Committee, Department of Mathematics, Southern Methodist University, P.O. Box 750156, Dallas, TX 75275-0156. The Search Committee can be contacted via e-mail at mathsearch@mail.smu.edu; (Tel: (214) 768-2452; Fax: (214) 768-2355).

To ensure full consideration for the position, the application must be received by December 18, 2009, but the committee will continue to accept applications until the position is filled. The committee will notify applicants of its employment decisions after the position is filled.

SMU, a private university with an engineering school, is situated in a quiet residential section of Dallas. Dallas is home to the University of Texas Southwestern Medical Center and its new Systems Biology Center. SMU will not discriminate on the basis of race, color, religion, national origin, sex age, disability, or veteran status. SMU is also committed to nondiscrimination on the basis of sexual orientation. Hiring is contingent upon the satisfactory completion of a background check.

000088

TEXAS A&M UNIVERSITY
Department of Mathematics

The Department of Mathematics anticipates several openings for tenured, tenure-eligible, and visiting faculty positions beginning fall 2010. The field is open, but we particularly seek applications from individuals whose mathematical interests would augment and build upon existing strengths both within the Mathematics Department as well as other departments in the university. Salary, teaching loads, and start-up funds are competitive. For a tenured position the applicant should have an outstanding research reputation and would be expected to fill a leadership role in the department. An established research program, including success in attracting external funding and supervision of graduate students, and a demonstrated ability and interest in teaching are required. Informal inquiries are welcome. For an assistant professorship, we seek strong research potential and evidence of excellence in teaching. Research productivity beyond the doctoral dissertation will normally be expected. We also have several visiting positions available. Our Visiting Assistant Professor positions are three-year appointments and carry a three course per year teaching load. They are intended for those who have recently received their Ph.D. and preference will be given to mathematicians whose research interests are close to those of our regular faculty members. Senior Visiting Positions may be for a semester or one-year period. A complete dossier should be received by December 15, 2009. Early applications are encouraged since the department will start the review process in October 2009.

Applicants should send the completed "AMS Application Cover Sheet", a vita, a summary statement of research and teaching experience, and arrange to have letters of recommendation sent to: Faculty Hiring, Department of Mathematics, Texas A&M University, College Station, Texas 77843-3368. Further information can be obtained from: http://www.math.tamu.edu/hiring.

Texas A&M University is an Equal Opportunity Employer. The university is dedicated to the goal of building a culturally diverse and pluralistic faculty and staff committed to teaching and working in a multicultural environment and strongly encourages applications from women, minorities, individuals with disabilities, and veterans. The university is responsive to the needs of dual career couples.

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TEXAS A&M UNIVERSITY
IAMCS-KAUST Postdoctoral Fellowships

The Institute for Applied Mathematics and Computational Science (IAMCS) at Texas A&M University is pleased to invite applications for its IAMCS-KAUST Postdoctoral Fellowships.

IAMCS is an interdisciplinary research institute at Texas A&M University named in 2008 as one of the four inaugural King Abdullah University of Science and Technology (KAUST) Global Research Partner Centers. Its core members number more than thirty faculty from the fields of mathematics, statistics, computer science, and engineering.

fostering collaboration and interdisciplinary research anchored in the mathematical sciences are at the heart of IAMCS's mission. To that end, IAMCS emphasizes among its activities annual research themes. Current and upcoming themes are mathematical and computational challenges in earth science, material science and engineering, and the life sciences. IAMCS postdoctoral candidates should have demonstrated interest and involvement in interdisciplinary research, and successful candidates will be encouraged to participate in the annual theme activities and to establish research collaborations exploring theme year topics. Moreover, each fellow will be invited to establish collaborations with KAUST faculty, postdocs, and students, as well as all of the KAUST Global Research Partner institutions and individual investigators. This offers an unprecedented opportunity for postdoctoral fellows to join a remarkable network of leading research institutions and eminent scholars assembled through the KAUST GRP program.

KAUST is a new graduate research university developed by the Kingdom of Saudi Arabia at a site along the Red Sea a short distance north of Jeddah. Opened in September 2009, it offers world class, state-of-the-art research and instructional facilities supporting its core research and graduate programs in earth sciences, materials science and engineering, biosciences, and applied mathematics and computational science. A key element in KAUST's development as a premier graduate research university is its Global Research Partnership (GRP) program. The GRP consists of its Academic Excellence Alliance Partners, Research Center Partners, and Individual Research Scholar Partners.

The IAMCS-KAUST Postdoctoral Fellowships at Texas A&M University are two-year appointments with the possibility of extension to a third year. The fellowship stipend is $53K over 12 months plus fringe benefits. Interested individuals should submit their application materials (CV, research statement, and three letters of recommendation) to the email address `KAUST@tamu.edu` by 15 December 2009. IAMCS intends to select up to four IAMCS-KAUST Fellows.

Texas A&M University is an Equal Opportunity Employer. The university is dedicated to the goal of building a culturally diverse and pluralistic faculty and staff committed to teaching and working in a multicultural environment, and strongly encourages applications from women, minorities, and individuals with disabilities.

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UTAH

UNIVERSITY OF UTAH
Department of Mathematics
Hiring 2009–2010

The Department of Mathematics at the University of Utah invites applications for the following positions: Full-time tenure-track or tenured appointments at the level of assistant, associate, or full professor in all areas of mathematics and statistics. Three-year Scott, Wylie, Burgess, and VIGRE Assistant Professorships, depending on funding availability.

Please see our website at `http://www.math.utah.edu/positions` for information regarding available positions, application requirements and deadlines.

Applications must be completed through the website `http://www.mathjobs.org`. The University of Utah is an Equal Opportunity, Affirmative Action Employer and encourages applications from women and minorities, and provides reasonable accommodation to the known disabilities of applicants and employees. The University of Utah values candidates who have experience working in settings with students from diverse backgrounds, and who possess a strong commitment to improving access to higher education for historically underrepresented students.

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WASHINGTON, DC

GEORGE WASHINGTON UNIVERSITY
Department of Mathematics

The Department of Mathematics of The George Washington University invites applications for a tenure-track assistant professor position in analysis. We are looking for a candidate who can enhance our undergraduate and Ph.D. programs and is working in a field compatible with and complementary to existing research strengths. Some examples of fields of interest include geometric analysis or dynamical systems: smooth, applied or infinite-dimensional.

Basic Qualifications: Applicants must possess a Ph.D., have excellent research potential as evidenced by strong publications or works in progress and letters of recommendation, and excellent teaching credentials or potential as demonstrated by either teaching evaluations or letters from peers or supervisors. Preferred Qualifications: Preference will be given to candidates with postdoctoral experience, an excellent approach to teaching, and whose research shows promise in attracting external funding.

The successful candidate is expected to teach at all undergraduate and graduate levels, excel in research, interact with researchers in mathematics and other disciplines, and become actively involved in the life of the department and the university.

Application Procedure: Applications should be submitted on-line at `http://www.mathjobs.org` and include CV, synopsis of research plans (not to exceed three pages), evidence of good teaching (which should include an overview of your teaching approach), and at least three letters of recommendation. Only complete applications will be considered. Review of applications will begin December 1, 2009, and continue until the position is filled. The George Washington University is an Equal Opportunity/Affirmative Action Employer and seeks to attract a culturally diverse faculty of the highest caliber.

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ISRAEL

ISRAEL INSTITUTE OF TECHNOLOGY
Department of Mathematics

The department of mathematics at the Technion, Israel Institute of Technology, is offering several postdoctoral research fellowships, starting October 1, 2010. These non-tenure-track one-year special research fellowships carry no teaching duties, and are extendable for up to two more years, subject to approval. The benefits offered are competitive and include 12 months of full financial support according to the Technion postdoctoral pay scale, airfare to and from Israel, and travel funds for conference participation abroad, subject to approval. The fellowships require residency of at least 11 months.

All research activities in the department, including seminars, colloquia and conferences are conducted in English. Postdoctoral researchers will be asked to give lectures on their research in faculty and graduate students seminars. Applicants should arrange to send their CV, research plan, and three letters of recommendations to the postdoctoral search committee at the department, to arrive before January 1, 2010. Prior informal inquiries are welcome.

Applications will be evaluated solely according to demonstrated excellence in research, and compatibility with research areas currently active in the department.

The Technion does not discriminate on the basis of race, religion, ethnicity, gender, age, national origin, or any other criteria, and all qualified postdoctoral researchers are welcome to apply.

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KOREA

KAIST
Professorships

The Department of Mathematical Sciences at KAIST invites applications for tenured and tenure-track faculty positions beginning September 2010 or earlier.

In recent years, KAIST, one of the top research universities in Korea, has been recruiting distinguished scholars of both Korean and foreign nationality. KAIST is located in Daejeon, a city with a population of 1.5 million, and its operation and students are financially supported by the government. Most of the courses at KAIST are taught in English.

Applications are encouraged from any area of pure, applied, or interdisciplinary mathematics. To be successful, applicants should demonstrate outstanding accomplishments or potential in research and teaching.

An internationally competitive salary commensurate with qualifications will be offered with attractive remuneration packages including relocation assistance, a start-up grant for research, medical insurance, and housing benefits. The regular teaching load is two courses for the first year and three courses a year thereafter.

Several visiting professorships and postdoc positions are available as well.

All applications must include the following:

(1) Cover letter (an AMS standard cover-sheet is sufficient),

(2) Curriculum Vitae with publication list,

(3) Description of previous research and future plans,

(4) Teaching statement,

(5) Four recommendation letters, including one about teaching.

After the screening process, candidates may be asked for additional materials.

Applications will be accepted until positions are filled and reviewed as soon as all materials are received, but priority will be given to those received by November 30, 2009. Please contact `dongsu.kim@kaist.ac.kr` for questions.

Application materials should be sent to:

`recruit@mathsci.kaist.ac.kr` (preferred) or

Dongsu Kim

Head, Department of Mathematical Sciences KAIST

335 Gwahangno, Yuseong-gu, Daejeon,

Republic of Korea

Zip Code: 305-701

Please visit `http://mathsci.kaist.ac.kr/recruit` for more information.

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SINGAPORE

The National University of Singapore (NUS) Department of Mathematics

The Department of Mathematics at the National University of Singapore (NUS) invites applications for tenured, tenure-track and visiting (including postdoctoral) positions at all levels, beginning in August 2010.

NUS is a research-intensive university that provides quality undergraduate and graduate education. The Department of Mathematics, which is one of the largest in the university, has about 70 faculty members and teaching staff whose expertise cover major areas of contemporary mathematical research.

We seek promising scholars and established mathematicians with outstanding track records in any field of pure and applied mathematics. The department offers internationally competitive salaries with start-up grants for research. The teaching load is particularly light for young scholars, in an environment conducive to research with ample opportunities for career development.

The department is particularly interested in, but not restricted to considering, applicants specializing in any of the following areas:

. Analysis and probability.

. Computational science, including but not restricted to, computational biology, medical imaging, computational materials science and nanoscience.

. Operations research and financial mathematics.

Application materials should be sent to Search Committee via email (as PDF files) to `search@math.nus.edu.sg`.

Please include the following supporting documentation in the application:

· an American Mathematical Society Standard Cover Sheet;

· a detailed CV including publications list;

· a statement (max. of 3 pages) of research accomplishments and plan;

· a statement (max. of 2 pages) of teaching philosophy and methodology. Please attach evaluation on teaching from faculty members or students of your current institution, where applicable;

· at least three letters of recommendation including one which indicates the candidate's effectiveness and commitment in teaching. Please ask your referees to send their letters directly to `search@math.nus.edu.sg`.

Enquiries may also be sent to this email address.

Review process will begin on 15 October, and will continue until positions are filled.

For further information about the department, please visit `http://www.math.nus.edu.sg`.

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Meetings & Conferences of the AMS

IMPORTANT INFORMATION REGARDING MEETINGS PROGRAMS: AMS Sectional Meeting programs do not appear in the print version of the *Notices*. However, comprehensive and continually updated meeting and program information with links to the abstract for each talk can be found on the AMS website. See `http://www.ams.org/meetings/`. Final programs for Sectional Meetings will be archived on the AMS website accessible from the stated URL and in an electronic issue of the *Notices* as noted below for each meeting.

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: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: Expired

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

David Ben-Zvi, University of Texas at Austin, *Representation theory and gauge theory*.

Alexander A. Kiselev, University of Wisconsin, *Surface quasi-geostrophic equation: A review*.

Michael C. Reed, Duke University, *Mathematics, cell metabolism, and public health*.

Igor Rodnianski, Princeton University, *Mathematics of general relativity*.

Special Sessions

Applicable Algebraic Geometry, **Luis David Garcia-Puente**, Sam Houston State University, and **Frank Sotille**, Texas A&M University.

Commutative Algebra: Module and Ideal Theory, **Lars W. Christensen**, Texas Tech University, **Louiza Fouli**, University of Texas at Austin, and **David Jorgensen**, University of Texas at Arlington.

Contemporary Complex and Special Function Theory, **Roger W. Barnard** and **Kent Pearce**, Texas Tech University, **Kendall Richards**, Southwestern University, and **Alexander Solynin** and **Brock Williams**, Texas Tech University.

Dynamic Equations on Time Scales: Analysis and Applications, **John M. Davis**, **Ian A. Gravagne**, and **Robert J. Marks**, Baylor University.

Formations of Singularities in Geometric Flows, **Maria-Cristina Caputo**, University of Texas at Austin, and **Natasa Sesum**, University of Pennsylvania.

Fusion Categories and Applications, **Deepak Naidu** and **Eric Rowell**, Texas A&M University.

Global Analysis on Homogeneous Spaces, **Ruth Gornett**, University of Texas at Arlington, and **Ken Richardson**, Texas Christian University.

Harmonic Analysis and Partial Differential Equations, **Susan Friedlander**, University of Southern California, **Natasa Pavlovic**, University of Texas at Austin, and **Nikolaos Tzirakis**, University of Illinois at Urbana-Champaign.

Interdisciplinary Session on Stochastic Partial Differential Equations, **M. Chekroun**, ENS-Paris and University of California Los Angeles, and **Shouhong Wang** and **Nathan Glatt-Holtz**, Indiana University.

Lie Groups, Lie Algebras, and Representations, **Markus Hunziker**, **Mark Sepanski**, and **Ronald Stanke**, Baylor University.

Mathematical Aspects of Spectral Problems Related to Physics, **Klaus Kirsten**, Baylor University, **Gregory Berkolaiko** and **Stephen Fulling**, Texas A&M University, **Jon Harrison**, Baylor University, and **Peter Kuchment**, Texas A&M University.

Mathematical Models of Neuronal and Metabolic Mechanisms, **Janet Best**, Ohio State University, and **Michael Reed**, Duke University.

Numerical Solutions of Singular or Perturbed Partial Differential Equation Problems with Applications, **Peter Moore**, Southern Methodist University, and **Qin Sheng**, Baylor University.

Recent Developments on Turbulence, **Eleftherios Gkioulekas**, University of Texas-Pan American, and **Michael Jolly**, Indiana University.

The Topology of Continua, **David Ryden**, Baylor University, **Chris Mouron**, Rhodes College, and **Sergio Macias**, Universidad Nacional Autonoma de Mexico.

Topological Methods for Boundary Value Problems for Ordinary Differential Equations, **Richard Avery**, Dakota State University, **Paul W. Eloe**, University of Dayton, and **Johnny Henderson**, Baylor University.

University Park, Pennsylvania

Pennsylvania State University

October 24–25, 2009

Saturday – Sunday

Meeting #1052

Eastern Section
Associate secretary: Steven H. Weintraub
Announcement issue of *Notices*: August 2009
Program first available on AMS website: September 10, 2009
Program issue of electronic *Notices*: October 2009
Issue of *Abstracts*: Volume 30, Issue 4

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: Expired

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Laurent Saloff-Coste, Cornell University, *Subelliptic heat kernel measures and holomorphic functions on complex Lie groups*.

Michael K. H. Kiessling, Rutgers University, *N-body problems in relativity*.

Kevin R. Payne, Dipartimento di Matematica, Universita' di Milano, *PDE of mixed type: The twin challenges of globalization and diversity*.

Robert C. Vaughan, Penn State University, *Diophantine approximation to curves and surfaces.*

Special Sessions

Algebraic Combinatorics, **Peter McNamara**, Bucknell University, and **Mark Skandera**, Lehigh University.

Analytic Number Theory, **Angel V. Kumchev**, Towson University, **Michael P. Knapp**, Loyola College, and **Robert C. Vaughan**, Pennsylvania State University.

Arithmetic and Profinite Groups, **Alireza Salehi-Golsefidy**, Princeton University, **Martin D. Kassabov**, Cornell University, and **Mikhail V. Ershov**, University of Virginia.

Automorphisms of Riemann Surfaces and Related Topics, **S. Allen Broughton**, Rose-Hulman Institute of Technology, **Anthony Weaver**, Bronx Community College, the City University of New York, and **Aaron D. Wootton**, University of Portland.

Combinatorial and Homological Aspects of Commutative Algebra, **Amanda I. Beecher**, United States Military Academy, and **Alexandre B. Tchernev**, University at Albany.

Commutative Algebra and Applications to Algebraic Geometry, **Janet Striuli**, Fairfield University, and **Jooyoun Hong**, Southern Connecticut State University.

Difference Equations and Applications, **Michael A. Radin**, Rochester Institute of Technology.

Function Fields and their Applications, **Mihran Papikian** and **Kirsten Eisentrager**, Pennsylvania State University.

Geometry of Integrable and Non-Integrable Dynamics, **Boris Khesin**, University of Toronto, and **Mark Levi** and **Sergei Tabachnikov**, Pennsylvania State University.

Heat Kernel Analysis, **Maria Gordina**, University of Connecticut, and **Laurent Saloff-Coste**, Cornell University.

Homotopy Theory, **James Gillespie** and **Mark W. Johnson**, Pennsylvania State University, Altoona, **Simona Paoli**, University of Haifa, and **Donald Yau**, Ohio State University.

Integrable Systems and Related Areas, **Sam Evans** and **Michael Gekhtman**, University of Notre Dame, and **Luen-Chau Li**, Pennsylvania State University.

Microlocal Analysis and Spectral Theory on Singular Spaces, **Juan B. Gil** and **Thomas Krainer**, Pennsylvania State University, Altoona.

New Trends in Triangulated Categories and their Associated Cohomology Theories, **Sunil Kumar Chebolu**, Illinois State University, and **Keir H. Lockridge**, Wake Forest University.

Nonlinear Waves, **Bernard Deconinck**, University of Washington, **Diane Henderson**, Pennsylvania State University, and **J. Douglas Wright** and **David Ambrose**, Drexel University.

Partial Differential Equations of Mixed Elliptic-Hyperbolic Type and Applications, **Barbara Lee Keyfitz**, Ohio State University, and **Kevin Ray Payne**, Universita' di Milano.

Random Dynamics: Where Probability and Ergodic Theory Meet, **Manfred Denker**, Pennsylvania State University, and **Wojbor A. Woyczynski**, Case Western Reserve University.

Symplectic, Contact, and Complex Structures on Manifolds, **Philippe Rukimbira**, **Tedi C. Draghici**, and **Gueo V. Grantcharov**, Florida International University.

Topics in Mathematical Finance, **Nick Costanzino**, **Anna L. Mazzucato**, and **Victor Nistor**, Pennsylvania State University.

n-Body Problems in Relativity, **Michael K. H. Kiessling**, Rutgers University, **Pavel B. Dubovski**, Stevens Institute of Technology, and **Shadi Tahvildar-Zadeh**, Rutgers University.

q-Series and Related Areas in Enumerative Combinatorics and Number Theory, **David Little**, **James Sellers**, and **Ae Ja Yee**, Pennsylvania State University.

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: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: Expired

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Spyridon Alexakis, Massachusetts Institute of Technology, *Global conformal invariants: A conjecture of Deser and Schwimmer*.

Kai-Uwe Bux, University of Virginia, *Arithmetic groups in positive characteristic*.

Dino J Lorenzini, University of Georgia, *The index of an algebraic variety*.

Eduardo D. Sontag, Rutgers University, *Systems biology as a source of interesting problems in mathematics*.

Special Sessions

Applied Partial Differential Equations, **Shar Sajjadi** and **Timothy A. Smith**, Embry Riddle Aeronautical University.

Arithmetic Geometry, **Pete L. Clark** and **Dino Lorenzini**, University of Georgia.

Commutative Ring Theory, **Alan Loper**, Ohio State University, and **Lee C. Klingler**, Florida Atlantic University.

Concentration, Functional Inequalities, and Isoperimetry, **Mario Milman**, Florida Atlantic University, **Christian Houdre**, Georgia Institute of Technology, and **Emanuel Milman**, Institute for Advanced Study.

Constructive Mathematics, **Robert Lubarsky**, **Fred Richman**, and **Martin Solomon**, Florida Atlantic University.

Dynamical Systems, **William D. Kalies** and **Vincent Naudot**, Florida Atlantic University.

Enumerative Combinatorics, **Christian Krattenthaler**, University of Vienna, and **Aaron D. Meyerowitz**, **Heinrich Niederhausen**, and **Wandi Wei**, Florida Atlantic University.

General Relativity and Related Partial Differential Equations, **Spyridon Alexakis**, Massachusetts Institute of Technology, and **Gilbert Weinstein**, University of Alabama Birmingham.

Geometry and Topology, **Alexander N. Dranishnikov** and **Yuli B. Rudyak**, University of Florida.

Graded Resolutions, **Christopher Francisco**, Oklahoma State University, and **Irena Peeva**, Cornell University.

Graph Theory, **Zixia Song** and **Yue Zhao**, University of Central Florida.

Harmonic Analysis, **Galia D. Dafni**, Concordia University, and **J. Michael Wilson**, University of Vermont, Burlington.

Homological Aspects of Module Theory, **Andrew R. Kustin**, University of South Carolina, **Sean M. Sather-Wagstaff**, North Dakota State University, and **Janet Vassilev**, University of New Mexico.

Hypercomplex Analysis, **Craig A. Nolder**, Florida State University, and **John Ryan**, University of Arkansas at Fayetteville.

Invariants of Knots and Links, **Heather A. Dye**, McKendree University, **Mohamed Elhamdadi**, University of South Florida, and **Louis H. Kauffman**, University of Illinois at Chicago.

Inverse Problems and Signal Processing, **M. Zuhair Nashed** and **Qiyu Sun**, University of Central Florida.

Lattices, Coxeter Groups, and Buildings, **Kai-Uwe Bux**, University of Virginia, **Jon McCammond**, University of California Santa Barbara, and **Kevin Wortman**, University of Utah.

Mathematical Models in Biology, **Patrick de Leenheer**, University of Florida, and **Yuan Wang**, Florida Atlantic University.

Modular Forms and Automorphic Forms, **Jonathan P. Hanke**, University of Georgia.

Partial Differential Equations from Fluid Mechanics, **Chongsheng Cao**, Florida International University, **Jiahong Wu**, Oklahoma State University, and **Baoquan Yuan**, Henan Polytechnic University.

Recent Advances in Probability and Statistics, **Lianfen Qian** and **Hongwei Long**, Florida Atlantic University.

Riverside, California

University of California

November 7–8, 2009

Saturday – Sunday

Meeting #1054

Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: September 2009
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: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: Expired

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Christopher Hacon, University of Utah, *Classification of algebraic varieties.*

Birge Huisgen-Zimmerman, University of California Santa Barbara, *Representations of quivers with relations. Geometric Aspects.*

Jun Li, Stanford University, *Toward high genus GW-invariants of quintic Calabi-Yau threefolds.*

Joseph Teran, University of California Los Angeles, *Scientific computing for movie special effects.*

Special Sessions

Algebraic Geometry, **Christopher Hacon**, University of Utah, and **Ziv Ran**, University of California Riverside.

Algebraic Structures in Knot Theory, **Alissa S. Crans**, Loyola Marymount University, and **Sam Nelson**, Claremont McKenna College.

Arithmetic Combinatorics, **Mei-Chu Chang**, University of California Riverside, and **Alex Gamburd**, University of California Santa Cruz and Northwestern University.

Calabi-Yau Manifolds, **Owen Dearricott**, University of California Riverside, **Jun Li**, Stanford University, and **Bun Wong** and **Yat-Sun Poon**, University of California Riverside.

Dynamical Systems, **Nicolai Haydn**, University of Southern California, and **Huyi Hu**, Michigan State University.

Fluid Mechanics, **James Kelliher** and **Qi Zhang**, University of California Riverside.

Fractal Geometry, Dynamical Systems, Number Theory and Analysis on Rough Spaces, **Michel L. Lapidus**, University of California Riverside, **Hung Lu**, Hawaii Pacific University, and **Erin P. J. Pearse**, University of Iowa.

Global Riemannian Geometry, **Fred Wilhelm**, University of California Riverside, and **Peter Petersen**, University of California Los Angeles.

History and Philosophy of Mathematics, **Shawnee L. McMurran**, California State University San Bernardino, and **James J. Tattersall**, Providence College.

Homotopy Theory and Higher Algebraic Structures, **John Baez** and **Julie Bergner**, University of California Riverside.

Interactions between Algebraic Geometry and Noncommutative Algebra, **Kenneth R. Goodearl**, University of California Santa Barbara, **Daniel S. Rogalski**, University of California San Diego, and **James Zhang**, University of Washington.

Knotting Around Dimension Three: A Special Session in Memory of Xiao-Song Lin, **Martin Scharlemann**, University of California Santa Barbara, and **Mohammed Ait Nouh**, University of California Riverside.

Noncommutative Geometry, **Vasiliy Dolgushev** and **Wee Liang Gan**, University of California Riverside.

Operator Algebras, **Marta Asaeda** and **Aviv Censor**, University of California Riverside, and **Adrian Ioana**, Clay Institute and Caltech.

Representation Theory, **Vyjayanthi Chari**, **Wee Liang Gan**, and **Jacob Greenstein**, University of California Riverside.

Representations of Finite-Dimensional Algebras, **Frauke Bleher**, University of Iowa, **Birge Huisgen-Zimmermann**, University of California at Santa Barbara, and **Markus Schmidmeier**, Florida Atlantic University.

Research Conducted by Students, **Robert G. Niemeyer** and **Jack R. Bennett**, University of California Riverside.

Stochastic Analysis and Applications, **Michael L. Green**, **Alan C. Krinik**, and **Randall J. Swift**, California State Polytechnic University Pomona.

Seoul, South Korea

Ewha Womans University

December 16–20, 2009

Wednesday – Sunday

Meeting #1055

First Joint International Meeting of the AMS and the Korean Mathematical Society.
Associate secretary: Georgia Benkart
Announcement issue of *Notices*: June 2009
Program first available on AMS website: Not applicable
Program issue of electronic *Notices*: Not applicable
Issue of *Abstracts*: Not applicable

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: October 15, 2009

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/internmtgs.html.

Invited Addresses

Young Ju Choi, Pohang University of Science and Technology, *Title to be announced.*

Bumsig Kim, Korea Institute for Advanced Study, *Title to be announced.*

Minhyong Kim, University College London, *Title to be announced.*

Ki-ahm Lee, Seoul National University, *Title to be announced.*

James T. McKernan, Massachusetts Institute of Technology, *Title to be announced.*

Frank Morgan, Williams College, *Title to be announced.*

Hee Oh, Brown University, *Title to be announced.*

Terence Tao, University of California Los Angeles, *Title to be announced.*

Van Vu, Rutgers University, *Title to be announced.*

Special Sessions

Algebraic Combinatorics, **Dongsu Kim**, Korea Advanced Institute of Science & Technology, **Soojin Cho**, Ajou University, and **Bruce Sagan**, Michigan State University.

Algebraic Geometry, **Yongnam Lee**, Sogang University, **Ian Morrison**, Fordham University, and **James McKernan**, Massachusetts Institute of Technology.

Arithmetic of Quadratic Forms, **Myung-Hwan Kim**, Seoul National University, and **Wai Kiu Chan**, Wesleyan University.

Combinatorial Matrix Theory, **Suk-Geun Hwang**, Kyungpook National University, and **Bryan Shader**, University of Wyoming.

Computational Science and Engineering, **Jeehyun Lee**, Yonsei University, and **Max Gunzburger**, Florida State University.

Creativity, Giftedness, and Talent Development in Mathematics, **Kyeong-Hwa Lee**, Seoul National University, and **Bharath Sriraman**, University of Montana.

Cryptography, **Hyang-Sook Lee**, Ewha Womans University, and **Alice Silverberg**, University of California Irvine.

Differential and Integral Geometry, **Young Jin Suh**, Kyungpook National University, **Byung Hak Kim**, Kyung Hee University, **Yongdo Lim**, Kyungpook National University, **Gaoyong Zhang**, Polytechnic University of NYU, and **Jiazu Zhou**, Southwest University.

Ergodic Theory and Dynamical Systems, **Keonhee Lee**, Chungnam National University, **Jeong-Yup Lee**, Korea Institute for Advanced Study, and **Jane Hawkins**, University of North Carolina.

Financial Mathematics, **Hyejin Ku**, York University, **Hyunggeon Koo**, Ajou University, and **Kiseop Lee**, University of Louisville.

Geometric Structures and Geometric Group Theory, **In Kang Kim**, Korea Advanced Institute of Science & Technology, and **Seonhee Lim**, Cornell University.

Geometry of Varieties, Syzygies and Computations, **Sijong Kwak**, Korea Advanced Institute of Science & Technology, **Hyungju Park**, Pohang University of Science & Technology, and **Jerzy Weyman**, Northeastern University.

Harmonic Analysis and Its Applications, **Sunggeum Hong**, Chosun University, and **Andreas Seeger**, University of Wisconsin.

Inverse Problems and Imaging, **Hyeonbae Kang**, Inha University, and **Gunther Uhlmann**, University of Washington.

Knot Theory and Related Topics, **Jae Choon Cha**, Pohang University of Science and Technology, and **Kent Orr**, Inidana University.

Lie Symmetries and Solitons, **Woo-Pyo Hong**, Catholic University of Daegu, **Anjan Biswas**, Delaware State University, and **Chaudry M. Khalique**, North-West University.

Mathematical Analysis in Fluid, Gas Dynamics, and Related Equations, **Minkyu Kwak**, Chonnam National University, **Hyeong-Ohk Bae**, Ajou University, **Seung-Yeal Ha**, Seoul National University, and **Simon Seok Hwang**, LaGrange College.

Mathematical Biology, **Eunok Jung**, Konkuk University, and **Jae-Hun Jung**, SUNY at Buffalo.

Mathematical Logic and Foundation, **Byunghan Kim**, Yonsei University, and **Ivo Herzog**, Ohio State University.

Modular Forms and Related Topics, **Youn-Seo Choi**, Korea Institute for Advanced Study, **YoungJu Choie**, Pohang University of Science & Technology, and **Wen-ching Winnie Li**, Pennsylvania State University.

Noncommutative Ring Theory, **Yang Lee**, Pusan National University, **Nam Kyun Kim**, Hanbat National University, and **Pace P. Nielsen**, Brigham Young University.

Nonlinear Elliptic Partial Differential Equations, **Jaeyoung Byeon**, Pohang University of Science & Technology, and **Zhi-Qiang Wang**, Utah State University.

Nonlinear Partial Differential Equations and Viscosity Solutions, **Ki-ahm Lee**, Seoul National University, and **Inwon Kim**, University of California Los Angeles.

Operator Theory and Operator Algebras, **Il Bong Jung**, Kyungpook National University, **Ja A Jeong**, Seoul National University, **George Exner**, Bucknell University, and **Ken Dykema**, Texas A&M University.

Operator Theory in Analytic Function Spaces, **Hyung Woon Koo** and **Boo Rim Choe**, Korea University, and **Kehe Zhu**, SUNY at Albany.

Representation Theory, **Jae-Hoon Kwon**, University of Seoul, and **Kyu-Hwan Lee**, University of Connecticut.

Spectral Geometry and Global Analysis, **Jinsung Park**, Korea Institute for Advanced Study, and **Maxim Braverman**, Northeastern University.

Symplectic Geometry and Mirror Symmetry, **Jae-Suk Park**, Yonsei University, **Cheol-Hyun Cho**, Seoul National University, and **Yong-Geun Oh**, University of Wisconsin.

San Francisco, California

Moscone Center West and the San Francisco Marriott

January 13–16, 2010

Wednesday – Saturday

Meeting #1056

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
Announcement issue of *Notices*: October 2009
Program first available on AMS website: November 1, 2009
Program issue of electronic *Notices*: January 2010
Issue of *Abstracts*: Volume 31, Issue 1

Deadlines

For organizers: Expired

For consideration of contributed papers in Special Sessions: Expired
For abstracts: Expired

Program Updates

MAA Sessions

The Theater of the Mathematically Absurd, Friday, 6:00 p.m.–7:00 p.m., presented by **Colin Adams** and the **Mobiusbandaid Players**. This theatrical presentation of short, humorous, mathematically-related pieces, including "Happiness is a Warm Theorem", "Immortality", and "The Lord of the Rings: The NSF Fellowship of the Ring" requires no particular math or theatrical background in order to thoroughly enjoy oneself.

Other Organizations

Association for Symbolic Logic
Invited Addresses on Friday and Saturday will be given by **Fernando J. Ferreira**, Universidade de Lisboa; **John Harrison**, Intel Corporation; **François Loeser**, École Normale Supérieure; **Christopher A. Miller**, Ohio State University; **Joseph S. Miller**, University of Wisconsin-Madison; **Slawomir J. Solecki**, University of Illinois at Urbana-Champaign; and **Stevo Todorcevic**, Université Denis Diderot, Paris VII, and University of Toronto. Specific days and times, as well as talk titles, will be announced at a later time.

Society for Industrial and Applied Mathematics
The titles, organizers, and days and times of the mini-symposia are

Economics and Sustainability, **Christian Traeger**, University of California, Berkeley, Wednesday morning;

Education, **Peter Turner**, Clarkson University, Thursday morning;

Mathematics and a Smart Planet, **Brenda Dietrich**, IBM T. J. Watson Research, Thursday afternoon;

Graph Theory, **Andre Kundgen**, California State University San Marcos, and **Hal Kierstead**, Arizona State University, Friday;

New Trends in Mathematical Biology, **Mariel Vazquez** and **Javier Arsuaga**, San Francisco State University, Saturday morning.

National Association of Mathematicians
The Cox-Talbot Address will be given by **Abdulalim A. Shabazz**, Grambling University, *title to be announced*, after the banquet on Friday evening.

Social Events

George Washington University Alumni Reception, Thursday, 6:00 p.m.–7:30 p.m. Please join the Department of Mathematics and the Alumni Association at this event for alumni, faculty, and current students. Mingle with old friends, reconnect with the faculty, meet current students, and network with fellow alumni.

Reception in Honor of Retiring MAA Secretary Martha Siegel, Saturday, 5:00 p.m.-6:15 p.m. Tirelessly for 14 years, Martha has served the MAA community well with her strong and fair leadership as secretary, putting in many hours overseeing the MAA Executive Committee and Board of Governors. Join us and your colleagues in thanking Martha for her dedicated service and wishing Martha well as she moves into in the next chapter of her life. Tickets are US$25 each, including tax and gratuity. There will be a cash bar and light hors d'oeuvres will be served.

Lexington, Kentucky

University of Kentucky

March 27–28, 2010

Saturday – Sunday

Meeting #1057

Southeastern Section
Associate secretary: Matthew Miller
Announcement issue of *Notices*: January 2010
Program first available on AMS website: February 11, 2010
Program issue of electronic *Notices*: March 2010
Issue of *Abstracts*: Volume 31, Issue 2

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: December 8, 2009
For abstracts: February 2, 2010

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Percy A. Deift, Courant Institute–New York University, *Title to be announced*.

Irina Mitrea, Worcester Polytechnic Institute, *Recent progress in the area of elliptic boundary value problems on rough domains*.

Bruce Reznick, University of Illinois at Urbana Champaign, *Title to be announced*.

Bernd Ulrich, Purdue University, *Title to be announced*.

Doron Zeilberger, Rutgers University, *3x+1* (Erdős Memorial Lecture).

Special Sessions

Advances in Algebraic Coding Theory (Code: SS 6A), **Heide Gluesing-Luerssen**, University of Kentucky, and **Jon-Lark Kim**, University of Louisville.

Advances in Algebraic Statistics (Code: SS 2A), **Sonja Petrović**, University of Illinois, Chicago, and **Ruriko Yoshida**, University of Kentucky.

Advances in Algebraic and Geometric Combinatorics (Code: SS 14A), **Richard Ehrenborg** and **Margaret A. Readdy**, University of Kentucky.

Analysis and Control of Dispersive Partial Differential Equations (Code: SS 25A), **Michael J. Goldberg** and **Bingyu Zhang**, University of Cincinnati.

Combinatorial Algebra (Code: SS 7A), **Juan C. Migliore**, University of Notre Dame, and **Uwe Nagel**, University of Kentucky.

Commutative Algebra (Code: SS 1A), **Alberto Corso**, University of Kentucky, **Claudia Polini**, University of Notre Dame, and **Bernd Ulrich**, Purdue University.

Complex Analysis and Potential Theory (Code: SS 4A), **James E. Brennan** and **Vladimir Eiderman**, University of Kentucky.

Financial Mathematics and Statistics (Code: SS 22A), **Kiseop Lee**, University of Louisville, and **Jose Figueroa-Lopez**, Department of Statistics, Purdue University.

Function Theory, Harmonic Analysis, and Partial Differential Equations (Code: SS 5A), **Joel Kilty**, Centre College, **Irina Mitrea**, Worcester Polytechnic Institute, and **Katharine Ott**, University of Kentucky.

Geometric Function Theory and Analysis on Metric Spaces (Code: SS 3A), **John L. Lewis**, University of Kentucky, and **Nageswari Shanmugalingam**, University of Cincinnati.

Homotopy Theory and Geometric Aspects of Algebraic Topology (Code: SS 16A), **Serge Ochanine**, University of Kentucky, and **Marian F. Anton**, Centre College.

Interactions between Logic, Topology, and Complex Analysis (Code: SS 23A), **Matt Insall**, Missouri University of Science and Technology, and **Malgorzata Marciniak**, University of Toledo.

Inverse Problems, Riemann-Hilbert Problems, and Nonlinear Dispersive Equations (Code: SS 10A), **Peter A. Perry**, University of Kentucky, and **Peter Topalov**, Northeastern University.

Large Scale Matrix Computation (Code: SS 19A), **Qiang Ye**, University of Kentucky, and **Lothar Reichel**, Kent State University.

Mathematical Economics (Code: SS 21A), **Adib Bagh** and **Robert E. Molzon**, University of Kentucky.

Mathematical Problems in Mechanics and Materials Science (Code: SS 20A), **Michel E. Jabbour** and **Chi-Sing Man**, University of Kentucky, and **Kazumi Tanuma**, Gunma University.

Mathematical String Theory (Code: SS 18A), **Al Shapere**, Department of Physics and Astronomy, University of Kentucky, **Eric Sharpe**, Physics Department, Virginia Polytechnic Institute and State University, and **Mark A. Stern**, Duke University.

Mathematics Outreach (Code: SS 26A), **Carl W. Lee** and **David C. Royster**, University of Kentucky.

Matroid Theory (Code: SS 9A), **Jakayla Robbins**, University of Kentucky, and **Xiangqian Zhou**, Wright State University.

Multivariate and Banach Space Polynomials (Code: SS 15A), **Richard A. Aron**, Kent State University, and **Lawrence A. Harris**, University of Kentucky.

Noncommutative Algebraic Geometry (Code: SS 24A), **Dennis S. Keeler** and **Kimberly Retert**, Miami University.

Partial Differential Equations in Geometry and Variational Problems (Code: SS 8A), **Luca Capogna**, University of Arkansas, and **Changyou Wang**, University of Kentucky.

Recent Progress in Numerical Methods for Partial Differential Equations (Code: SS 12A), **Alan Demlow**, University of Kentucky, and **Xiaobing H. Feng**, University of Tennessee at Knoxville.

Relative Homological Algebra (Code: SS 11A), **Edgar E. Enochs**, University of Kentucky, and **Alina C. Iacob**, Georgia Southern University.

Sharp Spectral Estimates in Analysis, Geometry, and Probability (Code: SS 17A), **Richard S. Laugesen** and **Bartlomiej Siudeja**, University of Illinois.

Spectral and Transport Properties of Schrödinger Operators (Code: SS 13A), **Peter D. Hislop**, University of Kentucky, and **Jeffrey H. Schenker**, Michigan State University.

St. Paul, Minnesota

Macalester College

April 10–11, 2010

Saturday – Sunday

Meeting #1058

Central Section
Associate secretary: Georgia Benkart
Announcement issue of *Notices*: February 2010
Program first available on AMS website: February 25, 2010
Program issue of electronic *Notices*: April 2010
Issue of *Abstracts*: Volume 31, Issue 2

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: December 22, 2009
For abstracts: February 16, 2010

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Charles Doering, University of Michigan, *Title to be announced*.

Matthew James Emerton, Northwestern University, *Title to be announced*.

Vladimir Touraev, Indiana University, *Title to be announced*.

Peter Webb, University of Minnesota, *Title to be announced*.

Special Sessions

Cohomology and Representation Theory of Algebraic Groups and Related Structures (Code: SS 7A), **Christopher Bendel**, University of Wisconsin-Stout, **Bobbe Cooper**, University of Minnesota, and **Terrell Hodge**, Western Michigan University.

Combinatorial Representation Theory (Code: SS 3A), **Tom Halverson**, Macalester College, and **Victor Reiner**, University of Minnesota.

Commutative Ring Theory (Code: SS 5A), **Michael Axtell**, University of St. Thomas, and **Joe Stickles**, Milliken University.

Geometric Flows, Moving Frames and Integrable Systems (Code: SS 8A), **Gloria Mari-Beffa**, University of Wisconsin-Madison, and **Peter Olver**, University of Minnesota.

Matrices and Graphs (Code: SS 9A), **Luz M. DeAlba**, Drake University, **Adam Berlinger**, St. Olaf College, **Leslie Hogben**, Iowa State University, and **In-Jae Kim**, Minnesota State University.

Partition Theory and the Combinatorics of Symmetric Functions (Code: SS 6A), **Eric S. Egge**, Carleton College, and **Kristina Garrett**, St. Olaf College.

Probabilistic and Extremal Combinatorics (Code: SS 2A), **Ryan Martin** and **Maria Axenovich**, Iowa State University.

Quantum Invariants of 3-manifolds and Modular Categories (Code: SS 1A), **Thang Le**, Georgia Institute of Technology, **Eric Rowell**, Texas A&M University, and **Vladimir Touraev**, Indiana University.

Universal Algebra and Order (Code: SS 4A), **Jeffrey Olson**, Norwich University, **Jeremy Alm**, Illinois College, **Kristi Meyer**, Wisconsin Lutheran College, and **Japheth Wood**, Bard College.

Albuquerque, New Mexico

University of New Mexico

April 17–18, 2010

Saturday – Sunday

Meeting #1059

Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: February 2010
Program first available on AMS website: March 4, 2010
Program issue of electronic *Notices*: April 2010
Issue of *Abstracts*: Volume 31, Issue 3

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: December 29, 2009
For abstracts: February 23, 2010

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Kenneth Bromberg, University of Utah, *Title to be announced.*

Danny Calegari, California Institute of Technology, *Title to be announced.*

Ioana Dumitriu, University of Washington, *Title to be announced.*

Steffen Rhode, University of Washington, *Title to be announced.*

Special Sessions

Dyadic and Non-Dyadic Harmonic Analysis (Code: SS 2A), **M. Cristina Pereyra**, University of New Mexico, and **Stephanie A. Salomone**, University of Portland.

Financial Mathematics: The Mathematics of Financial Markets and Structures (Code: SS 4A), **Maria Cristina Mariani**, University of Texas at El Paso, **Ionut Florescu**, Stevens Institute of Technology, and **Maria P. Beccar-Varela**, University of Texas at El Paso.

Geometric Combinatorics (Code: SS 6A), **Art M. Duval**, University of Texas at El Paso, and **Jeremy Martin**, University of Kansas.

Harmonic Analysis and Partial Differential Equations (Code: SS 5A), **Matthew Blair**, University of New Mexico, and **Hart Smith**, University of Washington.

Subjects in between Pure and Applied Mathematics (Code: SS 7A), **Hannah Makaruk** and **Robert Owczarek**, Los Alamos National Laboratory.

Topics in Geometric Group Theory (Code: SS 1A), **Matthew Day**, California Institute of Technology, **Daniel Peter Groves**, University of Illinois at Chicago, **Jason Manning**, SUNY at Buffalo, and **Henry Wilton**, University of Texas.

Trends in Commutative Algebra (Code: SS 3A), **Louiza Fouli**, New Mexico State University, and **Janet Vassilev**, University New Mexico.

Newark, New Jersey

New Jersey Institute of Technology

May 22–23, 2010

Saturday – Sunday

Meeting #1060

Eastern Section
Associate secretary: Steven H. Weintraub
Announcement issue of *Notices*: March 2020
Program first available on AMS website: April 8, 2010
Program issue of electronic *Notices*: May 2020
Issue of *Abstracts*: Volume 31, Issue 3

Deadlines

For organizers: November 23, 2009
For consideration of contributed papers in Special Sessions: February 2, 2010
For abstracts: March 30, 2010

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Simon Brendle, Stanford University, *Hamilton's Ricci flow and the sphere theorem in geometry.*

Konstantin M. Mischaikow, Rutgers University, *Computational topology applied to the global dynamics of nonlinear systems.*

Ricardo H. Nochetto, University of Maryland, *Curvature driven flows in deformable domains.*

Richard E. Schwartz, Brown University, *Polygonal outer billiards.*

Special Sessions

Expandable Computations, Algorithms, Methodologies and Experiments for Engineering Interpretation. (Code: SS 1A), **Mustapha S. Fofana**, Worcester Polytechnic Institute, **Marie D. Dahleh**, Harvard School of Engineering and Applied Sciences Harvard University, and **Kenji Kawashima**, Precision and Intelligence Laboratory Tokyo Institute of Technology.

Berkeley, California

University of California Berkeley

June 2–5, 2010

Wednesday – Saturday

Meeting #1061

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: April 22, 2010
Program issue of electronic *Notices*: June 2010
Issue of *Abstracts*: Volume 31, Issue 3

Deadlines

For organizers: November 3, 2009
For consideration of contributed papers in Special Sessions: February 16, 2010
For abstracts: April 13, 2010

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/internmtgs.html`.

Invited Addresses

Alejandro Adem, University of British Columbia and PIMS, *Title to be announced.*

Peter W-K Li, University of California Irvine, *Title to be announced.*

Ernesto Lupercio, CINVESTAV, *Title to be announced.*

Victor Perez Abreu, CIMAT, *Title to be announced.*

Alberto Verjovsky, IM-UNAM, *Title to be announced.*

Maciej Zworski, University of California Berkeley, *Title to be announced.*

Special Sessions

Analytic Aspects of Differential Geometry (Code: SS 2A), **Nelia Charalambous**, ITAM, **Lizhen Ji**, University of Michigan, and **Jiaping Wang**, University of Minnesota.

Harmonic Analysis, Microlocal Analysis, and Partial Differential Equations (Code: SS 1A), **Gunther Uhlmann**, University of Washington, and **Salvador Perez Esteva**, UNAM.

Syracuse, New York

Syracuse University

October 2–3, 2010

Saturday – Sunday

Meeting #1062

Eastern Section
Associate secretary: Steven H. Weintraub
Announcement issue of *Notices*: To be announced
Program first available on AMS website: August 19, 2010
Program issue of electronic *Notices*: October
Issue of *Abstracts*: Volume 31, Issue 4

Deadlines

For organizers: March 2, 2010
For consideration of contributed papers in Special Sessions: June 15, 2010
For abstracts: August 10, 2010

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Special Sessions

Nonlinear Analysis and Geometry (Code: SS 1A), **Tadeusz Iwaniec**, **Leonid V. Kovalev**, and **Jani Onninen**, Syracuse University.

Los Angeles, California

University of California Los Angeles

October 9–10, 2010

Saturday – Sunday

Meeting #1063

Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: August 2010
Program first available on AMS website: August 26, 2010
Program issue of electronic *Notices*: October 2010
Issue of *Abstracts*: Volume 31, Issue 4

Deadlines

For organizers: March 10, 2010
For consideration of contributed papers in Special Sessions: June 22, 2010
For abstracts: August 17, 2010

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Greg Kuperberg, University of California Davis, *Title to be announced*.

Cris Moore, University of New Mexico, *Title to be announced*.

Stanley Osher, University of California Los Angeles, *Title to be announced*.

Terence Tao, University of California Los Angeles, *Title to be announced* (Einstein Public Lecture in Mathematics).

Melanie Wood, Princeton University, *Title to be announced*.

Special Sessions

Large Cardinals and the Continuum (Code: SS 2A), **Matthew Foreman**, University of California Irvine, **Alekos Kechris**, California Institute for Technology, **Itay Neeman**, University of California Los Angeles, and **Martin Zeman**, University of California Irvine.

Topology and Symplectic Geometry (Code: SS 1A), **Robert Brown** and **Ciprian Manolescu**, University of California Los Angeles, and **Stefano Vidussi**, University of California Riverside.

Notre Dame, Indiana

Notre Dame University

October 29–31, 2010

Friday – Sunday

Meeting #1064

Central Section
Associate secretary: Georgia Benkart
Announcement issue of *Notices*: August 2010
Program first available on AMS website: September 16, 2010
Program issue of electronic *Notices*: October 2010
Issue of *Abstracts*: Volume 31, Issue 4

Deadlines

For organizers: February 19, 2010
For consideration of contributed papers in Special Sessions: July 20, 2010
For abstracts: September 7, 2010

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Laura DeMarco, University of Illinois at Chicago, *Title to be announced*.

Jordan Ellenberg, University of Wisconsin, *Title to be announced*.

David Fisher, Indiana University, *Title to be announced*.

Jared Wunsch, Northwestern University, *Title to be announced*.

Special Sessions

Commutative Algebra and Its Interactions with Algebraic Geometry (Code: SS 2A), **Claudia Polini**, University of Notre Dame, **Alberto Corso**, University of Kentucky, and **Bernd Ulrich**, Purdue University.

Hilbert Functions in Commutative Algebra and Algebraic Combinatorics (Code: SS 3A), **Fabrizio Zanello**, Michigan Technological University, **Juan Migliore**, University of Notre Dame, and **Uwe Nagel**, University of Kentucky.

Singularities in Algebraic Geometry (Code: SS 1A), **Nero Budur**, University of Notre Dame, and **Lawrence Ein**, University of Illinois at Chicago.

Richmond, Virginia

University of Richmond

November 6–7, 2010

Saturday – Sunday

Meeting #1065

Southeastern Section
Associate secretary: Matthew Miller
Announcement issue of *Notices*: September
Program first available on AMS website: September 23, 2010
Program issue of electronic *Notices*: November
Issue of *Abstracts*: Volume 31, Issue 4

Deadlines

For organizers: March 8, 2010
For consideration of contributed papers in Special Sessions: July 27, 2010
For abstracts: September 14, 2010

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Matthew H. Baker, Georgia Institute of Technology, *Title to be announced*.

Michael J. Field, University of Houston, *Title to be announced*.

Sharon R. Lubkin, North Carolina State University, *Title to be announced*.

Stefan Richter, University of Tennessee, Knoxville, *Title to be announced*.

Pucon, Chile

December 15–18, 2010

Wednesday – Saturday

First Joint International Meeting between the AMS and the Sociedad de Matematica de Chile.

Associate secretary: Steven H. Weintraub
Announcement issue of *Notices*: June 2010
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: To be announced
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

Iowa City, Iowa

University of Iowa

March 18–20, 2011

Friday – Sunday

Central Section
Associate secretary: Georgia Benkart
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: July 16, 2010
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Worcester, Massachusetts

College of the Holy Cross

April 9–10, 2011

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: September 9, 2010
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Las Vegas, Nevada

University of Nevada

April 30 – May 1, 2011

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: To be announced

For consideration of contributed papers in Special Sessions: To be announced

For abstracts: To be announced

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Special Sessions

Geometric PDEs (Code: SS 1A), **Matthew Gursky**, Notre Dame University, and **Emmanuel Hebey**, Universite de Cergy-Pontoise.

Salt Lake City, Utah

University of Utah

October 22–23, 2011

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: To be announced

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: Georgia Benkart

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, Baltimore Hilton, and Marriott Inner Harbor

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 2013
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*: Volume 36, Issue 1

Deadlines

For organizers: April 1, 2014
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Seattle, Washington

Washington State Convention & Trade Center and the Sheraton Seattle Hotel

January 6–9, 2016

Wednesday – Saturday

Joint Mathematics Meetings, including the 122nd Annual Meeting of the AMS, 99th 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: Michel L. Lapidus
Announcement issue of *Notices*: October 2015
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: January 2016
Issue of *Abstracts*: Volume 37, Issue 1

Deadlines

For organizers: April 1, 2015
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Atlanta, Georgia

Hyatt Regency Atlanta and Marriott Atlanta Marquis

January 4–7, 2017

Wednesday – Saturday

Joint Mathematics Meetings, including the 123rd Annual Meeting of the AMS, 100th 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: Georgia Benkart
Announcement issue of *Notices*: October 2016
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: January 2017
Issue of *Abstracts*: Volume 38, Issue 1

Deadlines

For organizers: April 1, 2016
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

2010 Joint Mathematics Meetings Advance Registration/Housing Form

2010 Joint Mathematics Meetings
San Francisco, CA
January 13–16, 2010

Name ____
(please write name as you would like it to appear on your badge)

Mailing Address ____

____

Telephone ______________________ Fax: ______________________

In case of emergency (for you) at the meeting, call: Day # __________ Evening #: __________

Email Address ____

Acknowledgment of this registration and any hotel reservations will be sent to the email address given here, unless you check this box: *Send by U.S. Mail* ☐

Affiliation for badge ______________________ (company/university) Nonmathematician guest badge name: ______________________ (accompanying registered mathematician; please note charge below)

☐ **I DO NOT want my program and badge to be mailed to me on 12/11/09. (Materials will be mailed to the address listed above unless you check this box.)**

Registration Fees

Membership ✓ all that apply. First row is eligible for JMM member registration fee.

❑ AMS ❑ MAA ❑ ASL ❑ CMS ❑ SIAM
❑ ASA ❑ AWM ❑ NAM ❑ YMN

Joint Meetings	by Dec 22	at mtg	Subtotal
❑ Member AMS, MAA, ASL, CMS, SIAM	US $220	US $288	
❑ Nonmember	US $342	US $444	
❑ Graduate Student	US $ 45	US $ 55	
❑ Undergraduate Student	US $ 35	US $ 45	
❑ High School Student	US $ 5	US $ 10	
❑ Unemployed	US $ 45	US $ 55	
❑ Temporarily Employed	US $177	US $206	
❑ Developing Countries Special Rate	US $ 45	US $ 55	
❑ Emeritus Member of AMS or MAA	US $ 45	US $ 55	
❑ High School Teacher	US $ 45	US $ 55	
❑ Librarian	US $ 45	US $ 55	
❑ Press	US $ 0	US $ 0	
❑ Nonmathematician Guest	US $ 15	US $ 15	
			$ ______

AMS Short Course: *Markov Chains and Mixing Times (1/11–1/12)*

❑ Member of AMS or MAA	US $ 98	US $135	
❑ Nonmember	US $132	US $165	
❑ Student, Unemployed, Emeritus	US $ 46	US $ 67	

The first 80 people who sign up for this course will receive a book (shipped by mid-late December). See details in announcement.
To ensure its receipt please list your home address above. $ ______

MAA Short Course: *Exploring the Great Books of Mathematics. (1/11–1/12)*

❑ Member of MAA or AMS	US $150	US $160	
❑ Nonmember	US $200	US $210	
❑ Student, Unemployed, Emeritus	US $ 75	US $ 85	
			$ ______

AMS Tutorial on Modeling: *An Introduction to Numerical and Statistical Modeling (1/11-1/12)* US $ 25 US $ 25 $ ______

MAA Minicourses (see listing in text)
I would like to attend: ❑ One Minicourse ❑ Two Minicourses
Please enroll me in MAA Minicourse(s) #_____ and/or #_____
In order of preference, my alternatives are: #_____ and/or #_____
Price: US $75 for each minicourse.
(For more than 2 minicourses call or email the MMSB.) $ ______

Employment Center *Please go to http://eims.ams.org to register. For further information contact Steven Ferrucci at emp-info@ams.org.*

Graduate Program Fair
❑ Graduate Program Table US $ 50 N/A
$ ______

Events with Tickets
MER Banquet (1/14) US $53.00 #___Regular #___Veg #___Kosher
NAM Banquet (1/15) US $53.00 #___Regular #___Veg #___Kosher
AMS Banquet (1/16) US $53.00 #___Regular #___Veg #___Kosher
Reception in honor of Martha Siegel (1/16) US $25.00 #___
$ ______

Other Events
❑ Graduate Student/First Time Attendee Reception (1/14) (no charge)

Total for Registrations and Events $ ______

Payment

Registration & Event Total (total from column on left) $ ______
Hotel Deposit (only if paying by check) $ ______

Total Amount To Be Paid **$** ______
(Note: A US $5 processing fee will be charged for each returned check or invalid credit card. Debit cards are not accepted.)

Method of Payment
❑ Check. Make checks payable to the AMS. Checks drawn on foreign banks must be in equivalent foreign currency at current exchange rates.
❑ Credit Card. VISA, MasterCard, AMEX, Discover (no others accepted)

Card number: ______________________

Exp. date: ______ Zipcode of credit card billing address: ______

Signature: ______________________

Name on card: ______________________

❑ Purchase order # ______________ (please enclose copy)

Other Information

Mathematical Reviews field of interest # ______
How did you hear about this meeting? Check one: ❑ Colleague(s) ❑ *Notices* ❑ *Focus* ❑ Internet
❑ This is my first Joint Mathematics Meetings.
❑ I am a mathematics department chair.
❑ For planning purposes for the MAA Two-year College Reception, please check if you are a faculty member at a two-year college.
❑ I would like to receive promotions for future JMM meetings.
❑ **Please do not include my name on any promotional mailing list.**
❑ Please ✓ this box if you have a disability requiring special services.

Mail to:

Mathematics Meetings Service Bureau (MMSB)
P. O. Box 6887
Providence, RI 02940-6887 Fax: 401-455-4004
Questions/changes call: 401-455-4143 or 1-800-321-4267 x4143; mmsb@ams.org

Deadlines *Please register by the following dates for:*

To be eligible for the complimentary room drawing:	**Nov. 4, 2009**
For housing reservations, badges/programs mailed:	**Nov. 18, 2009**
For housing changes/cancellations through MMSB:	**Dec. 14, 2009**
For advance registration for the Joint Meetings, Short Courses, MAA Minicourses, Tutorial & Tickets:	**Dec. 22, 2009**
For 50% refund on banquets, cancel by:	**Jan. 4, 2010***
For 50% refund on advance registration, Minicourses & Short Courses, cancel by:	**Jan. 8, 2010***

***no refunds after this date**

Registration for the Joint Meetings is not required for the Short Courses or the Tutorial, but it is required for the Minicourses & Employment Center.

San Francisco Joint Mathematics Meetings Hotel Reservations

Please see the hotel page in the announcement or web for detailed information on each hotel. To ensure accurate assignments, please rank hotels in order of preference by writing 1, 2, 3, etc., in the column on the left and by circling the requested room type and rate. If the rate or the hotel requested is no longer available, you will be assigned a room at a ranked or unranked hotel at a comparable rate. Please call the MMSB for details on suite configurations, sizes, availability, etc. Suite reservations can only be made through the MMSB to receive the convention rate. Reservations at the following hotels must be made through the MMSB to receive the convention rates listed. Reservations made directly with the hotels at the JMM rate will be changed to a higher rate. All rates are subject to a 15.5% sales tax. **Guarantee requirements: First night deposit by check (add to payment on reverse of form) or a credit card guarantee.**

❑ Deposit enclosed (see front of form) ❑ Hold with my credit card Card Number ______ Exp. Date ______ Signature ______

Date and Time of Arrival ______ **Date and Time of Departure** ______

Name of Other Room Occupant ______ **Arrival Date** ______ **Departure Date** ______ **Child (give age(s)** ______

Order of choice	Hotel	Single	Double 1 bed	Double 2 beds	Triple 2 beds	Triple 2 beds w/cot	Triple - king or queen w/cot	Quad 2 beds	Quad 2 beds w/cot	Suites Starting rates
	Marriott San Francisco (Hdqtrs)	US $175	US $175	US $175	US $195	N/A	US $195	US $215	N/A	US $349
	Marriott Student Rate	US $140	US $140	US $140	US $160	N/A	US $160	US $180	N/A	N/A
	Intercontinental San Francisco	US $175	US $175	US $175	US $195	N/A	US $215	US $215	N/A	US $269
	Intercontinental Student Rate	US $140	US $140	US $140	US $160	N/A	US $180	US $180	N/A	N/A
	W Hotel San Francisco	US $169	US $169	US $169	US $209	N/A	US $239	US $249	N/A	US $1000
	W Hotel Student Rate	US $140	US $140	US $140	US $180	N/A	US $210	US $220	N/A	N/A
	Serrano Hotel	US $160	US $160	US $160	US $180	N/A	N/A	US $200	N/A	US $259
	Parc 55 Hotel San Francisco	US $152	US $152	US $152	US $172	N/A	US $192	US $192	N/A	US $625
	Parc 55 Student Rate	US $135	US $135	US $135	US $155	N/A	US $175	US $175	N/A	N/A
	Handlery Union Square Hotel	US $146	US $146	US $146	US $156	N/A	N/A	US $166	N/A	US $300
	Handlery Student Rate	US $136	US $136	US $136	US $146	N/A	N/A	US $156	N/A	N/A
	Holiday Inn Civic Center	US $120	US $120	US $120	US $145	US $165	US $165	US $170	US $190	US $299
	Holiday Inn Student Rate	US $110	US $110	US $110	US $135	US $155	US $155	US $160	US $180	N/A
	The Powell Hotel	US $110	US $110	US $110	US $125	N/A	N/A	US $140	N/A	US $250
	Powell Hotel Student Rate	US $99	US $99	US $99	US $114	N/A	N/A	US $129	N/A	N/A
	Hotel Mark Twain	US $99	US $99	US $99	US $109	N/A	N/A	US $119	N/A	US $209
	Hotel Whitcomb	US $99	US $99	US $99	US $109	US $129	US $129	US $119	US $139	US $295

Special Housing Requests:.

❑ I have disabilities as defined by the ADA that require a sleeping room that is accessible to the physically challenged. My needs are: ______

❑ Other requests: ______

❑ I am a member of a hotel frequent-travel club and would like to receive appropriate credit. The hotel chain and card number are: ______

Email confirmations (no paper) will be sent by the Marriott, the Intercontinental, the Holiday Inn Civic Center, and the Hotel Whicomb. The other hotels will not be sending confirmations.

If you are not making a reservation, please check off one of the following:

❑ I plan to make a reservation at a later date.

❑ I will be making my own reservations at a hotel not listed. Name of hotel: ______

❑ I live in the area or will be staying privately with family or friends.

❑ I plan to share a room with ______, who is making the reservations.

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 92521-0135; 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: susan@math.nwu.edu; telephone: 312-996-3041. **Georgia Benkart** (after January 31, 2010), University of Wisconsin-Madison, Department of Mathematics, 480 Lincoln Drive, Madison, WI 53706-1388; e-mail: benkart@math.wisc.edu; telephone: 608-263-4283.

Eastern Section: **Steven H. Weintraub**, 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:

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 similarily 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:

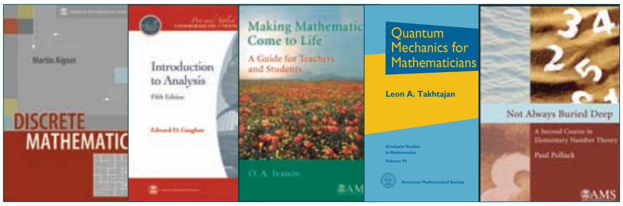
March 18-21, 2010: First International Conference on Mathematics and Statistics, AUS-ICMS '10, American University of Sharjah, Sharjah, United Arab Emirates (please see http://www.aus.edu/conferences/icms10/ for more information).

June 17-19, 2010: Coimbra Meeting on 0-1 Matrix Theory and Related Topics, University of Coimbra, Portugal (for more information please see http://www.mat.uc.pt/~cmf/01MatrixTheory).

AMERICAN MATHEMATICAL SOCIETY

TEXTBOOKS FROM THE AMS

Graduate and undergraduate level publications suitable for use as textbooks and supplementary course reading



Advanced Calculus
◆ UNDERGRADUATE

Second Edition

Patrick M. Fitzpatrick, *University of Maryland, College Park, MD*

Pure and Applied Undergraduate Texts, Volume 5; 2006; 590 pages; Hardcover; ISBN: 978-0-8218-4791-6; List US$82; AMS members US$66; Order code AMSTEXT/5

Discrete Mathematics
◆◆ UNDERGRADUATE GRADUATE

Martin Aigner, *Freie Universität Berlin, Germany*

2007; 388 pages; Hardcover; ISBN: 978-0-8218-4151-8; List US$59; AMS members US$47; Order code DISCMAT

Foundations of Mechanics
◆ GRADUATE

Second Edition

Ralph Abraham, *University of California, Santa Cruz, CA*, and **Jerrold E. Marsden**, *California Institute of Technology, Pasadena, CA*

AMS Chelsea Publishing, Volume 364; 1978; 826 pages; Hardcover; ISBN: 978-0-8218-4438-0; List US$99; AMS members US$89; Order code CHEL/364.H

Introduction to Analysis
◆ UNDERGRADUATE

Fifth Edition

Edward D. Gaughan, *New Mexico State University, Las Cruces, NM*

Pure and Applied Undergraduate Texts, Volume 1; 1998; 240 pages; Hardcover; ISBN: 978-0-8218-4787-9; List US$62; AMS members US$50; Order code AMSTEXT/1

Introduction to Probability
◆◆ UNDERGRADUATE GRADUATE

Second Revised Edition

Charles M. Grinstead, *Swarthmore College, PA*, and **J. Laurie Snell**, *Dartmouth College, Hanover, NH*

1997; 510 pages; Hardcover; ISBN: 978-0-8218-0749-1; List US$57; AMS members US$46; Order code IPROB

Making Mathematics Come to Life
◆ GRADUATE

A Guide for Teachers and Students

O. A. Ivanov, *Steklov Institute of Mathematics, St. Petersburg, Russia*

2009; approximately 326 pages; Hardcover; ISBN: 978-0-8218-4808-1; List US$69; AMS members US$55; Order code MBK/61

Not Always Buried Deep
◆◆ UNDERGRADUATE GRADUATE

A Second Course in Elementary Number Theory

Paul Pollack, *University of Illinois, Urbana-Champaign, IL*

2009; 303 pages; Hardcover; ISBN: 978-0-8218-4880-7; List US$62; AMS members US$50; Order code MBK/68

Numerical Analysis
◆ UNDERGRADUATE

Mathematics of Scientific Computing, Third Edition

David Kincaid and **Ward Cheney**, *University of Texas at Austin, TX*

Pure and Applied Undergraduate Texts, Volume 2; 2002; 788 pages; Hardcover; ISBN: 978-0-8218-4788-6; List US$89; AMS members US$71; Order code AMSTEXT/2

Quantum Mechanics for Mathematicians
◆ GRADUATE

Leon A. Takhtajan, *Stony Brook University, NY*

Graduate Studies in Mathematics, Volume 95; 2008; 387 pages; Hardcover; ISBN: 978-0-8218-4630-8; List US$69; AMS members US$55; Order code GSM/95

A View from the Top
◆ UNDERGRADUATE

Analysis, Combinatorics and Number Theory

Alex Iosevich, *University of Missouri, Columbia, MO*

Student Mathematical Library, Volume 39; 2007; 136 pages; Softcover; ISBN: 978-0-8218-4397-0; List US$29; AMS members US$23; Order code STML/39

AMS
American Mathematical Society

View the entire list of textbook titles: www.ams.org/bookstore/textbooks

Order an exam copy: www.ams.org/bookstore-exam-copy

Springer
the language of science

springer.com

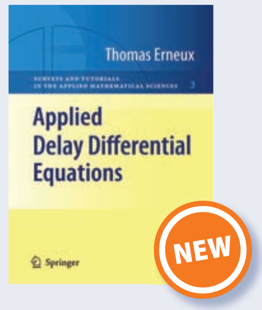
Highlights in Springer's eBook Collection

This book stresses applications of real analysis, detailing how its principles and theory can be applied in a variety of settings in subjects ranging from Fourier series and polynomial approximation to discrete dynamical systems and nonlinear optimization.

2009. Approx. 520 p. 80 illus. (Undergraduate Texts in Mathematics) Hardcover
ISBN 978-0-387-98097-3 ► **$79.95**

Starting with basic principles, this book provides a comprehensive classification of the various types of finite reflection groups and describes their underlying geometric properties. Numerous exercises at various levels of difficulty are included.

2010. XII, 172 p. 74 illus. (Universitext) Softcover
ISBN 978-0-387-79065-7 ► **$49.95**



This accessible book offers a general introduction to delay differential equations. It is a revised version of a series of lectures given at the Université Libre de Bruxelles and then at the Université Joseph Fourier (Grenoble) during the spring of 2003.

2009. XII, 204 p. (Surveys and Tutorials in the Applied Mathematical Sciences, Volume 3) Softcover
ISBN 978-0-387-74371-4 ► **$39.95**

For access check with your librarian

Colorado Mathematical Olympiad

The First Twenty Years and Further Explorations

A. Soifer, University of Colorado, Colorado Springs, CO, USA

In two decades, the Colorado Springs Mathematics Olympiad has become an annual state-wide competition. This book tells the history of the competition as well as an outline of the problems and solutions that have been a part of the contest.

2nd ed. 2010. Approx. 400 p. 140 illus. Softcover
ISBN 978-0-387-75471-0 ► **approx. $44.95**

Deformation Theory

R. Hartshorne, University of California, Berkeley, CA, USA

This first textbook on deformation theory begins by studying what happens over small infinitesimal deformations, and then gradually builds up to more global situations. The author provides plenty of motivation, including numerous exercises and examples.

2010. Approx. 240 p. 19 illus. (Graduate Texts in Mathematics, Volume 257) Hardcover
ISBN 978-1-4419-1595-5 ► **approx. $49.95**

A Course in Mathematical Logic for Mathematicians

Y. I. Manin, Max-Planck-Institut für Mathematik, Bonn, Germany

With contrib. by: **B. Zilber**, Mathematical Institute, University of Oxford, Oxford, UK

This new edition of the straightforward introduction to mathematical logic retains its appeal to the intuition of working mathematicians, yet along with material from the first edition, it has fresh chapters, one of which deals with Model Theory.

2nd ed. 2010. XII, 384 p. 12 illus. (Graduate Texts in Mathematics, Volume 53) Hardcover
ISBN 978-1-4419-0614-4 ► **$69.95**

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0002-9920(200911)56:10;1-2