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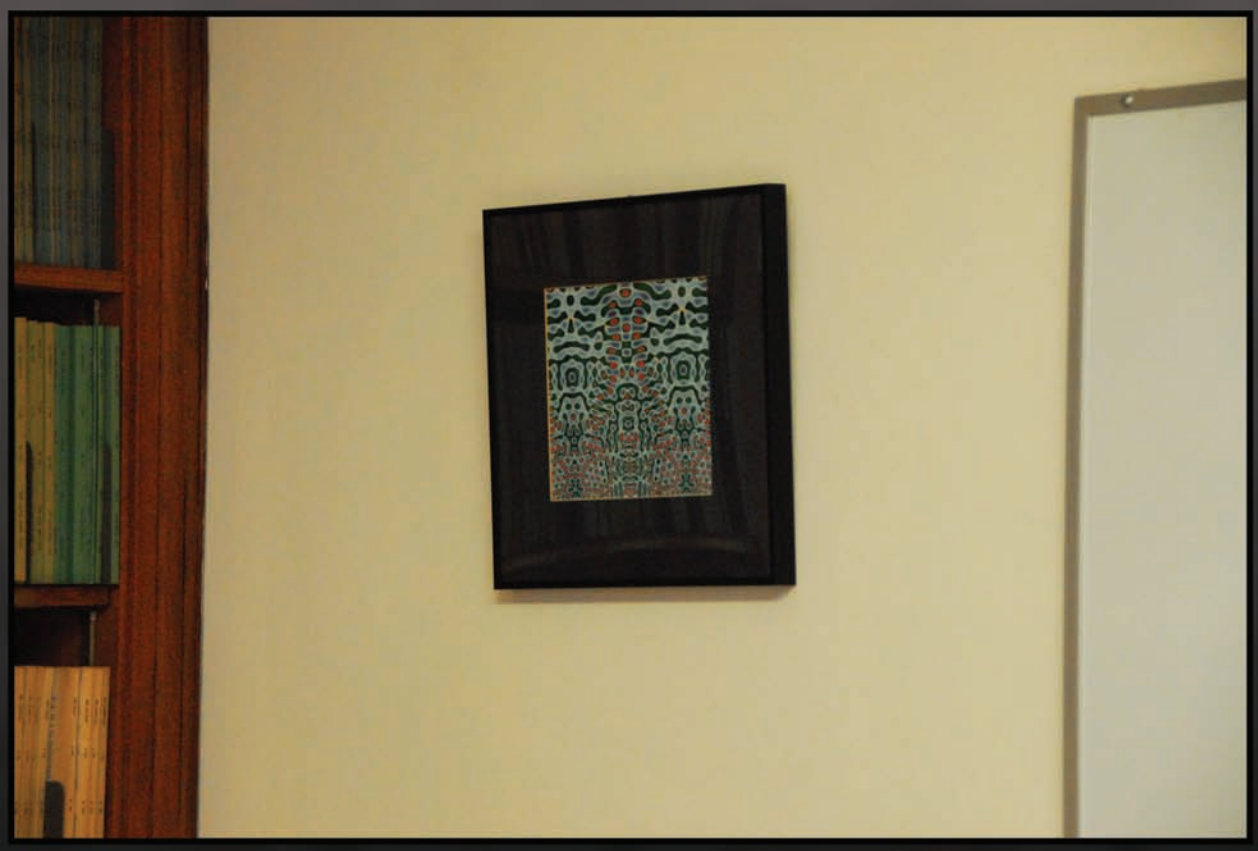
Notices

of the American Mathematical Society

June/July 2009 Volume 56, Number 6



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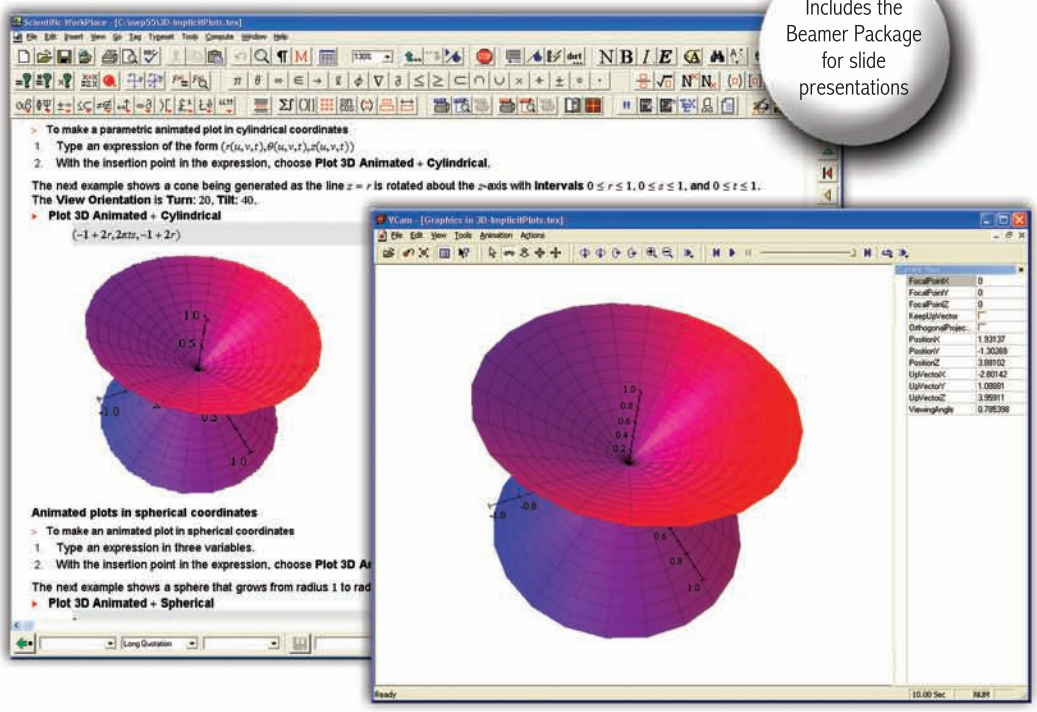

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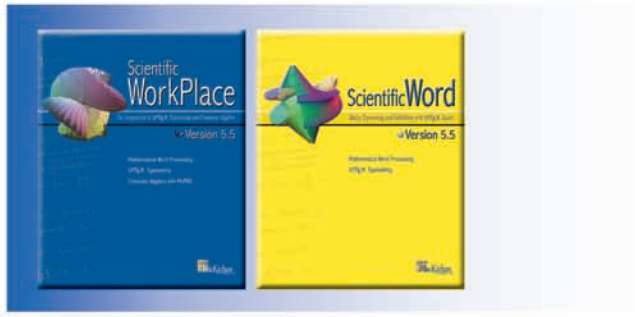

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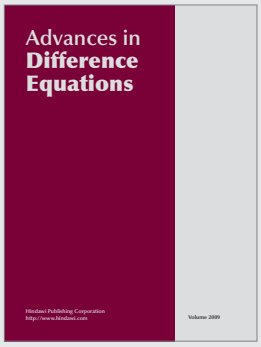

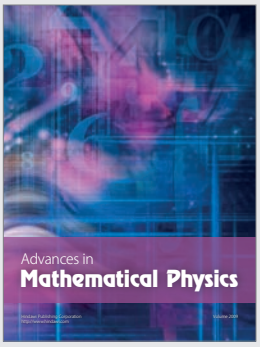

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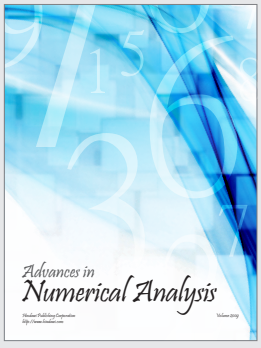

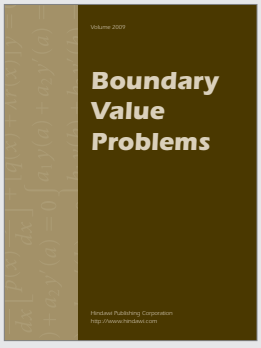

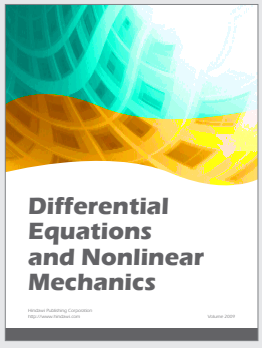

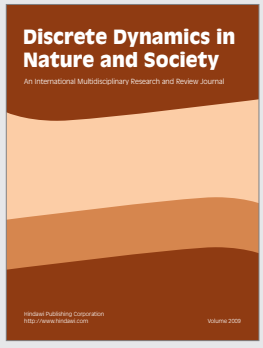

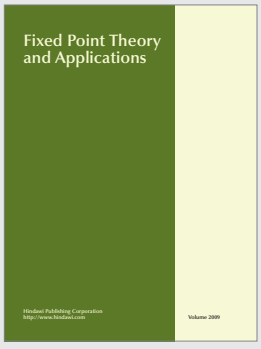

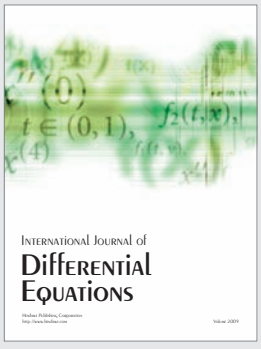

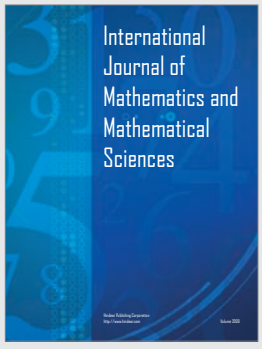

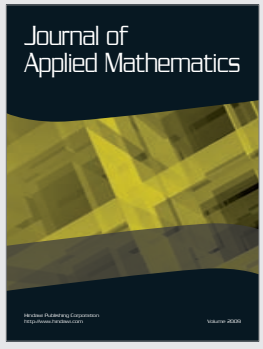

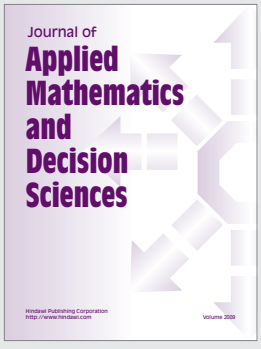

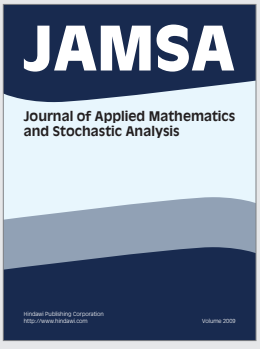

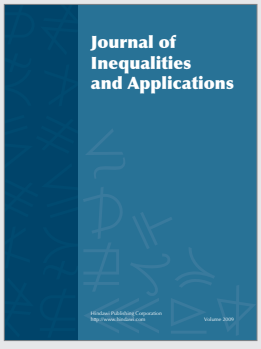

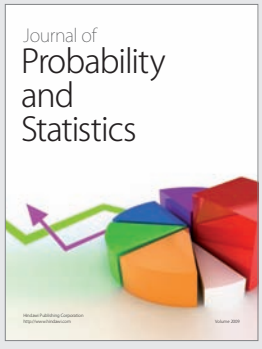

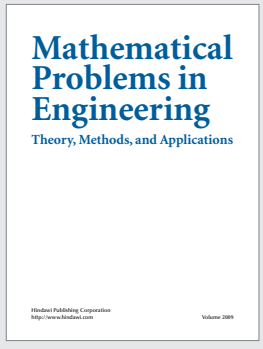

New and Forthcoming

BIRKHÄUSER

Inequalities

A Mathematical Olympiad Approach

Radmila Bulajich Manfrino, Universidad Autónoma del Estado de Morelos, Mexico; **José Antonio Gómez Ortega**, Universidad Nacional Autónoma de Mexico; **Rogelio Valdez Delgado**, Universidad Autónoma del Estado de Morelos, Mexico

This book presents classical inequalities and specific inequalities which are particularly useful for tackling and solving optimization problems. Most of the examples, exercises and problems that appear in the book originate from Mathematical Olympiad contests around the world.

2009. APPROX. 250 P. SOFTCOVER
ISBN 978-3-0346-0049-1 $39.95

Fourier–Mukai and Nahm Transforms in Geometry and Mathematical Physics

Claudio Bartocci, Università degli Studi di Genova, Italy; **Ugo Bruzzo**, SISSA, Trieste, Italy; **Daniel Hernández Ruipérez**, Universidad de Salamanca, Spain

Integral transforms, such as the Laplace and Fourier transforms, have been major tools in mathematics for at least two centuries. In the last three decades the development of a number of novel ideas in algebraic geometry, category theory, gauge theory, and string theory has been closely related to generalizations of integral transforms of a more geometric character. *Fourier–Mukai and Nahm Transforms in Geometry and Mathematical Physics* examines the algebro-geometric approach (Fourier–Mukai functors) as well as the differential-geometric constructions (Nahm). Also included is a considerable amount of material from existing literature which has not been systematically organized into a monograph.

2009. XVI, 418 P. 83 ILLUS. HARDCOVER
ISBN 978-0-8176-3246-5 $119.00
PROGRESS IN MATHEMATICS, VOL. 276

Applied Pseudoanalytic Function Theory

Vladislav V. Kravchenko, CINVESTAV, Querétaro, Mexico

Pseudoanalytic function theory generalizes and preserves many crucial features of complex analytic function theory. The Cauchy-Riemann system is replaced by a much more general first-order system with variable coefficients which turns out to be closely related to important equations of mathematical physics. This relation supplies powerful tools for studying and solving Schrödinger, Dirac, Maxwell, Klein-Gordon and other equations with the aid of complex-analytic methods. This book is dedicated to these recent developments in pseudoanalytic function theory and their applications as well as to multidimensional generalizations.

2009. APPROX. 195 P. SOFTCOVER
ISBN 978-3-0346-0003-3 $54.95
FRONTIERS IN MATHEMATICS

Pseudo-Differential Operators and Symmetries

Background Analysis and Advanced Topics

Michael Ruzhansky, Imperial College, London, UK; **Ville Turunen**, Helsinki University of Technology, Finland

This monograph develops a global quantization theory of pseudo-differential operators on compact Lie groups. Traditionally, the theory of pseudo-differential operators was introduced in the Euclidean setting with the aim of tackling a number of important problems in analysis and in the theory of partial differential equations. This also yields a local theory of pseudo-differential operators on manifolds. The present book takes a different approach by using global symmetries of the space which are often available.

2009. APPROX. 650 P. SOFTCOVER
ISBN 978-3-7643-8513-2 CA. $79.95
PSEUDO-DIFFERENTIAL OPERATORS, VOL. 2

Now available in softcover

A History of Algebraic and Differential Topology, 1900–1960

Jean Dieudonné

"This book is a well-informed and detailed analysis of the problems and development of algebraic topology, from Poincaré and Brouwer to Serre, Adams, and Thom. The author has examined each significant paper along this route and describes the steps and strategy of its proofs and its relation to other work. Previously, the history of the many technical developments of 20th-century mathematics had seemed to present insuperable obstacles to scholarship. This book demonstrates in the case of topology how these obstacles can be overcome, with enlightening results.... Within its chosen boundaries the coverage of this book is superb. Read it!"

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Hyperbolic Manifolds and Discrete Groups

Michael Kapovich, University of California, Davis, CA, USA

"The book is very clearly written and fairly self-contained. It will be useful to researchers and advanced graduate students in the field and can serve as an ideal guide to Thurston's work and its recent developments."

—Mathematical Reviews

Featuring beautiful illustrations, a rich set of examples, numerous exercises, and an extensive bibliography and index, *Hyperbolic Manifolds and Discrete Groups* continues to serve as an ideal graduate text and comprehensive reference.

2009. 1ST ED. 2001. 2ND PRINTING
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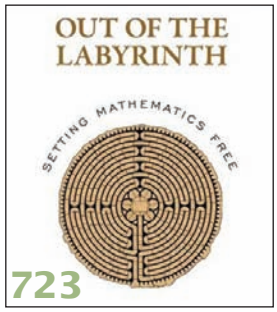
Notices

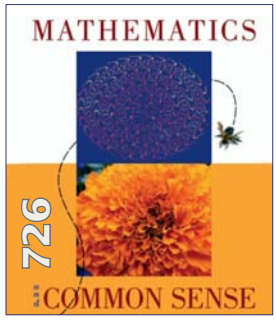
of the American Mathematical Society

June/July 2009

Communications

Commentary





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of the American Mathematical Society

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Monthly essays on mathematical topics

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Read the current column and explore the archive of essays. The Feature Column is a great way to share with your students your excitement about the beauty of, and developments in, mathematics.

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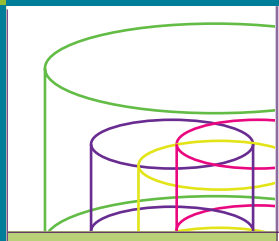

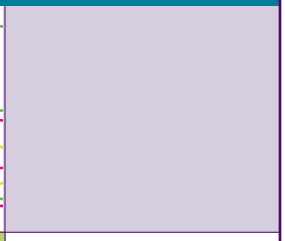

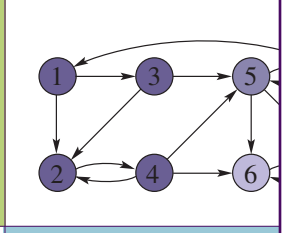

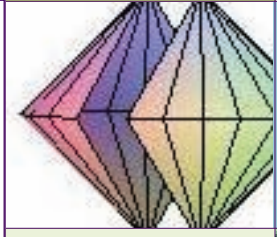

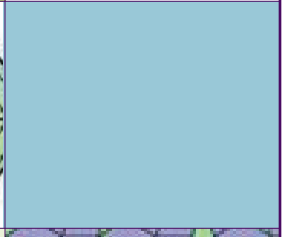

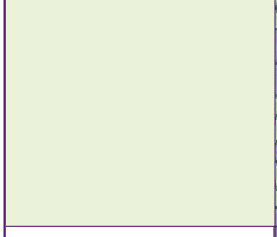

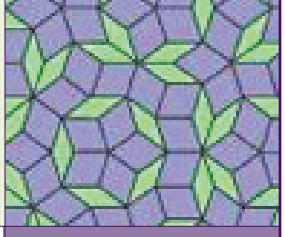

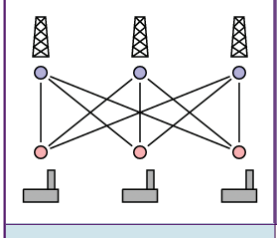

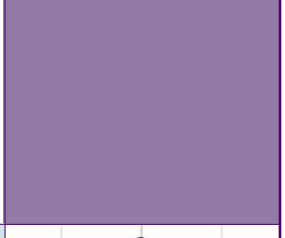

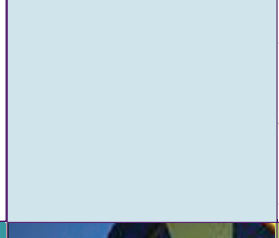

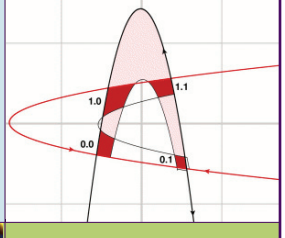

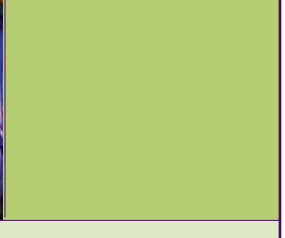

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My First Forty

Four decades ago, June 14, 1969, I received my Ph.D., becoming an officially certified member of the profession of mathematics. For some things I was prepared: I had been taught how to do research and had carried out some under my thesis advisor's supervision. I was prepared to teach, to the extent people were in those days—even though I had only been a paper grader and a section man as a graduate teaching assistant—by having lectured in seminars and having been a student.

One thing I was not prepared for was membership in the world mathematical community. By this I mean the web of relationships, scientific but also personal, that connect the people who spend time creating, teaching, and publishing mathematics. Exactly who belongs, and exactly how many of them there are, is probably not knowable with precision. I would guess there's about 15,000: the population of a small town (in fact the population of the town I grew up in). Not everyone in a town that size knows everyone else, of course. But distances on the acquaintance graph are quite short. So it is in the mathematical world. As most people find out experimenting with the collaboration graph tool in MatSciNet, there is a coauthorship chain of around length five or less from oneself to essentially every real mathematician one can think of. In fact, when things like having been at the same meetings or visited the same departments are included, the connection web seems to have much shorter diameter. This is manifest in submissions received by the *Notices*. Many contributions simply arrive, over the transom so to speak, from mathematicians I did not previously know, sometimes not even know of. And yet, with a little digging, it turns out that we have friends or experiences in common.

Shortly after receiving the Ph.D., I began a postdoctoral position. One of my fellow postdocs, older and wiser, thought one should consider one's mathematical interests as a solid cone $x^2 + y^2 = t^2$, with t representing time: $t = 0$ being the time of the thesis, $t < 0$ student days and $t > 0$ postgraduate, and the cross section at time t representing the areas of mathematics. Thus, for increasing t, the student focuses on narrower and narrower areas as he/she proceeds through graduate school and into thesis research, while the postgraduate mathematician sees his interests expand into new areas. The cone model has some things wrong with it (the time symmetry, the circular shape of the cross sections, for example), but the basic idea, that the thesis is a point from which mathematical growth expands, or should expand, seems true enough. The interests of the colleague who suggested the image, by the way, expanded to the point that he left mathematics, although not, of course, the mathematical relationship network.

Another colleague I met a few years later, when we were both assistant professors, although not at the same institution, also had an interesting image for the same phenomena: he liked to quip that his professional goal was to slow the increase in the distance between the mathematics he did and the mathematics he appreciated. His point, that as one continues working at learning, areas one thought would always be too difficult to understand can become accessible, if still too hard to be part of one's research agenda. For the record, this colleague was, and remains, a leader in his specialty.

Regardless of the metaphor, the point both colleagues make, that part of being a mathematician is learning mathematics for its own sake, and not only learning to do one's own mathematics, seems correct. That's why mathematicians attend departmental colloquia, participate in AMS national meetings lectures, and read the *Notices*.

Mathematics has grown enormously since 1969. Yet the continuity, of topics, structures, even basic references, over the past forty years is also remarkable. And the doing of mathematics is pretty much the same: individuals and small groups thinking, talking, and writing on a chalkboard or on paper. But of course the preparation for publication has changed dramatically. My thesis was typed professionally by a technical typist paid from my advisor's grant, but a paper I had prepared earlier I did myself, on the Remington portable I used as an undergraduate. That, by the way, was an excellent lesson in notational discipline, an important skill in the days journals were typeset, albeit moot in these times of TEX. Articles that appear in the *Notices* are prepared for production by *Notices* staff, who design layout, figure placement, column and page breaks, and so on, and who have won awards for doing so. Nonetheless, most of the articles you read in the *Notices* are submitted in TEX files, often with author supplied graphics, which streamlines that production process. For many of us, our TEX expertise is fixed—we continue to do what we learned to do the first time we needed to do it. TEX has continued to advance, however, and this year has seen some *Notices* articles and columns designed to help TEX users advance as well. I also note that the *Notices*, like all AMS publications, takes submissions in any format, including longhand.

Students receiving a Ph.D. degree this spring will complete their first forty years as mathematicians in 2049, a date that sounds to me like something out of a doomsday scenario prediction. But the only warning I have for them is simply to pay attention; it'll be there sooner than you think.

—Andy Magid

Letters to the Editor

Hedgehogs and Foxes, Not Birds and Frogs

Freeman Dyson's Einstein Lecture (*Notices*, February 2009) is a beautiful meditation on the distinction between two types of mathematical thinkers. But in calling them "birds" and "frogs", Dyson contravenes a metaphor that predates his by several thousand years. The common terminology is that referenced by the late philosopher Sir Isaiah Berlin in his essay "The Fox and the hedgehog", which comes from the words of the ancient Greek poet Archilocus: "The fox knows many things, but the hedgehog knows one big thing".

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Zoological Metaphors for Mathematicians

Freeman Dyson's impressive "Birds and frogs" (*Notices*, February 2009) reminds me of another zoological typology, proposed by Francis Bacon in 1620, in his *Novum Organum* (Aphorism I, 95): ants, spiders, and bees:

"Empiricists are like ants, who only collect things and make use of them. Rationalists are like spiders, who weave webs out of their own bodies. But the bee has a middle policy; it extracts material from the flowers of the gardens and meadows, and digests and transforms it by its own powers. The genuine task of philosophy is much the same. It does not depend on or mainly on the powers of the mind; nor does it deposit the raw materials supplied by natural history and mechanical observations in the memory just as they are, but as they have been worked over and transformed by the understanding. Therefore there is much to be hoped for from a closer marriage (which has not yet taken place) between these faculties, namely the experiential and the rational."

One can reconsider Bacon's metaphors as follows: ants are those scholars who remain involved in a particular field, trying to compensate by deepness what they miss by lack of extension and variety: Antoni Zygmund. The spider type is Georg Cantor, proposing a personal construction, with little reference to other authors. To the bee type belongs Paul Erdős, moving permanently from flower to flower, changing always his problems.

Dyson's and Bacon's typologies can be combined: Bolyai: ant and frog; von Neumann: frog and bee; Bourbaki: bird and spider; Hilbert: bird and bee; Gödel: ant and bird; Poincaré: bird and bee. Any researcher combines in various proportions different types, at different periods.

Open questions: Can we transfer these metaphors from individuals to historical periods? For instance, in the field of analysis, can we claim that the eighteenth century was preponderently frog and ant, while the second half of the nineteenth century and the beginning of the twentieth century were predominantly a bee and a bird? Can we describe in such terms the move, in algebraic geometry, from Castelnuovo and Severi to Zariski? etc.

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Some Comments on "Period Three Implies Chaos"

Freeman Dyson's beautiful article "Birds and frogs" (*Notices*, February 2009) refers to the well-known paper "Period three implies chaos" by Li and Yorke (1975). This paper is at the origin of the current use of the word chaos for differentiable dynamical systems. Li and Yorke proved that, for certain maps of the interval, the existence of a periodic orbit of period three implies the existence of periodic orbits of all periods. This is what Li and Yorke called chaos. The use, however, has changed and, as stated by Dyson, is now that "neighboring trajectories diverge exponentially". Most of the periodic orbits arising in the Li-Yorke theorem are unstable, i.e., a trajectory close to such an unstable periodic orbit diverges exponentially from it. Is this chaos? No, chaos occurs if the exponential divergence is present for long-term behavior, i.e., on an attractor. Unstable periodic orbits in a repeller are physically invisible, and do not imply chaos. So, with the modern use of the word chaos, period three does not imply chaos!

Interestingly, the theorem of Li and Yorke is a special case of a theorem by the Ukrainian mathematician Sharkovsky (1964). In its glorious simplicity, the theorem of Oleksandr Mikolaiovich Sharkovsky states that, if a continuous map of the real line to itself has a periodic point of (least) period m, then it also has a point of period n whenever n is to the right of m in the following unconventional ordering of the natural numbers: 3, 5, 7, 9,..., 2.3, 2.5, 2.7,..., 4.3, 4.5,..., 16, 8, 4, 2, 1 (we start with the odd numbers in increasing order, then have the odds multiplied by 2, 4, 8,..., and finally the powers of 2 in decreasing order).

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Separating Mathematicians

In the February 2009 *Notices*, Freeman Dyson elaborates on the division "birds" versus "frogs" among mathematicians. Usually, that division is described as "bird's eye view" versus "worm's eye view", but then Dyson avoids it, lest he may himself call a "worm", since he is considering himself to be a "frog".

Recently, a similar division in "seers" versus "craftspeople" was promoted by Lee Smolin in his amusing book *The Trouble with Physics*. And one of my good old and articulate colleagues likes to go even farther by dividing scientists into those who "think" versus those who "stink". No doubt, it is an irresistible urge of many a human intellect to discriminate, classify, and segregate; and then of course, judge, sentence, and

when possible, why not, also execute. And the most primitive and brutal way, needless to say, is to divide in merely two categories. Dyson appears to enjoy himself quite a bit with this "apartheid" venture, and on top of it, seems to be convinced to be doing something useful, if not in fact, even important. Among others, he judges von Neumann to be a "frog" and not a "bird", just like his old professor Abram Besicovitch at Cambridge. Beyond all such "apartheid" excursions, however, Dyson misses quite a few crucial facts related to the work of some of the mathematicians he sets out to segregate. With von Neumann, for instance, he misses two of his extraordinary insights. One of them is the basis of present and future computation, namely, that a computer program is allowed to act not only upon the data, but also upon itself, and do so in ways dependent on the data. This manifestly self-referential nature of computer programs has only come recently to a more systematic attention within a wider mathematical context, namely, with the emerging theory of the so-called non-well-founded sets, presented in the 1996 book *Vicious Circles* of Jon Barwise and Lawrence Moss. Indeed, ever since the ancient Greek Paradox of the Liar, not to mention its modern set theoretic version in Russell's Paradox, there has been a considerable reluctance among mathematicians to deal with any form of self-reference. After all, it indeed cannot be treated lightly, being nothing else but the name of God in Exodus 3:14 of *The Old Testament*. Well, von Neumann not only introduced self-referential programs into effective computation, but managed to do even one better when he proved the existence of self-reproducing automata, and showed that such automata can in fact be rather simple, having less than a few hundred elements. So much for applying hard and fast segregation methods of "apartheid" to truly remarkable scientists.

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Replies and Correction

I am grateful to the authors of the above letters for their criticisms and corrections. I am especially grateful to David Ruelle for telling us about the Sharkovsky theorem and explaining its meaning. I am sad to learn that the clarion statement of Yorke and Lee, "Period three implies chaos", is no longer true.

Surprisingly, none of these four letters calls attention to the worst errors in my lecture, which were pointed out by two other authors, Adrian Bondy and Manjit Bhatia, in personal letters to me. I am grateful to these two gentlemen for identifying my mistakes, which occur in the discussion of the $P = NP$ problem on page 217. To set the record straight, here is a description of the mistakes. I was wrong to say that the traveling-salesman problem, as usually formulated, the problem being to find the shortest route visiting a given set of cities, is NP. To find the shortest route is probably harder than NP. To obtain an NP problem, one should ask a more modest question, for example, whether there exists a route visiting the cities and not exceeding a given length. In addition to this mistake, I made a second mistake when I said that the traveling salesman problem is conjectured to be an example of a problem that is P but not NP. Here I should have said, "NP but not P". These mistakes occurred because I fell into the trap of talking about a subject of which I am ignorant, quoting some remarks that I heard from a friend who is equally ignorant. Thanks to Adrian Bondy and Manjit Bhatia, I am now a little less ignorant.

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Human Understanding and Formal Proof

By devoting a special issue to an extended discussion of prospects for formalization of mathematics, the *Notices* has done its readers a great service. The articles' authors have taken pains to motivate the long-term goals of their project as well as to present the state of the art in its accomplishments as well as limitations; they have managed the difficult feat of writing clearly about this highly technical subject for non-specialist readers while providing enough substance to make formalization credible. Whether or not Wiedijk's prediction is realistic that, in "a few decades suddenly all mathematicians will start using formalization for their proofs," I have no doubt that a project capable of attracting so many talented people around such clearly defined objectives for one of our central activities will ultimately change the practice of our profession in ways that are both profound and unpredictable.

Writing for an audience of mathematicians, the authors may be forgetting that among their readers will be those who do not necessarily share or sympathize with a common assumption they see no need to make explicit, namely that human understanding of proofs is of interest for its own sake. I am not mainly thinking of future mechanical proof assistants themselves, whose coming role in determining our priorities is scarcely addressed. Of more immediate concern are decision-makers who may well be convinced by the special issue to take the attainment of a given benchmark in the mechanization of mathematics as a signal to begin phasing out human mathematical research as a superfluous luxury. Harrison writes that a formalized proof "can be presented to others in a high-level conceptual way," but a pure cost-benefit analysis might see this as an unnecessary expense.

Harrison sees "the traditional social process" for verifying correctness of proofs as "an anachronism to be swept away by formalization." I would argue that this "woolly community process" is precisely what gives meaning to the peculiar practice of proving theorems. On the alternate view, human intervention in proof-making can easily be construed as a temporary inconvenience. The risk is real that we will lose one of the few fragile means we have evolved to come to terms with our experience

of the given world, and even more so of the virtual reality we all inhabit as participants in the society of human beings.

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Reply to Harris

Michael Harris reminds us that it is sometimes beneficial to say things that go without saying. For the record, I did not intend to disparage the understanding of proof for its own sake, nor the creative activity of human mathematicians generally. Neither, I'm sure, did any of the other authors of papers in the special issue.

I would draw a sharp distinction between (i) verification of a proof, and either (ii) its conceptual understanding, or (iii) the creative process that led to it in the first place. My critique of the "social process" relates solely to its role in verifying the correctness of proofs, as the text following the "anachronism" remark tried to make clear. As a vehicle for conveying understanding, I cannot seriously contemplate an alternative to communication between people. My goal with mechanical proof-checking isn't to put mathematicians out of work or eliminate the need for human creativity. On the contrary, the goal is to free the creative spirit from worrying about whether great imaginative constructs are invalidated by small errors in detail.

Riemann is supposed to have said "If only I had the theorems! Then I should find the proofs easily enough." I would like the mathematicians of the future (particularly those who are not of Riemann's caliber) to be able to say: "If only I had the broad outline of a proof! Then I should have my proof checker verify the details easily enough."

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Submitting Letters to the Editor

The *Notices* invites readers to submit letters and opinion pieces on topics related to mathematics. Electronic submissions are preferred (notices-letters@ams.org); see the masthead for postal mail addresses. Opinion pieces are usually one printed page in length (about 800 words). Letters are normally less than one page long, and shorter letters are preferred.

Correction

The September 2008 issue of the *Notices* carried a brief article I wrote about Grothendieck and the 75th anniversary of the Institut des Hautes Etudes Scientifiques (IHES). The article called the occasion the "sesquicentennial" of the IHES. Thanks to Jordan Bell, a mathematics graduate student at the University of Toronto, for pointing out that the word "sesquicentennial" refers to a 150th anniversary, not a 75th. Bell knows his Latin: He has translated forty of Euler's papers from the Latin and posted them on the arXiv.org with the author name "Euler".

—Allyn Jackson

The American Mathematical Society announces:

The AMS Graduate Student Blog

This blog will serve as a tool for graduate students in mathematics, providing them with information from fellow graduate students.

AMS Vice President Frank Morgan (Williams College) is managing the blog. He will be assisted by the Graduate Student Editorial Board, comprised of current graduate students, in content control of the blog.

The blog covers topics of importance to graduate students, offering advice on subject matter relevant to each stage of their development. Each writer brings a personal perspective based on experience, while keeping content broad enough to deliver valuable points to all those seeking assistance.

From the entry **"Finding an Advisor"** …
"After passing my qualifying exams, I went to a couple professors and asked them, if I were to be their advisee, what kinds of problems would I work on. They gave me papers and books to read on a variety of topics and we set up additional meetings so I could tell them if any of these subjects interested me or ask them more questions."

From the entry **"Navigating Seminars—A First Year's Perspective"** …
"The student seminars are often the most fun because they are talks given by your peers. Also you often get to see some of the intuition or 'how I think about it' that is sometimes left out in other seminars … If your afternoon seminars don't involve dinner afterward, try to get a group together yourself. It's a lot of fun."

From the entry **"Stick to the Content"** …
"A common pitfall I've seen among speakers—especially student speakers—is to apologize during the talk for such choices, or to make self-deprecating jokes. This is nearly always a bad idea, as it distracts from the point of your talk."

Student readers are invited to join the discussion by posting questions, comments, and further advice on each entry. Further, they may nominate themselves or a fellow graduate student to the Graduate Student Editorial Board. Please visit the blog at:

http://mathgradblog.williams.edu/

AMS
American Mathematical Society
www.ams.org

Remembering Atle Selberg, 1917–2007

*Dennis Hejhal, Coordinating Editor**

On August 6, 2007, Atle Selberg, one of the pre-eminent mathematicians of the twentieth century, passed away at his home in Princeton, NJ, at the age of ninety.

Born in Langesund, Norway, on June 14, 1917, Atle Selberg was the youngest of nine children in an academic family (his father held a doctorate in mathematics, and two of his brothers, Henrik and Sigmund, also became mathematics professors). He grew up near Bergen and then studied at the University of Oslo, earning his doctorate there in October 1943, a few weeks prior to the university being closed by German military authorities. Following a five-year research fellowship and encouraged by Carl L. Siegel, in 1947 (the newly married) Selberg moved to the U.S. and the Institute for Advanced Study in Princeton, where he was a member for one year. After spending the 1948–49 academic year at Syracuse as associate professor, Selberg returned to IAS as a permanent member and in 1951 was promoted to professor. He retired from IAS in 1987 but remained mathematically active for at least another decade.

Noted for his profound contributions to number theory, discrete groups, and automorphic forms, Selberg was honored with a Fields Medal in 1950, a Wolf Prize in 1986, and a special Abel Bicentennial Anniversary Prize in 2002.

The impact of Selberg's work can be seen from some of the many mathematical terms that bear his name: the Selberg trace formula, the Selberg sieve, the Selberg integral, the Selberg eigenvalue conjecture, and the Selberg zeta function.

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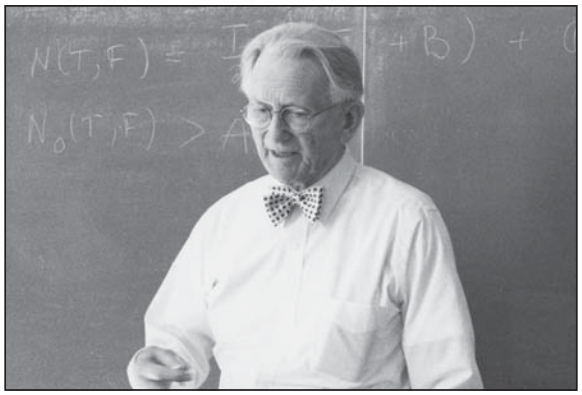

Atle Selberg at Columbia University, 1998.

During the course of his career—a career spanning more than six decades—he was variously a masterful problem solver, a creator of powerful and lasting tools, and a gifted theory builder. Depth, elegance, and simplicity of method were the hallmark of Selberg's style.

More detailed recent accounts of Selberg's life and work can be found in [3–6].

Curiously, in a 1989 interview [2], after first reminiscing how

> the things that Siegel tended to do were usually things that seemed impossible. Also, after they were done, they seemed still almost impossible…

and then describing the daunting effect that Siegel's lectures sometimes had on younger people at IAS, Selberg went on to say:

> Well, I knew of course that I could do *other* things. I couldn't do the kind of things that he did. I think the things I have done, really all of them, are things that—although sometimes there were technical details, and sometimes even a lot of calculation, in some of my

> early work—the basic ideas were rather simple always, and could be explained in rather simple terms. I think in some ways, I probably have a rather simplistic mind, so that these are the only kind of ideas I can work with. I don't think that other people have had grave difficulties understanding my work.

There was a certain understated (distinctively Scandinavian) quality in Selberg that could be quite inspiring, particularly for younger mathematicians.

Those who got to know him soon came to realize something else. Blessed with an impressive memory, Selberg was generally able—even during his seventies and beyond—to reconstruct with minimal need for "any faded old notes" the essential details of proofs that he had worked out years, if not decades, earlier.[1] There was an ongoing vitality not only in Selberg's ideas but also in the man.

What follows are some recollections of Atle Selberg by mathematicians from a number of generations. Together with the interview in [1], it is hoped that they can give the reader a glimpse of the remarkable person that Atle Selberg truly was.

References

[1] N. Baas and C. F. Skau, The lord of the numbers, Atle Selberg: On his life and mathematics, *Bull. Amer. Math. Soc.* **45** (2008), 617–649. See also the extended version in *Normat* **56** (2008), as well as at `www.math.ntnu.no/Selberg-interview/`.

[2] B. Devine, Interview with Atle Selberg, unpublished, IAS Archives, 1989, 57 pp.

[3] R. Heath-Brown, Obituary: Atle Selberg, *The Guardian*, 25 September 2007, p. 41.

[4] D. Hejhal and P. Sarnak, Some commentary on Atle Selberg's mathematics, *Bull. Amer. Math. Soc.* **45** (2008), 485–487.

[5] In Memoriam: Atle Selberg, *The Institute Letter*, IAS, Fall 2007, pp. 6–7, and Summer 2008, p. 10. (See `http://www.ias.edu/about/publications/`) The IAS website also contains streaming videos from the Selberg Memorial (at: `video.ias.edu/`).

[6] *Norsk Biografisk Leksikon*, vol. 8, Kunnskapsforlaget, Oslo, 2004, p. 161 ff. (See also the 1958 edition, vol. 13, H. Aschehoug, Oslo, p. 195 ff.)

G. D. Mostow

Atle Selberg was a mathematician whose accomplishments will be admired throughout the ages. Having enjoyed his friendship for nearly sixty years, I would like to describe how he was seen by his contemporaries.

We differed in age by only six years, but to call myself a contemporary is a bit misleading, because in 1943 he had published more than ten articles and was receiving his Ph.D. at the University of Oslo, while I was a college undergraduate with no publications.

Selberg in 1935, shortly before graduation from Gjøvik Gymnasium.

We both came to the Institute for Advanced Study in Princeton in mid-September of 1947, each of us being newly wed. I came with my wife, Evelyn; his wife, Hedvig, was delayed for several weeks because of immigration formalities.

I first heard of Atle Selberg from one of my colleagues at Fine Hall, where I had an office. My officemate spoke of Selberg with such awe that I can still remember his exact words, uttered in hushed tones, to this day: "There came out of the North a star who lit up for the first time a large piece of the Riemann Conjecture." That mythic aura persisted throughout his career.

From a 1949 rotogravure section of a Norwegian newspaper, in an article on his elementary proof of the prime number theorem.

As it turned out, Atle became my neighbor. Evelyn and I were housed in one of the two apartments in the converted carriage house of Maxwell Manor; Hedi and Atle occupied the other apartment.

As is customary in Norway, Atle was reserved with strangers. There was a single narrow footpath leading from Fuld Hall to our building. Before Hedi's arrival in the U.S., Atle would avert his eyes as our paths crossed. Hedi's ebullience changed all that, and we gradually became good friends.

In one conversation Atle even poked fun at Norwegian reserve, telling the following anecdote. He was walking along the main street of Oslo when he encountered a cousin who stopped to talk to him. As they were conversing, the cousin's twin brother passed by. The twins acknowledged each other with only the tip of a hat. Atle asked his cousin, "Do you see your brother frequently?" The cousin replied, "We haven't seen each other for a year."

[1] *One senses that the relative paucity of detailed working notes found either at home or in his office after his death (and linked, e.g., to specific results in lectures or published papers) is at least partially reflective of this fact.*

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At that time, the Fuld Hall Common Room could hold all of the Institute members. After the daily tea the members of the School of Mathematics would often linger in the Common Room to talk shop and gossip. Among the Institute members, Atle had the reputation of answering questions on number theory immediately or, if he could not answer fully, he invariably got to the core of the problem at once.

His self-confidence was enviable. That may have been genetic, as the following story suggests. One day early in the summer of 1949, one of Atle's brothers was visiting him in Syracuse. They had been invited by Arthur Milgram to watch a doubles tennis match. Unfortunately, at the last minute one of the four players canceled. Milgram, seeing Atle's brother getting out of the car, ran over to him and asked anxiously, "Can you play tennis?" The reply, delivered deliberately with a Norwegian lilt, was: "Well, I don't know, because I have never tried." This is reminiscent of an exchange in a filmed interview with Nils Baas and Christian Skau where they posed the question: "Could you have summed an arithmetic progression at the same age that Gauss did?" Those who have seen that film will remember Atle's response: "Well, I don't know. No one asked me to."

Atle, who was a professor in the Syracuse math department, was the principal influence in my decision to join that department. As Atle and I looked through a list of the department members and their fields of research, I referred to him as a number theorist. He dissented, saying, "My mathematical interests center on function theory."

Atle not only was engaged in the deep problems of mathematics but also in the serious problems of the world. This may have been due in part to his experience with the Nazi occupation during World War II. For example, after World War II, Atle served for many years as a member of the Science Advisory Committee of the Belfer Graduate School of Yeshiva University in New York City. I believe that his impulse to serve was due to his desire to support an institution of a people that had gone through the Holocaust.

His friends and colleagues are proud to have known him.

Dennis Hejhal

During the Atle Selberg Memorial at IAS, one of the remarks I made at the start of my tribute was this:

> If someone asked me to pick just one word to describe how Atle affected me over all these years, the word I'd select would be *inspiration*. In the 1970s, when I was at Columbia, Atle and I met quite regularly as I prepared volume one of my book on the trace formula. I remember how, after we got done discussing math, I would always come back home feeling so inspired to work! I was twenty-six years old then. It's strange…but even thirty-some years later, whenever Atle and I discussed math, he still had that *same* effect on me. I'll miss that.

Atle was for me not only a wonderful mathematical colleague and mentor, but also a dear friend. There was a kind of synergy in our interactions, a kind of eclectic give-and-take, that Atle seemed to enjoy. In my lines here I'd like to expand on this a bit.

I first met Atle early in 1974 after something of a zig-zag. As a graduate student at Stanford, I had already heard the name "Atle Selberg" spoken of with great respect by both George Pólya and Paul Cohen in connection with the zeta-function. Following my degree from Stanford in 1972, I moved cross-country to Harvard to continue my work in one complex variable with Lars Ahlfors (with whom I had already established contact as a high school student). Though my work at Harvard started out in complex analysis, my interests there soon began shifting more towards discontinuous groups and automorphic forms. In the spring of 1973 Ahlfors invited his old friend André Weil to Harvard for a colloquium. In a conversation with Weil the following day, one of the things I learned was that "the zeros of the zeta-function are *not* going to be understood by complex analysis!" Weil suggested that I study his papers on the explicit formula and focus more on Selberg's work on the trace formula. I did so starting that fall after familiarizing myself with Selberg's earlier papers on the zeta-function. Enrico Bombieri's visit to Harvard that semester motivated me further in all this.

In trying to understand things better, I decided to see if I couldn't compute the trace formula explicitly for a number of congruence subgroups of $SL(2,\mathbb{Z})$, Selberg's 1956 paper being vague on this point. My calculations got to be so messy that I began to wonder if *anyone* had ever done them before! I mentioned this to Ahlfors and asked him if he thought going to see Selberg might be a good idea. (A letter to Selberg several months earlier had not garnered any response.) Though Ahlfors had known Selberg for many years, he responded hesitantly, telling me, "I'm not so sure; Atle has a reputation for being rather reserved and difficult to talk to." At about the same time, Lipman Bers was trying to entice me to move to Columbia. Bers heard about my predicament from Ahlfors, and the next thing I knew, I got a phone call from Bers, who said, "Don't worry! I'm on very good terms with Atle. Let me give him a call for you." Bers must have said some magic words, because I soon found myself knocking on the door at Fuld Hall 112 and being warmly welcomed by Atle.

After moving to Columbia as associate professor in the summer of 1974, I generally got together with Atle every few weeks or so, usually on Friday mornings at 10:30 for about two hours, following which we'd eat lunch together in the IAS cafeteria. If the weather was good, we'd sometimes follow that with a walk in the Institute woods.

We talked about all kinds of things, mathematical and non. Atle tended to be quite open with me, and I responded with enthusiasm. It did not take me long to decide that I wanted to try to write a book on the trace formula for $SL(2,\mathbb{R})$. Atle reacted positively. A typical morning get-together would start with a progress report and discussion of my latest ideas, then gradually morph into "news reporter mode", where I'd ask questions and then sit scribbling notes based on Atle's responses or on what he sketched out for me at the blackboard. (I actually preferred sketches, because to really understand things, I felt it best to try to work out full details on my own. Though it was slow going at times, once or twice I uncovered snags in what Atle had asserted.)

Things went on like this for about a year and a half until I finished volume one of my book; they then continued, albeit with slightly modified focus and a bit less frequency, during the remainder of my years in New York.

Atle told me any number of things over lunch or on our walks which still stand out vividly in my mind. Once, while we were discussing the Riemann Nachlass, Atle went off on a tangent and commented to me that of all the mathematicians he had ever met or known, in terms of technical strength he was most impressed by Carl L. Siegel and Arne Beurling.

On another occasion Hermann Weyl's name came up. After telling me how greatly he admired him, he paused and explained that "with Weyl, this went beyond his mathematics. As Weyl aged, he became a better and better human being. He made a conscious effort at this." This latter point was evidently an important one for Atle: in the 1990s he told me the story for a second time.

After moving to Minnesota in 1978, I kept in regular touch with Atle, particularly via occasional visits to IAS. Besides being fun, such return visits helped spur the completion of the second volume of my book.

In the mid-1980s, Bombieri and I became interested in trying to use Minnesota's Cray-1 computer to study the distribution of the zeros of Epstein zeta-functions. Hedi Selberg, who had coded some of the very first experiments run on John von Neumann's "IAS Machine" in the early 1950s (e.g., with Kummer's Conjecture) and who sometimes employed supercomputers in her work at the Princeton Plasma Physics Lab, reacted enthusiastically. Atle was also supportive; I remember his early comment to me that in number theory there was

Archives of the Mathematisches Forschungsinstitut Oberwolfach.

Selberg, right, with André Weil in 1968.

a long tradition of theory and experiment stimulating each other and that a well-formulated conjecture (born partly in experiment) could well have greater impact on the development of mathematics than a rigorously proved theorem.

Atle continued to follow our work with interest. I was at IAS when Enrico and I started to get our first results. I remember with fondness the way Atle would occasionally greet me with an upbeat, "Anything new?" when I first encountered him in the morning.

I decided to speak about this work at ICM'86 and was very pleased when Atle, who was visiting Stanford that summer, came up to Berkeley to hear my lecture.

Atle had a strong sense of honesty as a person; also a certain dispassionate candor, particularly when it came to scientific matters. Over the years I came to appreciate Atle's old-school ways very much.

During 1990, a year I spent entirely at IAS, this appreciation was enhanced by an eye-opening conversation the two of us had in June. Around nine months earlier I had been mulling over possibly organizing a broad-based computer project in automorphic forms. One day Atle asked me about this, and I lamentingly commented that due to skeptical reactions from several key senior people (one tantamount to a "Well, what can you actually *prove*?"), my earlier enthusiasm had pretty much lapsed. Atle first responded by recalling his earlier words to me about well-formulated conjectures and experimental insights. He then looked at me and in an almost admonitional tone said, "You know, one should *question authority*." He repeated the phrase, saying that he had learned this early—in connection with Hardy and Littlewood's work on the zeta-function.

Selberg and his family (daughter Ingrid, son Lars, wife Hedi) near their house in Princeton in 1960 or 1961.

Atle's words struck me for several reasons, not the least being the fact that I remembered seeing a similarly worded bumper sticker on his son Lars's car in the late 1970s.

Suggestions from Atle were always things to be taken seriously. Ironically, on several subsequent occasions, Atle's advice to me (coupled with a little logical consistency) proved to be just what was needed to resolve various points of contention that arose between *us*. Later that year, for instance, after a comment that Atle made to me began to gnaw away at my sense of basic fairness, I decided to stop by his office the next morning. I still smile at the way Atle unwittingly facilitated matters after I began by "casually" asking him if he recalled Lars's old bumper sticker, and he serendipitously replied, "Even if it's no longer there, I hope he *still* believes it!" Things went well. Our exchange of views ended on an up-note, with Atle reminiscing about his formative days as a mathematician in Norway and telling me several stories that I doubt I would ever have heard otherwise. (On the phone a couple days later, Hedi commented in her unique way, "You learned something important about Atle.")

In 1994, when I started spending part of my time each year in Uppsala, Atle was pleased. He had spent several months in Uppsala in 1939 and liked Uppsala's historical atmosphere. Atle came for return visits to the university in 1995, 1997, and 1998. In 1996 he came for a shorter stay to attend my formal ("white tie and tails") professor's installation in the University Aula. Atle joked that he was there to provide moral support, since my lecture needed to be in Swedish.

There was something about Atle being (almost) on his "home turf" that seemed to put him in an especially good mood. This made for *a lot* of memorable happenings. From a mathematical standpoint, perhaps the most significant occurred in 1997. Atle was visiting for two months but preferred not to give a lecture series. Our department's finances were tight, and the department head commented to me that if Atle's pay could somehow be classified as a stipend (tax-free in Sweden), we could pay Atle a *more respectable* amount. He joked that perhaps I could get Atle to agree to "study something" with me—or at least work on a common topic. I told Atle. He laughed, and we promptly agreed to study zeros of linear combinations of L-functions. To stay out of each other's way, he would work *on* the critical line, I would work *off*. Atle took his assignment seriously, telling me one afternoon that he had been up 'til 2 a.m. trying to rework several technical aspects of his Ph.D. thesis.[2]

A couple of months after leaving Uppsala, Atle finally succeeded—at age 80—in proving his beautiful positive proportion result for linear combinations.

Atle's visits to Uppsala were always a special treat for the department; he stirred things up, and people looked forward to having him around. Continuing a long-standing habit of Atle and Hedi's, I especially enjoyed going lap swimming with Atle several times a week for 45 minutes at our local aquatic center, after which we'd then normally enjoy a very relaxed lunch together in the center's restaurant.

During subsequent summertime visits to Princeton, I would occasionally[3] meet Atle at 7 a.m. for a 45-minute swim in the Nassau Swim Club's outdoor pool near the IAS housing complex; lunch followed four hours later. Chilly conditions, e.g., after a heavy rain, never bothered Atle. As a schoolboy in Norway, he recounted, "we" swam down to a water temperature of 12°C (54°F); to be excused, the teacher, a former military man, insisted on a note *from one's father*. Though in the mid-1980s Atle still had a mean backstroke (once encountered first-hand thanks to a narrow lane!), his preference more recently was for an unusual-looking, slow, underwater sidestroke of his own design that he could keep up for long periods of time.

Atle inspired subtly…and in many ways. He was also fun. As I look back, I feel very fortunate

[2] *It turns out the 2 a.m. was not without precedent; Lars and Ingrid Selberg recently told me that years earlier (during the 1960s and 1970s, at least) their father had a habit of working late in his study at home, very often to well past midnight.*

[3] *(and typically with only one eye open!)*

to have gotten to know him the multifaceted way I did. The warm hospitality and many kindnesses shown to me over the years by Hedi, and later by Mickey Selberg, made a real difference in this.

Following his ninetieth birthday dinner, I stopped by to wish Atle well, and to tell him that I hoped to visit him again later that summer to discuss a bit of math. Very sadly, that hope would never come to pass.

A few days prior to Atle's memorial at IAS, I came across a reprint of his in Norwegian from 1979 that I had simply put aside (not being able to read it at the time). It was a tribute in honor of Viggo Brun. Leafing through it, I found that I could now read large portions of it relatively easily. The way it closed struck me with some poignance as being eminently appropriate also for Atle. I paraphrase:

> *Atle Selberg som vi minnes i dag, var ikke bare en stor matematiker, men også stor som menneske. Hans minne gjør oss alle rikere.*
>
> [Atle Selberg was indeed not only a great mathematician, but also great as a human being. And our memories of him do enrich us. In spirit.]

Peter Sarnak

In a recent *Bulletin of the American Mathematical Society* article (October 2008), Dennis Hejhal and I give a brief account of the impact of some of Selberg's mathematical contributions. What follows are some personal reminiscences about him.

I cannot remember exactly when I first heard the name "Atle Selberg", but it was certainly in South Africa when I was still an undergraduate. By the time I was a third-year graduate student at Stanford, his name was very familiar to me, and it was during this period (1979) that I first met him. My advisor, Paul Cohen, arranged for me to meet Selberg at the Institute, as I had been working on topics around the trace formula. Paul warned me that Selberg could be intimidating, and indeed, like most other mathematicians, I found that to be the case. Now that I think back on it, I understand better why. Given his stature in the field, one's first conversations with him (and for many perhaps also their last) were bound to be around some aspects of his work. This, coupled with his profound understanding of any issue related to what he had thought about in depth and his direct and matter-of-fact Norwegian style, was bound to leave one feeling somewhat intimidated. However, this image quickly changed for me and, I think, for others who were also fortunate to get to know Selberg. He was kind and generous, he had a keen sense of humor, and he valued his friendships deeply.

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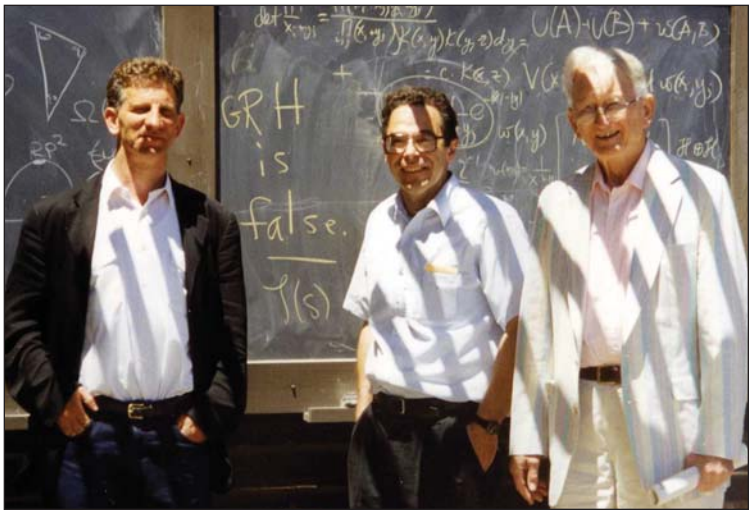

Peter Sarnak, Dennis Hejhal, and Atle Selberg in a humorous mood at MSRI in 1999. (Photo courtesy of D. Hejhal.)

In my case I got to know him a little later when, in 1980, he came for the first of what was to be a number of long-term visits to Stanford. During each visit he gave a series of lectures on some aspect of his work. He and his wife, Hedi, enjoyed very much the hospitality of the mathematics department, in particular that of Paul Cohen, Ralph Phillips, and their families, and especially Isolde Field. Selberg's rating of the faculty club at Stanford as being the "best in the country" pleased Ralph Phillips, who was of a similar opinion, and they enjoyed eating lunch together there daily.

During this first visit, Selberg gave a series of lectures on the trace formula. He also served as one of the examiners on my thesis. I was quite worried that he would, in the Scandinavian tradition, take the position as the official "attacker" of the thesis, but after posing some probing questions, he seemed quite content. Immediately after the examination and on many later occasions, he offered some excellent general as well as some specific advice, much of which I carry with me to this day.

During this same visit I drove him up to Berkeley, where he had agreed to give a colloquium. The colloquium chair there had been pushing him to talk about sieves, a topic that he wasn't thinking about at the time, and he was quite irritated by being put in the position of not obliging. The topic Selberg chose for his colloquium is known today as the "Selberg Integral", but in the early 1980s it was hardly known, if at all. The colloquium hall was packed, as he didn't lecture often, and most people just came to *see* him. But in true Selberg style, he started the lecture by explaining that he was going to compute an integral that he had done in his youth. He offered no reason for choosing to talk

about this. It took some months after this event for people to digest the fact that his old paper contained the solution to conjectures of Dyson and MacDonald, which were "hot" topics at that time. It was in response to Bombieri and Dyson's questions about related integrals that Selberg pointed out his old paper, and he took this occasion to make it better known. Most of the audience left the lecture perplexed about what they had witnessed, and Selberg seemed to enjoy that.

Photograph by Betty (Mickey) Selberg.

At the February 14, 2003, wedding of Atle and Mickey Selberg: left, Enrico Bombieri, best man; maid of honor Shirley Dwork (center); and Atle Selberg.

Paul Cohen and I had spent much of 1979 and 1980 studying Selberg's work on harmonic analysis on locally symmetric spaces and filling in details of the many results which had simply been stated with only hints of the methods used to prove them. (Selberg later told me that he was very lazy by nature and that once he understood something, he found it very difficult to energize himself to write it up for publication. I used to be unsympathetic towards this attitude, but as I grow older I find myself being much more sympathetic.) In putting ourselves in his mindset as we supplied proofs of his results, we found ourselves explaining things to each other in Selberg's accent and manner, so much so that it became a competition between us as to who "did a better Selberg". Ten years later the opportunity arose for us to resolve this and to act out our Selberg imitations in front of him. The Stanford mathematics department gave me a farewell dinner on the occasion of my leaving for Princeton, and Selberg happened to be visiting at that time and he too was invited. In Paul Cohen's speech (better called a roast) he proceeded to imitate me doing "a Selberg". In my response, I had the chance to do the same. Selberg was amused by the two of us putting on strange Norwegian accents, but he didn't seem too impressed. Here and in other circumstances (e.g., when fantasizing naively on some notorious unsolved mathematics problem!), he had the knack of sobering you up by making a key observation.

Once you got to know him, Selberg liked to talk and to tell stories from his experiences, mathematical and otherwise, and there were many. One which sticks in my mind is about his joint work with Chowla. (Selberg was particularly fond of Chowla, who is distinguished by being Selberg's unique scientific coauthor and the one responsible for Selberg's "Erdős number" being 2.) It was before the days of computers, and Chowla had noted that $L(\frac{1}{2}, \chi)$ must be nonnegative for a quadratic Dirichlet character, for otherwise the Riemann Hypothesis is false for this Dirichlet L-function. He wanted to compute these numbers for various χ's, such as the one corresponding to $\mathbb{Q}(\sqrt{-163})$, where he expected the value was small. Selberg provided an efficient method to compute these values using Eisenstein series, and Chowla went home that evening to do the calculation. The next day Chowla was waiting nervously for Selberg outside his office. He had found that for the specific character above, the value was negative. They quickly set out to redo the calculation and soon found the "error". In describing his method, Selberg used Dirichlet's notation for binary quadratic forms, $ax^2 + bxy + cy^2$ (as most of us do today), but Chowla was old-fashioned and used Gauss's notation, $ax^2 + 2bxy + cy^2$. Once this inconsistency was clarified, the value turned up positive (it is 0.0685…). This was good news, of course and, even better, it led them quickly to their well-known "Chowla-Selberg" formula.

When I and my family moved to Princeton, Atle and Hedi were very welcoming, and we enjoyed many lunches, dinner parties, and outings together. During this period I would often use Atle to lure a desired speaker by saying that Atle would join us for dinner. Later, when Atle's hearing deteriorated to the point where he was no longer comfortable sitting at a crowded table, he came less often to such events. However, even well into his eighties, if there was a special seminar, he would come and also join us for dinner, the most recent instance that I can recall being a few years ago when Dan Goldston came to speak about his joint breakthrough concerning the differences between consecutive primes.

After Hedi passed away in 1995, Atle made an effort to be more directly outgoing, but he was clearly very lonely. In 1998 Atle and I made a joint tour of China. We traveled together extensively by air, train, minibus, and taxi and were treated lavishly by our local hosts. Our days consisted of lecturing, listening to lectures by locals, discussions with young Chinese mathematicians about mathematics and their work, and a lot of touring and shopping (for Atle, this meant mainly acquiring new dragons for his already quite large collection). This was quite a "bonding" experience for the two of us. Our host in Beijing, Professor Pan, was very concerned that no harm would come to

Atle. In particular, he insisted that Atle retire to his room immediately after dinner, which on a number of occasions was as early as 7 p.m. Atle was quite frustrated by this and insisted that I come to his room for a drink (unknown to Professor Pan, Atle had stashed quite a bit of alcohol in unusual places). I could see Atle's disappointment with my lack of tolerance of any quantity of alcohol.

During this trip Atle mentioned a few times that on the way back to Princeton he planned to stop over in Palo Alto for a week or so. When I asked if he was lecturing at Stanford, he answered no, and I was quite perplexed by his breaking his trip home in this way. When I saw him next after China (which was three weeks later at a conference in Vienna on the Riemann Hypothesis), he explained to me with a twinkle in his eye and a broad smile that his stopover in Palo Alto was a success. His purpose was to propose to his and Hedi's longtime friend, Betty (Mickey) Faith, that she move to Princeton to be his partner. She was taken by surprise, but after thinking about it for a short time, she agreed. A few years later they were married. From that time on until his death, Mickey was always by his side, and Atle appeared to be constantly in a good mood.

Atle Selberg stands as a towering mathematical figure whose works have allowed a number of mathematicians to achieve quite striking goals. I was fortunate to benefit not only from his mathematics but also from his excellent general advice, his inspiration, and, not least, his friendship. I will miss him.

John Friedlander

I first heard of Professor Selberg some years before I met him when, as a beginning number theory student, I attended a series of lectures (by J. Chalk) on the Selberg sieve.

By the time I finished my graduate studies, I had heard and read quite a bit more about his work, and I was thrilled when—no doubt partly because my supervisor, Chowla, was an old friend of his—he responded to a letter from me with an offer of my first academic position, as his assistant at IAS. Apart from bed and bath, that letter remained on my person for several weeks thereafter.

Only a few minutes after I first arrived at the Institute the following autumn (1972), I was introduced to Selberg by Deane Montgomery, with whom I had become acquainted during his stay at Penn State the previous spring. Selberg was at the time sitting in the Fuld Hall lounge reading the *New York Times*, the first of what seems a few hundred times I was to come upon him doing just that over the thirty-five years to follow. Fighting desperately to find conversation, I asked him if there were many lectures given at the Institute. He responded that there were in his opinion far too many of them (within a few weeks I discovered to my surprise that I had begun to agree with him).

Perhaps a week later I went to his office to tell him about a problem I had just begun to look at. I had picked a rather difficult problem that had seen no progress for many years, and I had concocted a somewhat artificial modification of it which one could hope to attack. Selberg listened patiently, and after I finished he offered the opinion that it was often possible to modify an interesting and difficult problem, getting a question about which one could obtain some information. However, he said, before going to the trouble of obtaining this information, one should probably ask oneself whether this will then be information about something that anyone would want information about. As I left his office, I vowed to myself that in the future, even if I had nothing worthwhile to say about them, the problems he would see me working on would be subject to no such criticism. Within a few days I had an idea to tell him for what seemed a reasonable attack on a much-studied and difficult problem. Selberg from that day on always offered me his time, his attention, and his encouragement.

These were just my first glimpses of the crusty sense of humor and the bit of feigned conceit that cloaked the kindness and modesty lying beneath the surface, and not so far beneath as to be that difficult to uncover.

During my second year at IAS there were a number of junior visitors interested in analytic number theory, and Selberg decided to run a weekly seminar. He gave the first lecture, and afterwards each of us took a turn. Each week at the end of the lecture he'd ask for a volunteer for the next week. After we'd each given one, he gave a second one. A few of us then did the same. Gradually, however, we realized that when there was no volunteer, Selberg would pull some manuscript from his desk and give a lecture on a piece of work that nobody had ever seen before. After that there were very few volunteers. Much of this work did appear years later in the second volume of his *Collected Papers*.

The job market was very tough. At the first AMS Employment Register, in January 1972 in Las Vegas, there had been over 1,400 interview requests for a position at a branch campus of one of the less illustrious state universities, a number I was told by their chairman while sharing a cab to the airport. After my two years at the Institute, I had a succession of temporary positions. Selberg was writing letters for me almost every year for about a decade. After I finally received tenure I was told by one of the members of my tenure committee that Selberg had said in his letter about me: "He's a pretty good mathematician, but are you guys sure you want to put up with his pipe for the

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rest of your lives?" I guess he just wanted to write letters for another ten years!

Up until 1981 I was a very heavy pipe smoker. At that time it was already frowned upon, but not the anathema it has since become. During one of my trips back to Princeton in the late 1970s, Selberg had invited me to stay at his home. When I arrived, he greeted me at his front door with the words: "Hedi says you are not to smoke in the house." (I remember that it was his late wife, Hedi, who taught me that he was to be called "Atle" and not "Professor Selberg".) I said that this was fine with me, but I hoped he wouldn't mind if I went out for a walk and a smoke after dinner. When the time came for me to go out, he absolutely insisted on accompanying me throughout and did so despite the quite cold weather and a strong wind which, flouting my best efforts to position myself, seemed determined to blow the smoke directly in his face.

There was an interesting story that took place about the same time. I know of it only second-hand (not third), but I believe it completely, and it very accurately depicts the protagonists. A young number theorist spending a year at the Institute had been trying to evaluate a certain integral and, finding it beyond him, was going from person to person asking for help. Having no success after several attempts, he spied Chowla at teatime and showed it to him. Chowla's response was, "For five dollars I can get you the answer in half an hour." Half an hour later they met again, and Chowla showed him the answer. The postdoc paid the five dollars and said, "That's amazing, Professor Chowla. How did you do it?" "It was easy," said Chowla. "I showed it to Selberg and asked 'How do you do this?' Selberg looked at it and went 'Hmmm, oh yes' and wrote down the answer."

There are many other stories about Selberg that one can tell, and perhaps in an article like this more than one person will tell the same story. Some of the ones I remember best are the ones where he exhibits the humorous comment that on the surface sounds a bit immodest but really isn't, … well maybe it is to those who wanted to see it that way. A good example came on an afternoon bus excursion during the Durham meeting (July 1979). The tour leader, having given us the requisite free time to tour Durham Castle, boarded the bus and, seeing it still half-empty, called out facetiously: "Is everybody here?" The response from Selberg: "Everybody who counts!"

In early 1996, after a several-months stay at IAS and just before my departure, Atle took me to dinner at the Institute dining room. We talked about my work with Henryk Iwaniec on primes that are the sum of a square and a fourth power, the details of which were maybe twenty percent complete but of which, because we already had a full sketch of the argument, I was fearlessly confident (not my usual posture). Atle cautioned me that often it is the details that are one's undoing, and yet I felt that in spite of his always careful nature, he seemed to believe in my optimism. I then started to reminisce about how proud I was of having been his assistant. This, of course, was too much for him to take: "What time period was that?" he asked. "Oh, no wonder you didn't mind; my children were grown up by then. A few years earlier and you would have had to baby-sit. Your memories would be rather less positive."

The last time I saw Atle was at the dinner for his ninetieth birthday, to which a few of us took him at the Princeton University Faculty Club. He was already somewhat unwell, but I don't think any of us had a clue just how serious this was going to turn out to be.

Atle was a really wonderful teacher and friend to me in many ways. I sort of knew that I would be quite sad when he passed away. Yet, when he did die, I was really surprised at the extent to which this was the case. And still is.

Dorian Goldfeld

I first met Selberg at the 1969 conference on number theory at Stony Brook, but because I was very young and there were so many famous number theorists there, I spoke only a few words with him at that time. My long and wonderful association with him really began in 1973, when I had a teaching position at Tel Aviv University and was living in Jerusalem. I would go to the Hebrew University on occasion. I was utterly shocked when one day I saw Atle sitting at a desk in an office at the Hebrew University. He told me he came to Israel every few years because his wife had family there and that he would be there for one term, going to his office three times a week. At the time there were almost no number theorists in Israel, and I felt quite isolated with very little hope of obtaining a good job in the United States.

Seizing the opportunity, I visited Selberg as often as possible, and we spent most of the time talking about mathematics. I seemed to be the only one spending serious time with him in Jerusalem. He taught me automorphic forms, the trace formula, and how to see the essence of a proof by looking for elegance and simplicity. Just before he left Israel for Princeton, he asked me what I was planning to do the year after. I told him I had no prospects other than staying at Tel Aviv University, and he suggested that I apply to be a member of the Institute for Advanced Study for the next year instead. I therefore returned to the United States and became Selberg's assistant at the Institute, where I continued to have the extraordinary opportunity to interact with one of the greatest

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mathematical minds of our age. Selberg turned my career around and put me on the path to success. That year Bombieri, who was also visiting the Institute, offered me the chance to go to Pisa to work with him for two years. While in Italy, I learned of the Vaughn Foundation, whose main purpose was to fund research on Fermat's Last Theorem (FLT). With a letter from Bombieri, I soon obtained a grant from the Vaughn Foundation.

In 1981 I was at MIT, and James Vaughn suggested that it might be worthwhile to have a meeting on mathematical work relating to FLT. Now at that time no self-respecting mathematician would publicly admit that they were working on famous problems such as the Riemann Hypothesis or FLT. However, I was fairly certain that they were working on them and thus thought it would be a good idea to get people out of the closet about it. In an attempt to do so, I approached Barry Mazur and asked him if he'd like to organize such a meeting. He immediately agreed and said that many other people were also interested. In the end, Harold Edwards, Nick Katz, Neal Koblitz, Barry Mazur, Andrew Wiles, and I were the organizers. I invited Selberg to the conference, and he promptly accepted the invitation. He told me he had always been interested in FLT.

The FLT conference, generously funded by the Vaughn Foundation, was held at MIT's Endicott House, a magnificent 1930s mansion built in the style of a French manor on a secluded 25-acre estate. We arranged for the Selbergs to have one of the best rooms at Endicott House. I fondly remember shooting darts and chatting with Atle every evening after dinner at Endicott House.

A few years after the FLT meeting, I received a call from Hedi Selberg. She told me that Atle was soon going to be seventy years old and that they wanted to do a conference in his honor in Oslo. She reminded me how much they enjoyed the Endicott House conference, and she wanted to know if I was interested in organizing a meeting for Atle in 1987. I was extremely honored that Atle would think of me for organizing such an event, and I immediately accepted her offer. I called James Vaughn, who said his foundation could provide support for the conference. Later I found out that the Selbergs had also contacted Karl Aubert and Enrico Bombieri for organizing this event. The Selberg seventieth birthday conference was probably the most successful one I have ever attended; in the end, it was funded by various Norwegian councils and societies, as well as Landon Clay and the James Vaughn Jr. Foundation Trust.

Years later, when Selberg was in his late seventies, I asked him if he'd like to give a talk at the Columbia Number Theory Seminar. He looked at me with his boyish smile and said people at his age don't give talks. In the next few years I brought the question up a couple of times, but he didn't seem interested in speaking about mathematics anymore, so I thought I'd give up asking. Then one day he came to me and said he had something to talk about. I was surprised and delighted when I heard this. It was one of his last mathematical talks, and the room was packed as he explained how linear combinations of L-functions will have a positive proportion of their zeros on the critical line. His result is probably the best theorem ever proved by a mathematician over eighty!

I feel extraordinarily fortunate in having such a long and close personal friendship with Atle Selberg. Much of my own work in mathematics was inspired by what I learned from him over the years. He was a remarkable man in many ways, and I shall cherish our time together for the rest of my life.

Oslo, 1987: Selberg with family after being named Knight Commander with Star of the Royal Order of Saint Olav by the king of Norway.

Samuel J. Patterson

My first encounter with Atle Selberg was a virtual one. In 1972, during my first year as a research student in Cambridge, I had been studying Joe Lehner's *Discontinuous Groups and Automorphic Functions*. In the final chapter of that book there is a brief introduction to the theory of automorphic functions of several variables. Joe Lehner wrote at the end of the introduction to that chapter: "But the reader cannot fail to improve himself [*sic*] if he consults the following publications." The list included Selberg's "Indian" paper. Shortly afterwards I consulted Volume 20 of the *Journal of the Indian Mathematical Society* to make a copy of Max Deuring's paper therein and, remembering

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Lehner's injunction, made a copy of Selberg's paper as well. I took it home and looked at it the same evening. This was my epiphany. Although it was to be some time before I understood it in detail, I knew this was where I wanted to work. One thing that fascinated me from the beginning was the theory of Eisenstein series. In the "Indian" paper, Selberg only asserts the analytic continuation of these functions without any hint of a proof. I was intrigued and found a little later the brief sketch of a proof in his Stockholm address. At that time there was apparently no one in the United Kingdom who knew anything about these matters, and I spent several months reconstructing Selberg's proof in the case of Fuchsian groups. It was difficult, but I learnt a great deal from the effort, and because of it I count Selberg as one of my teachers.

A little later Selberg came to Cambridge—I think it must have been in 1973—and I saw him for the first time. Two things remain in my memory here. First, I was overawed by him. I was a mere research student at the time, and I did not have the nerve to go up and speak to him. I cannot recall anyone else who had this effect quite so strongly on me. Later I got to know him a little, and he was both courteous and kind. A few years ago I learnt that Selberg in his turn was overawed by Carl Ludwig Siegel, who really could be very intimidating, and this made me feel much better about it.[4]

The second thing was that he was quite different in appearance from what I had expected. The "Indian" paper is written in a somewhat old-fashioned style and becomes very concrete. I had not expected its author to be a very elegantly and fastidiously dressed gentleman. He would be my choice for the "Best-Dressed Mathematician". His two lectures then were on the arithmeticity of groups operating on products of the upper half-plane and on Siegel's conjecture about irregular primes. The lectures were unlike any others. He stood at the front, facing the audience and speaking slowly with his gentle Norwegian accent. He only rarely wrote anything on the board, and consequently, despite the relaxed diction, it was very hard to take notes. I have often regretted that neither of the Cambridge talks ever appeared in print.

I had much more contact with him around 1980. First, he was a central figure in the Durham conference of 1979, organized by Christopher Hooley and Heini Halberstam. From shortly after that conference up to February 1981, I was a Benjamin Peirce Lecturer at Harvard. Dorian Goldfeld had invited Selberg in 1979 to MIT to lecture over a term on Eisenstein series, so I saw him both there and on other occasions in Princeton. He was very helpful whenever I had questions. What always impressed me was his remarkable memory for what he had done. (This did not seem to always work, as noted, for instance, in the footnote on p. 152 of Vol. 2 of his *Collected Papers*.) I still have somewhere the notes of his explanation to me of his version of the Shimura Correspondence (he had apparently discovered it somewhat earlier than Shimura but did not set much store by it). This method was rediscovered later by Winfried Kohnen and Don Zagier and is quite different from the method that Shimura presented at the Antwerp conference.

Selberg had a very developed persona as a country gentleman. I found that I could imagine him in an Irish country house, at least if he were not quite so well dressed. He was very keen on talking about matters other than mathematics, for example, about the natural world. He also adopted the appropriate political stance. With the intention of shocking me, I suspect, he once spoke about his time in the Norwegian Army and said that "a cannon is a very beautiful piece of equipment—at least, if you are on the right side of it." One has to remember that he lived through the German occupation of Norway and that, therefore, his early years of maturity were lived in much more difficult circumstances than most of us have had to cope with.

Because of the German occupation of Norway, Selberg was isolated in his early twenties. He had worked very much on his own. He describes his early years in his notes "Reflections around the Ramanujan centenary" (pp. 695–706 of the *Collected Papers*, Vol. 1). Selberg liked to tell one how few books he owned; this may have been so, but he was very well read. He seems to have done his reading mainly in libraries, starting with that of his father. It is then no surprise that he knew the works of the great Scandinavian mathematicians well. Of Abel he spoke with highest praise; admittedly, no one who has read Abel can do anything else. He also knew the work of Ivar Fredholm well. One can see how the theory of Eisenstein series arose when one compares his first version, the one in the Göttingen notes, with the work of Fredholm. The second proof of the analytic continuation of Eisenstein series, the one sketched in the Stockholm address, was more in the Hilbert mold and was based on an idea of Walter Roelcke. There have been various variations since then; Selberg spoke several times in later years about one particularly simple proof (cf. pp. 629–631 of the *Collected Papers*, Vol. 1).

The theory of Eisenstein series seems to me to be one of Selberg's most important achievements. It has become part of our way of thinking about automorphic forms, and it has led to many insights, of which perhaps the best-known example is Langlands' idea of L-groups. Also the many generalized Rankin–Selberg integral representations of L-functions would be impossible without this concept. Most importantly, it offered analytic number theory new methods for proving the analytic

[4] *When I spent my first year in Göttingen (1974–75) Siegel was sometimes to be seen, but I considered it to be out of the question to even think of talking to him.*

continuation of interesting functions, methods not based on the Poisson Summation Formula.

On the subject of mathematics, one topic on which Selberg's opinion was frequently sought was the Riemann Hypothesis. During the later 1980s I had been thinking about Kleinian groups and also the Riemann zeta-function (trying to come to terms with H. Matsumoto's purported proof of the Riemann Hypothesis). While talking about the latter at the conference in Tel Aviv on the occasion of Ilya Piatetskii-Shapiro's seventieth birthday, I ventured, incautiously, the opinion that the Riemann Hypothesis would mean that we were living in the best of all possible worlds but that it was not given to us mortals to know whether this was the case. Selberg came up to me afterwards, somewhat irritated, and said that whereas it was clear that the everyday world was by *no* means the best possible, in matters of real importance, that is, the Riemann Hypothesis, he was convinced that we were living in the best of all possible worlds. It should be added here that his views on this were not at all immutable despite the thought that he had put into it; for example, on the last page of his article on "The zeta-function and the Riemann Hypothesis" (*Collected Papers*, Vol. 1, pp. 341–354) he takes a thoroughly skeptical stance.

There was another side to Selberg that rather surprised me. Once, in the 1980s, when I was visiting the Institute, he invited a large number of us to a party. Around 11 p.m. people started muttering about babysitters and so on. Selberg (and Hedi) were rather upset; he said that in earlier days, in the 1950s, things really only got underway around midnight, when they would roll up the carpets to dance. I never experienced Selberg as a socialite, but I suspect that he really was one.

With regard to his house, a phrase he once used has remained embedded in my memory. The first time I was invited there, he explained very carefully how to get there. I could not miss it, for "it has a *very* red door." The house did indeed have a very red door.

Selberg writes in a note at the end of the second volume of his *Collected Papers* that writing did not come easily to him. He told me that when he became a permanent member of the Institute, his first thought was that he would never have to worry about publishing papers in journals again. Indeed, almost all of his papers afterwards are in conference proceedings, even if these appeared in journals. It clearly needed a bit of pressure from an editor to get the paper out of him. He had then much more time than Hedi, who was a researcher at the Princeton University Plasma Physics Laboratory. Despite the image as the mildly conservative country gentleman he affected, it was Selberg who was in charge of the house and children. This domesticity was very uncharacteristic of his generation. The persona he cultivated of the urbane country gentleman was only one part of the story.

Roger Heath-Brown

I first met Selberg in 1978, I think, when he came to give a lecture in Cambridge. I had finished my Ph.D. and was just starting a Junior Research Fellowship at Trinity College. By that stage I was well aware of his wonderful achievements in so many of the areas on which I had worked: on the zeros of the zeta-function, on the elementary proof of the prime number theorem, and on sieves. They were awe-inspiring pieces of work which I had studied in detail. I do not remember the title of his talk, but the subject was the zeros of the zeta-function. Naturally, I was very much looking forward to hearing the great man speak!

A few months beforehand, my interest in the zeta-function had led me to examine Levinson's work on the proportion of zeros on the critical line. In the 1940s Selberg had shown, by a very natural route, that a positive proportion of the nontrivial zeros of the zeta-function must lie on the critical line. Indeed, since the method detected sign changes, the zeros found by Selberg were necessarily of odd order. I therefore asked myself what one might say about the zeros produced by Levinson's method and discovered to my surprise that, in effect, they were all simple. I was pleased with this observation and had written to Montgomery about it but had not told people in Cambridge.

So imagine my surprise—my horror—when Selberg's lecture described exactly the same deduction from Levinson's analysis. In later years I heard tales of Selberg's unpublished manuscripts, of how an unfortunate student might lecture on his prized result in front of Selberg only to be told, "I made the same observation in 1943, but decided not to publish it."

After the talk I was given the task of walking Selberg from the lecture theatre back to college for dinner. Somehow I plucked up the courage to broach the subject of my own work on Levinson's method and simple zeros. Selberg was very kind and insisted I should go ahead with publication.

And so, for me, there was a happy ending. For this kindness and for all his other gifts to mathematics, I will remember him.

K. M. Tsang

It was in the spring term of 1981 that Professor Atle Selberg gave a series of lectures on

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On the Great Wall of China, 1998. Kai-Man Tsang (with sunglasses) is just behind Selberg.

sieve methods at the Institute for Advanced Study. The very first lecture had attracted a large crowd to F119 of Fuld Hall. The number of listeners then quickly shrank to a steady state of five or six after the first two lectures, and I was proudly amongst the few that persisted till the end of the whole lecture series.

But I have to confess that I had difficulties in following closely Selberg's lectures and that my understanding of his beautiful sieve theory was superficial. However, as a graduate student at Princeton University I was keen on exploring whatever new things that I found interesting. Another reason I went to these lectures was that I wished to meet the famous speaker, Professor Atle Selberg. A couple of times after his lectures, I gathered my courage and was brave enough to talk to him and to raise some questions. I never expected that he would be so kind as to lead me into his office and even give me an offprint of his Stony Brook lectures, which he was doing in his lecture series. These were my first encounters with Professor Selberg, who later became my teacher and friend.

One afternoon in November of 1981, a few weeks after I passed my general examination at Princeton University, I went to see Professor Selberg in his office without making an appointment. I expressed to him my interest in analytic number theory, in particular on sieves and the theory of the Riemann zeta-function, and asked if he would be willing to be my thesis adviser. To my surprise, he agreed on the spot. I guess my attendance at his lectures earlier had played a role. That marked the beginning of our long association, which, for me, will last forever.

From that time onwards, Professor Selberg kept every Friday afternoon reserved for me. In his office he went through with me many of the things that he had done in the past, including mainly sieve methods and the theory of the Riemann zeta-function. But we also frequently digressed to other problems that interested both of us. He wrote on the boards in his office and patiently explained every detail. This was not his typical style of lecturing. He had evidently put in extra effort to accommodate my pace. In addition, he also organized his materials in such a way that would allow me to see clearly the flow of his simple, elegant ideas. I still remember vividly the way he constructed what is now called the Beurling function, an analytic function of order one which approximates the characteristic function of an interval.

Our weekly meetings had no preset finishing time. If we finished around 3:30–4:00 p.m., we would go together to the tea and cookies in the common room. He would then sit down to read the *New York Times* and work on the crossword puzzles. Sometimes, when we finished a bit late, he would bring me to the cafeteria for coffee. This coffee time offered me excellent opportunities to talk to him and to learn from him about things other than mathematics. We talked leisurely and freely on anything of common interest, ranging from wildlife (one of his favorite topics) to U.S. politics and the environment. Sometimes we also shared stories about his family and mine. To a young man from the Orient and with a totally different cultural background, the views and experience of this knowledgeable old man were inspiring and refreshing. On some festive occasions, he and Hedi (his first wife) would invite me to join their family gatherings. They tried to enrich my social life in Princeton as well.

The generous support of Professor Selberg kept going even after I completed my doctoral study at Princeton University. He offered me the opportunity of staying on at the Institute for Advanced Study by appointing me to be his assistant (though, in actual practice, just the reverse was true). Even after I returned to Hong Kong in 1985 to reunite with my family and to teach there, his help continued. He arranged for me to be invited to conferences, first to the Oslo conference which celebrated his seventieth birthday and then to several others following that. He also invited me for shorter visits at IAS in later years. In the summer of 1990 my wife and I visited them again at IAS. At that time my wife had just gotten pregnant, and she was experiencing all kinds of typical and atypical discomforts. Hedi helped to allay her fear and gave her valuable advice. We still have the book on pregnancy which she gave us.

Professor Selberg had much interest in visiting Mainland China, and his first trip to the Far East was to Hong Kong in 1993 to attend a conference our department organized. That was a great honor for our whole university. Later, in May 1998, he visited us in Hong Kong again. This time he stayed for a whole month and gave altogether eight lectures. He then continued on to visit three places in Mainland China, namely, Beijing, Shandong, and Xian. He was still enjoying good health and even climbed the Great Wall under his own steam at the age of eighty-one.

I got to know Professor Selberg in the later part of his life. During this period I could see that he had been very generous with his ideas and expertise to whoever came to talk to him. Many young mathematicians, including Amit Ghosh, Brian Conrey, Heng Huat Chan, etc., had benefited enormously from his ideas and help. But I can boldly conclude that among all of them, I am the most privileged, for I had been with Selberg for one afternoon each week for more than three years. Besides learning mathematics from him and seeing him do mathematics on the spot, his rich and unique experience of life has enlightened and inspired me all the way through my development as a professional mathematician. I once accepted an offer of a position from an institution, and then, for some reason, I wished to change my mind. I went to see him and asked how I could make up some kind of excuse for withdrawing. But he told me, "Things are best explained by the truth." I remembered this valuable advice verbatim and have kept it as my motto ever since.

Many mathematical friends of mine have been curious about how I got to be Selberg's student. In response, I simply told them the facts: "I went to see him, expressed my interests in the subject, and then asked." I don't know whether anyone else ever approached him on the same question, but I do think he would have been willing to take as his student anyone who had strong interests in the subject. Under his supervision I was given absolute freedom to develop and do whatever I was interested in. He seldom asked me what I was doing or checked my progress. While I enjoyed this high degree of freedom, I also felt the pressure. I knew that I was on my own and that I had to be self-driven.

From time to time he would be consulted by mathematicians concerning new results they had obtained. Sometimes his comment was, "I obtained the same (or even more) in 1941 and so on…." Such a remark to some mathematicians may sound a little embarrassing, but to me this amounts to a great compliment. In my reminiscences, it was in only a couple of instances that I was able to obtain something on a par with what Selberg had done in the early 1940s.

I once asked Selberg whether he believed in luck. He replied, "Luck certainly plays a not insignificant role in one's life." With this I fully concur. I have been most fortunate to have had Professor Selberg as a teacher and friend in my life.

Wenzhi Luo

Atle Selberg left us with an immense scientific legacy. He will be remembered as one of the chief architects of the twentieth century who shaped the global outlook of modern mathematics. His profound, monumental works on number theory and automorphic forms are a continuing source of inspiration. He discovered and established grand theories in mathematics and settled some of the most challenging problems. Simplicity and elegance are the hallmarks of Selberg's work, for which I have deep admiration.

Atle was a true genius and gentleman, with classic style and exquisite taste and sense of humor. I have vivid and fond recollections of the academic year 1993–94, when I was at IAS, and the period 1995–99, when I was a junior faculty member at Princeton University and was able to have more personal contact with him. Talking to Atle was a real pleasure for me. He had lunch regularly in the Institute dining hall, and I often joined him there. We talked about a wide range of topics. His views had extraordinary insight and depth, and his conversation was dotted throughout with wit and wisdom. He liked to talk about C. L. Siegel and his friendship with the late Chinese mathematicians L. K. Hua and J. R. Chen.

In the fall of 1997 I mentioned to Selberg that Professor Chengbiao Pan hoped to invite him and Peter Sarnak to visit Peking University at a convenient time. Atle expressed great interest in such a trip. Thus, in June 1998, he and Peter visited and lectured at Beijing, as well as in Jinan and Xian. Atle seemed to enjoy this trip a lot, and after his return, he vividly described to me his pleasant, joyful experiences in China.

In Atle's Fuld Hall study I was fortunate to be able to learn some of his theories and methods directly from him. I particularly remember how, at that time, I was using his mollifier method to study the zero density of L-functions and was stuck with something. One day I spoke to Atle about this. To my surprise, the next day I found a large envelope addressed to me from Atle. In it, there was a three-page sketch of a simple and beautiful approach to overcome the difficulty. This idea turned out to be the exact key to solving my problem!

Brian Conrey

Selberg was a giant among mathematicians. We used to refer to him reverentially as "the king". I first met him when I came to the Institute for Advanced Study for a year beginning in the fall of 1982. Amit Ghosh introduced me. Amit and he were good friends, and I think that helped pave the way for me.

A highlight of that year was when Amit, Dan Goldston, and I took Selberg and Hedi to dinner one night at a fancy French restaurant in New Hope. I was very nervous driving, since the safety

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of one of the most brilliant mathematicians of the century was in my hands! The dinner was a success, and upon returning to Princeton, the Selbergs invited us into their home, where they showed us Selberg's Fields Medal and his collection of seashells. I returned to the Institute in 1987–88 and again in 1990–91 and enjoyed the hospitality of the Selbergs on numerous occasions. They were very friendly to the young number theorists.

After Amit and I went to Oklahoma State in 1983, Amit decided to invite number theorists from around the world to a conference in Stillwater so that they could see our new home. The first thing he did was to invite Selberg. After Selberg generously agreed to attend, Amit had no trouble organizing a most amazing conference with many of the top number theorists. At the banquet, Selberg stood up to give a toast and said that it was the best organized conference he had ever been to.

One example of Selberg's brilliant mathematical intuition that was especially exciting for me was when I first heard Selberg's lecture at Amalfi in September of 1989 (delivered by Bombieri), in which he laid out his set of axioms for a class of Dirichlet series, providing a precise list of what ingredients should imply the Riemann Hypothesis and generally describing with a simple analytic formulation what an L-function is.

Ghosh and I wrote the first follow-up paper to Selberg's preprint, and in that we named the class the "Selberg Class". What is striking about Selberg's formulation is that he got exactly the right set of axioms (down to the—at first sight mysterious—$\theta < 1/2$) to provide an analytic framework for future work. I have just heard that Kaczorowski and Perelli have established that the only elements in the Selberg Class of degree smaller than two are the Riemann zeta-function and Dirichlet L-functions associated with primitive characters. This is a beautiful theorem that I think Selberg would like to have seen. (He once told me that it would be very difficult to prove such a result.) I think it is accurate to say that this result simply would not have happened if not for Selberg setting things in motion with his axioms.

Another way in which Selberg had a profound influence on my own career was in helping to get the American Institute of Mathematics (AIM) off the ground. The initial AIM event was a workshop in Seattle called "In Celebration of the Centenary of the Proof of the Prime Number Theorem: A Symposium on the Riemann Hypothesis". After getting AIM's permission to sponsor such a meeting, the first thing I did was to call Selberg, and he kindly agreed to attend. Selberg gave the opening lecture; it was an expository lecture on events leading up to the proof of the prime number theorem. Speaking to a packed lecture hall of three hundred or so, he argued that Riemann must have known that the zeta-function did not vanish on the 1-line (a fact equivalent to the Prime Number Theorem) but that since he was interested in an exact formula for the prime counting function, he did not write down the proof! At the end of the lecture, Selberg received a standing ovation—the only time I've ever witnessed that after a math lecture. After the meeting I was offered the directorship of AIM, which in part I attribute to the success of the Seattle conference.

I have fond memories of when Selberg and Mickey came to visit AIM in Palo Alto during the summers of 1999 and 2000. He loved to play games at lunchtime, especially bocce, and was fiercely competitive, winning more often than not. I especially cherish a barbecue at my home in Morgan Hill. After dinner we walked with our wine glasses over to the newly created golf course that will contain AIM's future home, and about fifteen of us drove golf carts around (Mickey drove Selberg) to see the various ponds and gardens on a tour led by AIM's founder, John Fry.

Selberg was always very generous to me personally, professionally, and mathematically. He was my hero and a friend; we all miss him.

Amit Ghosh

My first exposure to Selberg's mathematics came in 1977, when, as an undergraduate, I attempted to understand Titchmarsh's book on the zeta-function. I soon learned that Selberg was one of the living legends, and I hoped someday to study his papers. About two years later I was fortunate, as a graduate student, to attend the Durham Conference in Analytic Number Theory. My advisor, Heini Halberstam, was a coorganizer. Selberg was in attendance and made a striking figure, dressed in a bold bright maroon jacket, but I did not have it in me to approach him.

After the conference Halberstam informed me that Selberg said he was able to improve upon one of his results from a 1946 paper on the distribution of zeros of the zeta-function. Halberstam suggested that perhaps I should see if I could come up with a proof of my own, and a few months later I succeeded. While I was quite pleased, I was not at all sure what Selberg would think. A letter arrived soon after with the comment, "He has done a quite good job"; I thought that perhaps Selberg did not think much of my effort. I followed Halberstam to the University of Illinois in 1980 and applied for various postdoctoral positions the following year. When the Institute (IAS) called with a two-year offer, it then became clear to me that I must have made some impression on Selberg after all. This was how I met him.

Before meeting Selberg, I was familiar with his reputation of being very hard to impress, and I

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was told that, in all probability, if one had an idea, Selberg probably had had a better one thirty years earlier but did not wish to publish it. Armed with this baggage, my confidence level was not high when I arrived at IAS in 1981. However, my small success with his 1946 paper indicated to me (with my youthful ego) that even Selberg was capable of missing a result every now and then.

My first meeting was an hour-long conversation. Technically speaking, I did most of the listening and had to learn quite quickly how to converse with him: if he ever paused after a sentence, you waited, and if he looked at you, then he was done and your turn could begin (years later we dropped this system). In those two years at IAS, though I developed a rapport with Selberg which I would not call a friendship, I did notice that I was more at ease with him than were my friends and colleagues (perhaps we joked with each other more). With hindsight, I know that my generation had a much easier time interacting with Selberg, as he had mellowed a great deal with age.

In the academic year 1982–83, a group of number theorists was at IAS, and some of us began collaborating. As the end of the year approached, it was time to move on to permanent positions elsewhere. At this time, Brian Conrey and I were working on the zeta-function, and we decided to move to Oklahoma State University as part of a group of four number theorists hired by William Jaco. We wanted to bring the department to the attention of our fellow mathematicians, so we decided to hold a conference in the summer of 1984. To make this conference attractive to attend on such short notice, I asked Selberg if he would attend and if I could use his name when I approached other mathematicians. I must admit I did not expect him to agree, but he did so there and then.[5] This was the kind of support he gave the younger generation.

After I left IAS my contact with Selberg dwindled, except during the summer months, when I made a habit of spending my summers at IAS as a visitor (at that time IAS had a summer visitor program). We would meet for lunch and talk mainly about mathematics, interspersed with history of all kinds.

At this stage I must mention Hedvig (Hedi) Selberg. To me she was a formidable presence, and I was always concerned that I might somehow offend her. While Selberg laughed at my jokes, Hedi just smiled (one never quite knew exactly what that meant). It was obvious that they were extremely close, and as the summers went by, I came to realize that it was she who made some of my summer visits to IAS possible. She told me that my company was good for Selberg, as he did not interact much with other younger members at IAS. (I recall encouraging Selberg to sit with others at lunch, but he said that he didn't think they would be interested.) Soon we were having dinners out and later with my wife, Priscilla. These dinners revealed to me the personal sides of the Selbergs, and he became Atle to me. I remember a birthday party for Atle to which Hedi invited several of us who were at IAS in the summer of 1988. There was a very cheerful mood, and some of us were "discussing" various political issues. Atle joined in, and soon we seemed to be arguing on opposite sides (it was very humorous). The next day, concerned that I might have offended Atle, I was surprised to find him thinking the same toward me. I think we developed a friendship without really thinking about it. My summers at IAS came to an end in 1995 as the program was discontinued.

That last summer was a turning point in our lives. Priscilla and I met the Selbergs many times for lunch. Hedi encouraged us to see the Kirov Ballet in New York City, which we did. Before we could see her again, she was dead. This unexpected event was a great shock, yet I could only think of what it was going to do to Atle. At the memorial service a few weeks later, we heard lovely memories of Hedi. But when Atle got up to speak, it was not possible to control one's emotions. I did not know when Atle would come back to lunch at IAS, but one day he appeared and joined me. He broke down, and we talked about Hedi and his life with her. We continued to meet periodically for lunch the rest of that summer. When it was time to say goodbye, I wondered how he would endure living in that house alone. It was good that he had some trips planned, but I was concerned that his loss was going to be too hard on him.

I did not go to Princeton the next summer when our son Armand was born, but I did keep in touch with Atle. When we returned to Princeton (not IAS) in the summer of 1997, Atle had a twinkle in his eye. He had been spending some time in California, and when he returned, we decided to go out for dinner. He had not yet met Armand and wanted to stop at a toy store; after quite a while he decided on a turtle hand-puppet (Atle had a very keen interest in botany and zoology). Along the way, he told me of a new love in his life and was happy to tell Priscilla and me of "glorious days". We were so happy for him, and my worries for him disappeared. Thus began a new phase in our friendship in the coming years.

While I saw him less frequently each summer (we were now returning with our daughter, Saskia, as well as Armand), our conversations grew more personal in nature. As we got older and as he got more ailments, he invariably would wonder how much longer he would last. But Atle was not one to brood. He dealt with any setbacks with an

[5] *As the conference approached, I reminded him that the summer would be his sixty-seventh year and so he would be class number one. His response was, "It would be much better to make the next one," namely, 163.*

Photograph by Ingrid Selberg.

Crossing a fjord with Mickey Selberg, 2000.

infectious sense of humor that I loved. We talked of his childhood, his children and grandchildren, and we talked of friendships. He said that almost all his friends were really Hedi's friends, that he had difficulty making connections, and that he thought he had some autistic tendencies (we laughed, as clearly every mathematician appears to have some autistic tendencies).

In the last three years of his life, it was difficult for him to come for lunch. We would meet at his office for a bit of a chat. In 2006 I told him that I was thinking of spending my sabbatical in Princeton and that I could see him more. He said, "That would be very nice." I told him of a formula I was working on and wrote it on his blackboard; it was still there a year later when he died (we had come full circle). For the summer of 2007 my family and I were fortunate to rent a house across from the Institute lawn leading to Atle's house. I had high hopes of seeing much more of him and I told him so when we got there. He said he would be more mobile after some minor surgery and told me of a party at IAS commemorating his ninetieth birthday. I did not hear from him, but a few weeks later Peter Sarnak contacted me on behalf of Atle to tell me that Atle was not well enough to see me. I asked to visit him and then did so with Peter. He was in high spirits and thought he would recover, as did we. As I left he said, "We will spend more time next summer." He died two weeks later.

Lennart Carleson

I first saw Atle on August 30, 1950. The occasion was the award of the Fields Medals and the place was the Saunders Theater at Harvard during the International Congress. I was twenty-two and had just defended my thesis at Uppsala University in Sweden. My advisor, Arne Beurling, was an invited speaker, and this was my first trip abroad. The work of Atle, especially his elementary proof of the prime number theorem, impressed me very much. In contrast, it took me many more years to mature enough to appreciate the work of the other prizewinner, Laurent Schwartz.

Since that time I've always considered Atle a colleague of my teacher and regarded him with respect and admiration. He appreciated Beurling very much and actively promoted Beurling's move to IAS. They were not very close and never worked together (as far as I know), but they shared a common view of many aspects of life, in particular, of what constitutes good mathematics: hard basic problems, simplicity, and beauty.

Through the years Atle and I tended to meet mainly during my visits to IAS. Atle also spent two long periods at the Mittag-Leffler Institute. He and his first wife, Hedi, were always most helpful and generous to me and my family. We had a special relation to Hedi, as she was, so to say, almost Swedish, having lived and worked in Sweden for several years following the end of the war. I especially remember the 1977–78 academic year. The Mittag-Leffler Institute had then organized a special year in analytic number theory, and Atle spent four months there. He gave an extended series of lectures on sieve methods. It was an exciting year, with long-term visits by Paul Cohen, Enrico Bombieri, and a host of other noted mathematicians. The Riemann Hypothesis was constantly on the agenda with occasional sparkles of hope. Atle's presence was, in a way, a catalyst. I frankly wonder if ever a more serious effort to find a proof has taken place in conjunction with a scientific institute's annual program.

Paul Malliavin

I first met Atle Selberg in September of 1954 at the Institute in Princeton. Having presented Selberg's elementary proof of the prime number theorem at the University of Paris some months earlier, it was only natural that, while at IAS, I followed closely his 1955 winter course, in which he presented his famous trace formula for the first time. The audience was, as I remember, not very large. In addition to myself, it generally included Leon Ehrenpreis, Friedrich Mautner, Josephine Mitchell, her husband, Lowell Schoenfeld, and a few graduate students from Princeton University (when the snow was not too high).

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During the 1960–61 academic year I was invited back to IAS by Arne Beurling in connection with our common work on harmonic analysis. I had, however, a subsidiary plan to try to develop certain Tauberian-type theorems in a number-theoretic setting. On the suggestion of Arne Beurling and Jean Leray, I asked to be Atle Selberg's assistant for the year. As a result of this side program, in 1961 I published a paper in *Acta Mathematica* in which I show that the remainder term for Beurling's generalized primes has order-of-magnitude structurally similar to I. M. Vinogradov's remainder term valid in the case of ordinary primes. From this result I became persuaded that progress in classical prime distribution theory would not depend merely on some improvement in Tauberian methodology.

During 1960–61 I also discussed with Selberg some perspectives concerning progress on the Lindelöf Hypothesis. I remember that Selberg was quite convinced that a proof of the Lindelöf Hypothesis would be a decisive step toward the Riemann Hypothesis.

From these memories of the 1950s and early 1960s, Atle Selberg stands for me as a man of the utmost scientific integrity.

Nils A. Baas

I met Atle for the first time in 1972 when I went to the Institute for Advanced Study as a young member. We soon became very good friends, and my wife, Vivian, and I had a very close friendship with Hedi and Atle and also later with Mickey.

I discussed all kinds of subjects with Atle. In mathematics, it was actually an advantage for me to be in a different field, since he would then explain his thoughts in a more elementary way. Atle did not like fat books and big papers. He told me that he considered himself an amateur compared to some of his colleagues. He wanted to work on his own, penetrating problems by his own thinking and at his own pace. His knowledge outside of mathematics was extremely impressive—in botany, zoology, history, geography, and many other subjects as well—and his memory was hard to beat.

Atle had very high standards both in his professional work and in other activities. He had very clear and well-founded opinions, and when you asked him about something, you could always be certain to get his honest opinion without any unnecessary wrapping. His honesty was uncompromisable. When he, with great clarity, expressed his opinions, it was as if he was carving the message with capital letters in Norwegian granite; and when he, in his characteristic manner, raised his hand, there was no room for debate. Hedi once told Vivian and me: "There is one thing that Atle is incapable of—lying!" What a wonderful statement from a spouse.

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Atle Selberg in his IAS office, 2005. (Photograph courtesy of N. A. Baas.)

Atle was very relaxed with respect to his own time. Once Vivian met him in the morning at the Princeton Shopping Center, and he explained why he was there: "I do the shopping, because Hedi has a job." Atle visited our home many times in Trondheim, and he loved to be served halibut and Norwegian layer cake "heavily soaked with sherry."

Atle was a true Norwegian. He loved Norway—the nature, the language, and the culture. He spent sixty years in the U.S., but I sometimes felt that his mind never left Norway. He visited Norway regularly, and he was a great inspiration for younger Norwegian mathematicians. We were all very proud of Atle being a Norwegian.

I remember an episode from the summer of 1974. I was a member of the Institute for Advanced Study, and we were staying for the summer. Atle was just about to leave for Norway in order to visit his brother, Sigmund, in his cabin by the beautiful Hardangerfjord. We were sitting in the common room in Fuld Hall chatting just after teatime. The temperature was in the high nineties, so was the humidity, and outside it rained cats and dogs. Atle looked out the window and commented in his characteristically cryptic way: "Actually, I prefer the rain in Norway." To me this sounded like the deepest declaration of love for his home country that anyone could give.

After a lecture in Trondheim in the 1980s, he gave a list of problems he felt were important. I asked him then: If the Good Lord would offer him a solution to one of them, which one would he choose? "Without any doubt, the Riemann Hypothesis," he said. "I would not like to have the complete solution, but a small clue would be nice."

About the Cover

Atle Selberg and automorphic forms

The cover shows a framed image of a Maass form for SL(2,$\mathbb{Z}$) hanging on the wall of the office of Atle Selberg at the Institute for Advanced Study. Dennis Hejhal and Peter Sarnak, contributors to the Selberg memorial article in this issue, write:

"The theory of Eisenstein series lies at the center of the modern theory of automorphic forms. They are a fundamental tool in the theory, and understanding them has uncovered many of the deeper truths in the subject. Selberg's very original investigation of their meromorphic continuation marked the beginning of the modern theory. In the case of the classical modular group, their closer analysis—combined with the trace formula—enabled Selberg to establish the existence of the simplest building blocks of the theory, viz., nonholomorphic cusp forms. Known also as 'Maass waveforms', such forms are, in the present setting, simply nonconstant eigenfunctions of the non-Euclidean Laplacian on the familiar triangular-shaped fundamental domain for the modular group. The picture on the cover is a color-coded topography plot of such a cusp form having eigenvalue approximately 15,700. It was computed numerically by Hejhal in 1992, and was one of the few decorations that Selberg placed on the walls in his office. (Very similar patterns are found with Eisenstein series.)"

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

Photograph by Bill Casselman.

When alone, Atle and I always spoke Norwegian. In connection with the celebration of his ninetieth birthday, Atle initially did not want any reception. Peter Sarnak and I tried to persuade him during a lunch at the Institute, but our attempt was inconclusive. A bit later I went home to Atle and suggested that a reception in his honor would be nice. First he nodded willingly, but then he switched to English and objected to the plans. I managed to get the conversation back into Norwegian, and then he agreed swiftly. Language is indeed a subtle thing.

Over the years we often discussed Norwegian literature, especially poetry. We both liked the Norwegian poet Tor Jonsson, and I remember showing one of his poems to Atle. To me, it offers a symbolic characterization of Atle's life and work. I think it would be in Atle's spirit to present it in Norwegian, and I offer a nonpoetic translation as well:

Å DIKTE

Å dikte er å vera
det vesle some ein vart
og sleppe kvite fuglar ut
i nattesvart

Å leva er å vera
det store som ein er
og stå i einsleg undring
og høyre fuglar flyge inn
frå ukjend verd.

TO COMPOSE

To compose is to be
the little you were created as
and let white birds out
in the dark night.

To live is to be
the great thing that you are
and stand alone and wonder
and hear birds fly in
from unknown worlds.

Atle was indeed a lonely wonderer and a great human being. With Atle gone, the world has lost one of its greatest mathematicians, Norway one of her greatest sons, and we have all lost a good and dear friend. But his spirit and work will continue to live in us and in generations to come!

Editor's note: Unless otherwise noted, all photographs in this article are courtesy of the Selberg family.

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On the Concept of Genus in Topology and Complex Analysis

Friedrich E. P. Hirzebruch and Matthias Kreck

The English word "genus" hails from biology, where it is used to connote a grouping of organisms having common characteristics. In mathematics the word is also used to group objects with common characteristics. The concept of genus arises in various mathematical contexts, such as number theory, as well as in the areas we consider in this article, topology and complex analysis. Even within the latter two areas there are various notions of genus that historically originated with the genus of an oriented surface. We begin with these origins and afterward treat generalizations and modifications. We provide no detailed definitions and proofs; rather, our goal is to give the reader an intuitive feeling for the concept of genera.

The Genus of a Surface

In his paper "Theorie der Abel'schen Functionen" [20] Riemann studied the topology of surfaces. He classified a surface by looking for simple closed curves along which to cut in order to obtain a simple presentation of the surface. He called the minimal number of such curves $2p$ and showed that this invariant determines the surface. A few years later, when Clebsch studied surfaces from a more algebraic geometric viewpoint, he called p "*das Geschlecht (genus)*" of the surface.

In more modern terms one can formulate Riemann's insight as follows: every connected, closed (meaning compact without boundary), oriented surface F is obtained from the 2-sphere S^2 by taking repeated connected sums with the torus, $T = S^1 \times S^1$. The number of tori added is a topological invariant called the *genus of* F, $g(F)$, which equals Clebsch's p.

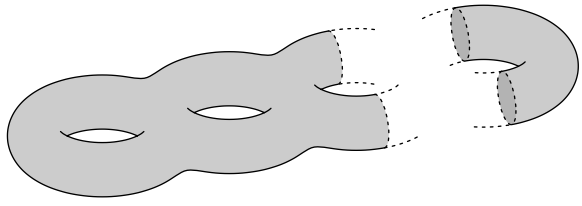

Figure 1.

Riemann's concept of surface is not easy to summarize. It is something like a ramified covering of the plane, and he implicitly assumes that a surface has a sort of differentiable structure, which is a great technical help. But the genus is actually a topological invariant. One can prove this by using either the fundamental group or the first homology group $H_1(F)$. Specifically, $H_1(S^2) = 0$, and the formula

$$H_1(F \sharp T) \cong H_1(F) \oplus \mathbb{Z}^2,$$

where $\sharp$ stands for connected sum, implies that a surface F_n obtained from S^2 by connected sum with n tori has

$$H_1(F_n) \cong \mathbb{Z}^{2n}.$$

The rank of the k-th homology group is called the k-th *Betti number*,

$$b_k(X) := \operatorname{rank}(H_k(X)),$$

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and so we obtain the formula

$$g(F) = b_1(F)/2.$$

Instead of the Betti number one can use the *Euler characteristic*,

$$e(X) := \sum_i (-1)^i b_i(X),$$

to determine the genus of F, namely, $b_0(F) = b_2(F) = 1$, and so $e(F) = 2 - b_1(F) = 2 - 2g(F)$, implying

$$g(F) = 1 - e(F)/2.$$

The Euler number itself can be computed combinatorially without referring to homology. Every surface has a *triangulation* (see next section), which we can visualize by putting a net of triangles over F

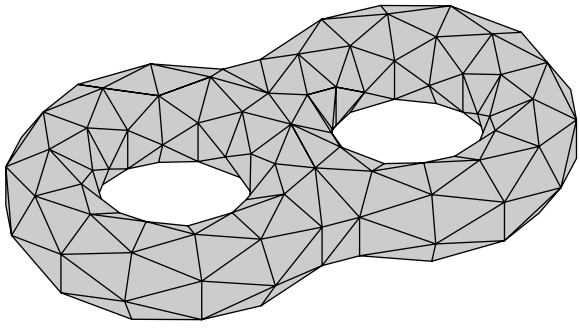


Figure 2.

and then

$$e(F) = number\ of\ vertices - number\ of\ edges + number\ of\ triangles.$$

However, to show that the combinatorially defined Euler characteristic is a topological invariant needs a proof.

What Is the Topological Significance of the Genus?

So far we have attached a topological invariant, a certain characterization, to a surface: the genus. How powerful is this invariant? What is its topological significance? One can interpret Riemann as saying that a differentiable surface is determined by its genus. A modern proof of this can be obtained from elementary Morse theory [6], [7]. But a stronger statement is true: the genus characterizes the homeomorphism type. This result was proved by Rado long after Riemann's work:

Theorem [19]. *Two connected closed oriented surfaces F and F' are homeomorphic if and only if*

$$g(F) = g(F').$$

This is not an easy result. The central step in Rado's proof is to show that a topological surface with countable basis has a triangulation, and then a proof in the combinatorial world is not difficult.

What Is the Analytic Significance of the Genus?

The main intention of Riemann's topological considerations was to study surfaces as objects in complex analysis: in modern terms, as *complex manifolds* of complex dimension 1, *complex curves*. A complex manifold is a topological manifold (meaning a topological Hausdorff space with countable basis locally homeomorphic to $\mathbb{R}^n$) together with an atlas whose coordinate changes are holomorphic maps. We note that in complex dimension 1 a countable basis follows from the existence of a complex structure [19]. On such a complex curve Riemann considered divisors D, which are finite formal linear combinations of points in the surface with coefficients in $\mathbb{Z}$. Each meromorphic function on a closed surface (in the following we assume that the surfaces are closed) determines a divisor D by its zeroes and poles (counted with multiplicity). To each divisor we attach the sum of the coefficients called $\deg(D)$. Given D we can consider the vector space of meromorphic functions characterized by the property that its divisor plus the given divisor does not have negative multiplicities. This vector space is finite-dimensional, and its dimension is denoted by $l(D)$.

For a divisor D Riemann [20] proved his inequality

$$l(D) \geq deg(D) + 1 - g.$$

This is the starting point of the famous Riemann-Roch theorem [21], which gives an equality using the *canonical divisor* K:

$$l(D) - l(K - D) = deg(D) + 1 - g.$$

Why is this an important result? If we look at the right-hand side of the equation, we see the sum of a very simple invariant of a divisor, its degree, and a topological invariant, $1 - g$. However, the left-hand side is a complicated analytic invariant: the difference of dimensions of certain function spaces, more precisely spaces of meromorphic functions with restricted zeroes and poles.

The Arithmetic Genus of Algebraic Varieties

It should be noted that the passage from differentiable structures to complex structures is a dramatic change, since there are in general many different complex structures on a given surface. One has a moduli space of complex structures which for $g \geq 2$ is itself a complex manifold of complex dimension $3g - 3$. For $g = 0$ the moduli space is a point, and for $g = 1$ it has complex dimension 1.

One can proceed further and impose even more refined structures on a surface, for example, complex algebraic structures. Whereas topological and smooth manifolds were intensively studied in the first half of the last century, complex manifolds of dimension greater than 1 were not investigated very much by complex analytic methods (of course the function theory of several complex variables in open domains in $\mathbb{C}^n$ was a subject of great interest). In contrast, *algebraic varieties*, the set of zeroes of a family of polynomials, were the subject of constant mathematical investigations, at least by constructing interesting examples and studying their geometry. Many formulae were found that led to interesting questions and conjectures.

In this context another genus, the *arithmetic genus*, played an important role. In the early 1950s four definitions of the arithmetic genus of a projective smooth algebraic variety V of complex dimension n were known. The first two are denoted by $p_a(V)$ and $P_a(V)$. Severi conjectured that these numbers agree and can be computed in terms of the dimension $g_i(V)$ of the vector space of holomorphic differential forms of degree i:

$$p_a(V) = P_a(V) = g_n(V) - g_{n-1}(V) + \cdots + (-1)^{n-1} g_1(V).$$

The expression on the right-hand side is the third definition, which we recommend to the reader (actually in a slightly modified form described below). Using sheaf theory, Kodaira and Spencer [14] proved that the three expressions agree.

The expression on the right looks like an Euler characteristic, but in a strange form. The "correct" Euler number is the *holomorphic Euler number*,

$$\chi(V) := \sum_{i=0}^{n} (-1)^i g_i(V),$$

called the *arithmetic genus*. The number of components of V is $g_0(V)$. Thus for a connected variety $1 + (-1)^n p_a(V) = \chi(V)$. Often $g_n(V)$ is called the *geometric genus* of V. For the case of a curve (Riemannian surface) we have

$$g_1(V) = g(V),$$

and so the geometric genus and Riemann's genus agree.

Both the arithmetic and geometric genus are multiplicative:

$$\chi(V \times V') = \chi(V)\chi(V')$$

and

$$g_{n+m}(V \times V') = g_n(V) g_m(V'),$$

where $n = \dim V$ and $m = \dim V'$.

The $g_i(V)$ are birational invariants [25], and so the arithmetic genus is a birational invariant.

The Todd Genus

The fourth definition of the arithmetic genus was given by J. A. Todd [24]. A canonical divisor of a smooth projective algebraic variety of dimension n is given as a divisor of a meromorphic n-form. It is an algebraic cycle of topological codimension 2. Todd introduced geometric canonical cycles for all even codimensions. He defined polynomials in these cycles, where the product is given by intersections. The n-th Todd polynomial is of codimension $2n$ and represents for a variety of dimension n a certain number called the *Todd genus*. Todd believed that his genus was the same as the arithmetic genus, but rigorous justification of this fact came much later.

The Todd canonical classes represent homology classes, and they are up to signs Poincaré dual to the *Chern classes* of the tangent bundle of the variety [18]. More generally, Chern classes are defined for complex vector bundles. In contrast to complex manifolds, where holomorphic maps play a definitive role, complex vector bundles are purely topological objects; roughly speaking, they are a family of complex k-dimensional vector spaces parametrized by the points of a topological space X. There is also a topology on the disjoint union of these vector spaces, and the key property is that locally this family of vector spaces is homeomorphic to a product $U \times \mathbb{C}^k$, where U is an open subset of X. The formal definition of Chern classes is too complicated for an article such as this one, but the basic idea behind them can be explained by considering the case of a differentiable complex vector bundle E over a closed differentiable manifold X. Then the Chern class $c_i(E) \in H^{2i}(X;\mathbb{Z})$ is the first obstruction to the existence of $k - i + 1$ linearly independent sections on E. If one chooses, for example, a single section on E and the choice is generic, then the set of zeroes is a submanifold of X of dimension $\dim X - 2 \dim E$. Thus we obtain a homology class whose Poincaré dual sits in $H^{2k}(X)$ and is the k-th Chern class $c_k(E)$ of E. If X is a closed complex k-dimensional manifold and E its complex tangent bundle, then $c_k(E)$ evaluated on the fundamental cycle is the Euler characteristic of X by the Poincaré-Hopf theorem.

The Todd genus in terms of the Chern classes of the tangent bundle is the evaluation of a certain rational polynomial in the Chern classes $T(c_1, c_2, \dots)$ on the fundamental class. To motivate the construction of these polynomials (which are rather complicated expressions), we note that if the Todd genus agrees with the arithmetic genus, then certainly for complex projective spaces (where the arithmetic genus takes the value 1) they have to agree. Furthermore, the Todd genus has to be multiplicative in a way that reflects the multiplicativity of the arithmetic genus, and so it should be a multiplicative sequence in the sense of [8]. This was the motivation for the first author to introduce

the general concept of multiplicative sequences of polynomials. He characterizes the Todd sequence by a special multiplicative sequence with value 1 on each complex projective space.

The first four polynomials are

$$T_1 := \frac{1}{2}c_1,$$

$$T_2 = \frac{1}{12}(c_1^2 + c_2),$$

$$T_3 = \frac{1}{24}c_1c_2,$$

$$T_4 = \frac{1}{720}(-c_4 + c_3c_1 + 3c_2^2 + 4c_2c_1^2 - c_1^4).$$

Theorem [8]. *Let V be a nonsingular compact complex algebraic variety of dimension n. Then*

$$\chi(V) = \langle T_n(V), [V] \rangle,$$

the evaluation of the Todd polynomial T_n on the fundamental class.

We see that this result has a similar flavor to the Riemann-Roch Theorem, since it relates analytic information, the holomorphic Euler number, to a topologically defined invariant, the Todd genus.

If the complex dimension of V is 1, the case of a Riemannian surface, the theorem above is a special case of the Riemann-Roch formula above, namely, the case where $D = 0$. In the same sense, the theorem above is the special case of the Hirzebruch-Riemann-Roch formula for $D = 0$ [8]. In 1957 Grothendieck generalized this by considering a parametrized version of the Riemann-Roch formula [2]. All this is a long story, and although closely related to genera, it would lead us too far away from our main themes.

Bordism and Generalized Genera

When we said that the Todd genus is topologically defined, this was too brief. In addition to the underlying differentiable manifold, one needs a complex structure in a weaker sense: *a complex structure on the sum of the tangent bundle with a trivial bundle*. This structure is called a stable almost complex structure. A manifold with a stable almost complex structure is called a stable almost complex manifold. Note that with this definition, even an odd-dimensional manifold can have a stable almost complex structure.

Since the Chern classes are stable invariants, which means that they are unchanged if we add a trivial (complex) bundle, the structure one needs for defining the Todd genus is a stable almost complex structure. For such manifolds the Todd genus has the following fundamental properties:

- it is additive (i.e., the Todd genus of a disjoint union is the sum of the Todd genera)
- it is multiplicative (i.e., the Todd genus of a product is the product of the Todd genera).

These properties of the Todd genus motivated the first author to introduce the general concept of *genus*. This is an invariant Φ for certain classes of manifolds in terms of characteristic classes of the tangent bundle (perhaps equipped with a stable almost complex structure) with values in a ring Λ fulfilling the two properties above. We note that for a Riemannian surface F the Todd genus is $c_1(F)/2$, which is half the Euler characteristic of F, namely, $1 - g(F)$. Thus the Todd genus is in this case essentially the genus of a Riemannian surface.

An important invariant of oriented manifolds is the *signature* $(b_+ - b_-)$, which is the signature in the sense of linear algebra of the intersection form of a $4k$-dimensional closed oriented manifold M (if the dimension is not divisible by 4, the signature is defined as zero). It is denoted by

$$sign(M) \in \mathbb{Z}.$$

The first author was looking for a formula that, in analogy to the formula for the arithmetic genus, computes the signature in terms of characteristic classes. This was done at a time when the Riemann-Roch formula was only conjectured. In fact, the signature theorem became an important ingredient in the proof of the Riemann-Roch formula. Since there is no complex structure on the tangent bundle, one has to use the Pontrjagin classes $p_i(M) \in H^{4i}(M)$ instead of the Chern classes. These are (up to sign) the Chern classes of the complexification of the tangent bundle. In analogy to the Todd genus, the first author used his formalism of multiplicative sequences to construct polynomials in Pontrjagin classes that take for each even-dimensional complex projective space the value 1, the signature of M. These are the L-polynomials. The first three L-polynomials are

$$L_1 = \frac{1}{3}p_1,$$

$$L_2 = \frac{1}{45}(7p_2 - p_1^2),$$

$$L_3 = \frac{1}{945}(62p_3 - 13p_2p_1 + 2p_1^3).$$

If, as for the arithmetic genus, one knew that the values on the even-dimensional projective spaces characterize the signature, one would obtain the desired formula. This would follow if, after passing to a multiple if necessary, each manifold were bordant to a linear combination of products of projective spaces. The reason is that both the signature and the L-polynomials are bordism invariants. Here two oriented manifolds M and N are bordant if there is a compact oriented manifold W with boundary being the disjoint union of M and $-N$, the manifold N with the opposite orientation.

The bordism classes of closed oriented n-dimensional manifolds form a group under disjoint union, denoted by Ω_n. The sum

$\Omega_* := \sum_n \Omega_n$ is a ring with respect to the product of two manifolds. Thom [23] computed $\Omega_* \otimes \mathbb{Q}$. It is the polynomial ring with generators, the even-dimensional projective spaces. These considerations lead to:

Theorem *(Signature Theorem)* [8]. *Let M be a closed smooth oriented manifold. Then*

$$sign(M) = \langle L(M), [M] \rangle.$$

Returning to the Todd genus, we noted that it is defined for closed manifolds with stable almost complex structure. In analogy to the bordism groups of oriented manifolds, Milnor [16] defined and computed bordism groups of stable almost complex manifolds. The answer is simpler than for oriented bordism groups: the bordism ring of stable almost complex manifolds is a polynomial ring over $\mathbb{Z}$ in variables x_i corresponding to stable almost complex manifolds of real dimension $2i$, which Milnor explicitly describes. If one takes the tensor product with $\mathbb{Q}$, generators are given by the projective spaces $\mathbb{CP}^i$.

The Relevance of the Signature

Here we can only indicate some aspects (in a nonhistorical order). The classical genus of a Riemannian surface completely characterizes the homeomorphism type (which for surfaces agrees with the diffeomorphism type). In a certain sense one has an analogous result for closed smooth simply connected 4-manifolds.

Theorem [5], [3]. *Two closed differentiable simply connected 4-manifolds are homeomorphic if and only if the Euler characteristic, the signature, and the type (even or odd) agree.*

Here the type is even if and only if all self-intersection numbers are even. This is a very deep result based on independent difficult theorems by Freedman and Donaldson. Freedman classified simply connected topological 4-manifolds in terms of the intersection form and a $\mathbb{Z}/2$-valued invariant, the Kirby-Siebenmann invariant. This vanishes for smooth manifolds as well as for manifolds homotopy equivalent to S^4. Thus, as a special case, Freedman proves the topological 4-dimensional Poincaré conjecture: A 4-dimensional manifold homotopy equivalent to S^4 is homeomorphic to S^4. Every unimodular symmetric bilinear form is the intersection form of a closed simply connected topological 4-manifold, and the classification of such forms is unknown. But for smooth manifolds Donaldson used gauge theory to show that the intersection forms are very special and, because of some classical results, are classified by the rank (equivalent to the Euler characteristic), the signature, and the type.

In contrast to Riemann surfaces, the analogous result for a diffeomorphism classification is completely different in dimension 4. There are many simply connected 4-manifolds M that have an exotic smooth structure, which means there exists another manifold homeomorphic but not diffeomorphic to M. The first example was found by Donaldson [4]. Later on, his techniques were applied to show that many simply connected 4-manifolds have infinitely many smooth structures, for example, the $K3$-surface $\{x \in \mathbb{CP}^3 \mid \sum x_i^4 = 0\}$ (a complex surface, so the real dimension is 4).

The following is one of the big open problems in differential topology: Is there any closed 4-manifold with no exotic structure? The most interesting examples would be the complex projective plane $\mathbb{CP}^2$ or the 4-sphere S^4. If S^4 has a unique smooth structure, this is the smooth 4-dimensional Poincaré conjecture, which one can formulate as follows: A closed smooth simply connected 4-manifold with Euler characteristic 2 is diffeomorphic to S^4 (it has automatically second Betti number 0 and so signature 0; thus by the theorem above it is homeomorphic to S^4).

The existence of infinitely many smooth structures on a closed manifold is something that happens exclusively in dimension 4. In all other dimensions this number is finite. This result is closely related to the Hauptvermutung, which says that if a topological manifold can be triangulated, then this triangulation is unique up to refinement. This is not true (the first counterexamples were given by Milnor [17]), but in dimension > 4 the work of Kirby and Siebenmann about the Hauptvermutung [13] shows that a topological manifold of dimension > 4 has at most finitely many piecewise linear structures. Using surgery theory, one can show that a piecewise linear manifold of dimension > 4 has at most finitely many smooth structures. Combining these two results, one sees that a topological manifold of dimension > 4 has at most finitely many smooth structures.

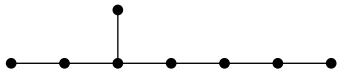
In this last result the classification of smooth structures on spheres plays an essential role (for the first examples by Milnor, see [15]; for the general classification in dimension > 4 by Kervaire and Milnor, see [12]). The signature and in particular the signature theorem are as much central tools for the existence of exotic structures on spheres as tools for the classification of such structures. We indicate this for existence. Milnor constructs certain compact smooth manifolds W with boundary homeomorphic to S^{4n-1}. Then he considers the union of W with the cone over its boundary. If the boundary is diffeomorphic to S^{4n-1}, then this is a smooth manifold, and thus one can compute its signature by the signature theorem in terms of the L-polynomials. Except for the expression in the top Pontrjagin class p_n, all other terms in the L-polynomial can be computed in terms of the Pontrjagin classes of W. Thus one can use the signature formula to compute the term in p_n

in the L-polynomial. The coefficient of p_n in the L-polynomial is a rational number,

$$\frac{2^{2n}(2^{2n-1}-1)}{2n!}(-1)^{n-1}b_{2n},$$

where b_{2n} is the Bernoulli number. If the boundary of W is diffeomorphic to S^{4n-1}, the fact that p_n is an integer gives a certain congruence between the difference of the signature of the union of W with the cone over the boundary and the other expressions in the L-polynomial (we will carry out an especially simple example). If this congruence does not hold, the boundary of W is not diffeomorphic to the sphere. This way one can produce examples of exotic structures on spheres of dimension $4n-1$ for $n>1$ (see also [17]).

We want to use plumbing [9] similar to a construction used by Milnor to give explicit examples of exotic spheres and at the same time the construction of a topological manifold without smooth structure (the existence of such manifolds was first shown by Kervaire [11]). We consider the E_8-graph



Using E_8, we construct a manifold with boundary of dimension 12 by gluing together for each edge a copy of the disc bundle of the tangent bundle of S^6 using the following recipe. If two vertices are joined by an edge, we take a trivialization of the disc bundle over a disc D^6 in S^6 to obtain an embedding of $D^6\times D^6$ into the disc bundle, where the first component maps to S^6 and the second to the fibres. Then we identify (x,y) in the first product with (y,x) in the second:

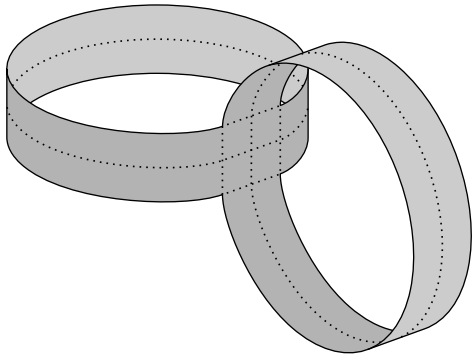


Figure 3.

The result is a compact 12-dimensional manifold $W(E_8)$ with boundary and corners, which one can smooth. By construction it is homotopy equivalent to a wedge of eight copies of S^6. By general position the fundamental group is trivial. Using the unimodularity (meaning that the intersection form has determinant ±1) of the E_8-form, we find that the Mayer-Vietoris sequence implies that the boundary of $W(E_8)$ is a homotopy sphere. Application of the Poincaré conjecture proved by Smale [22] shows that the boundary is homeomorphic to S^{11}. We now apply the signature theorem to show that it is not diffeomorphic to S^{11} following the principle explained above. If there were a diffeomorphism $f:\partial W(E_8)\to S^{11}$, then we could consider $M:=W(E_8)\cup_f D^{12}$ and obtain a smooth manifold whose homology is trivial except in degree 0, 6, and 12. The intersection form of this manifold is by construction the E_8-form, whose signature is 8. Now we apply the signature theorem and obtain

$$8=\frac{62}{945}\langle p_3(M),[M]\rangle,$$

a contradiction (note that the only potentially nontrivial Pontrjagin class is $p_3(M)$, an *integral* cohomology class). Thus $\partial W(E_8)$ is an exotic sphere. If instead of a diffeomorphism we use a homeomorphism, we obtain a topological manifold M, which by the same argument as above cannot admit a smooth structure.

The use of the E_8-graph is motivated by the fact that the resolution of the singularity in $(0,0,0)$ of $z_1^2+z_2^3+z_3^5=0$ consists of eight nonsingular rational curves of self-intersection number -2 whose intersection behavior is given by E_8.

The Atiyah-Singer Index Theorem and Other Genera

Except for the signature, the left-hand sides of our formulas related to the genus were of an analytic nature, being given by dimensions of certain vector spaces of functions or differential forms. In fact the signature can also be interpreted as an analytic invariant via Hodge theory. It is the index of a differential operator, the *signature operator*. Thus the signature theorem is an index theorem expressing the index of an elliptic differential operator in topological terms.

During the 1960s Atiyah and Singer [1] proved a general index theorem for elliptic differential operators on smooth manifolds extending for example the signature theorem. Besides the signature the most important operators are the Laplace operator whose index is the Euler characteristic and the Dirac operator on a manifold with spin-structure. The topological side of the index formula for the Dirac operator, the $\hat{A}$-genus, was studied in [8]. In the 1980s Ochanine and Witten defined very interesting genera for spin, respectively string, manifolds, the *Ochanine*, respectively *Witten, genus*. The remarkable property of these genera is that they take values in rings of modular forms (compare, for example, [10]). One can conjecture that these genera are only a shadow of interesting new (co)homology theories associated

with the term *elliptic cohomology*. In the end one expects that elliptic cohomology will play a central role in index theory on the loop space of a manifold in analogy with the role that K-theory plays in index theory on smooth manifolds.

Acknowledgment. We would like to thank the reviewer for a careful reading and very helpful comments.

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Noticed

Medicine and Mathematical Humor

Citations to *Notices* articles crop up in many places—but in a medical journal? In 2006, *Best Practice & Research Clinical Obstetrics and Gynaecology* carried an article called "Assessing new interventions in women's health". Written by University of Birmingham biostatistician Robert K. Hills and research fellow Jane Daniels, the article discusses principles for running or assessing clinical trials of medical treatments for women, with an emphasis on how to evaluate the treatments' efficacy in the face of unclear or conflicting trial results. "[I]t is not acceptable to rely on proof by anecdotal evidence, eminent authority, or vigorous handwaving," the authors write, citing the widely read *Notices* article "Foolproof: A sampling of mathematical folk humor", by Alan Dundes and Paul Renteln (January 2005). As he later explained to *Notices* Editor Andy Magid, Hills was an undergraduate mathematics student at the University of California, Los Angeles, and heard jokes about the various methods of proof (such as "proof by intimidation"), many of which are listed in the Dundes-Renteln piece. Hills and Daniels also quote Bertrand Russell: "The fact that an opinion has been widely held is no evidence whatever that it is not utterly absurd."

WHAT IS...

an Elliptic Genus?

Serge Ochanine

An elliptic genus is a special type of genus developed as a tool for dealing with questions related to quantum field theory. We first define the general notion of a genus and discuss Hirzebruch's theory of multiplicative genera, into which elliptic genera fit nicely.

Genera. A *multiplicative genus*, or simply a *genus*, is a rule that to every closed oriented smooth manifold M^n associates an element $\varphi(M^n)$ of a commutative unital $\mathbb{Q}$-algebra Λ and satisfies the following conditions:

(1) $\varphi(M^n \amalg N^n) = \varphi(M^n) + \varphi(N^n)$.

Here $M^n \amalg N^n$ is the disjoint union of two closed oriented manifolds of dimension n.

(2) $\varphi(M^n \times V^m) = \varphi(M^n)\varphi(V^m)$.

(3) $\varphi(M^n) = 0$,

if $M^n = \partial W^{n+1}$ is the oriented boundary of a compact oriented manifold W^{n+1}.

Properties (1) and (3) imply that if M^n and N^n are *cobordant*, i.e., if there is a compact oriented manifold W^{n+1} with boundary $M^n \amalg (-N^n)$, where $-N^n$ stands for N^n with reversed orientation, then $\varphi(M^n) = \varphi(N^n)$. In other words, $\varphi(M^n)$ depends only on the element $[M^n]$ represented by M^n in the *oriented cobordism ring* Ω_*^{SO}, and we may view φ as a ring homomorphism

$$\varphi : \Omega_*^{SO} \longrightarrow \Lambda.$$

The structure of Ω_*^{SO} is rather complicated. However, $\Omega_*^{SO} \otimes \mathbb{Q}$ is the polynomial ring $\mathbb{Q}[[\mathbb{C}P^2], [\mathbb{C}P^4], [\mathbb{C}P^6], \ldots]$ in the cobordism classes of the complex projective spaces $\mathbb{C}P^{2k}$. This implies that a genus vanishes on manifolds whose dimension is not divisible by 4 and is completely determined by its values on $\mathbb{C}P^{2k}$. The formal power series

$$g(u) = u + \frac{\varphi(\mathbb{C}P^2)}{3}u^3 + \frac{\varphi(\mathbb{C}P^4)}{5}u^5 + \cdots \in \Lambda[[u]]$$

is called the *logarithm* of φ. It satisfies

$$g(-u) = -g(u), \quad g(u) = u + o(u)$$

and completely determines φ. Conversely, every such series is the logarithm of a multiplicative genus.

Maybe the best known example of a genus is the *signature* $\sigma(M^n)$ of a closed oriented manifold of dimension $n = 4m$. It can be defined in terms of the de Rham cohomology $H^*_{\mathrm{DR}}(M^n)$ as follows: If α and β are closed $2m$-forms on M^{4m}, then the formula

$$\langle \alpha, \beta \rangle = \int_M \alpha \wedge \beta$$

defines a nonsingular symmetric bilinear form on the finite-dimensional vector space $H^{2m}_{\mathrm{DR}}(M^n)$. The index of this form is by definition the signature of M^{4m}. It follows from Poincaré duality that σ is a cobordism invariant. It can be viewed as a genus with logarithm

$$g(u) = u + \frac{u^3}{3} + \frac{u^5}{5} + \cdots = \tanh^{-1}(u).$$

Another important example of a genus is given by the $\hat{A}$-*genus* whose logarithm is $g(u) = 2\sinh^{-1}(u/2)$. The $\hat{A}$-genus has important connections with the *arithmetic genus* in algebraic geometry.

Hirzebruch's Formalism. In the early 1950s F. Hirzebruch discovered a beautiful way of expressing multiplicative genera in terms of other cobordism invariants, the Pontrjagin numbers. If M^n is a Riemannian manifold, the Pontrjagin class $p_i \in H^{4i}_{\mathrm{DR}}(M^n)$ is represented by a closed $4i$-form ρ_i extracted from the curvature tensor of M^n. If $n = 4m$ and $\omega = (i_1, i_2, \ldots, i_s)$ is a partition of m, then the Pontrjagin number $p_\omega[M^n]$ is defined by

$$p_\omega[M^n] = \int_M \rho_{i_1} \wedge \rho_{i_2} \wedge \ldots \wedge \rho_{i_s}.$$

R. Thom's pioneering work showed that any homomorphism $\Omega_n^{SO} \longrightarrow \Lambda$ is a linear combination (over Λ) of Pontrjagin numbers. This applies, in particular, to multiplicative genera. Let φ be a genus with logarithm $g(u)$, and let $s(u) \in \Lambda[[u]]$ be the formal

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functional inverse of $g(u)$, i.e., $g(s(u)) = u$. This series has properties similar to those of $g(u)$: $s(-u) = -s(u), s(u) = u + o(u)$. Consider the product

$$\prod_{i=1}^{N} \frac{u_i}{s(u_i)},$$

where $u_1, u_2, \ldots, u_N$ are some formal variables of weight 2 (N is assumed to be large). Since this is a symmetric expression in $u_1, u_2, \ldots, u_N$, and even in each variable, it can be expressed in terms of elementary symmetric functions of $u_1^2, u_2^2, \ldots, u_N^2$. Substitute p_i for the i-th elementary symmetric function and let $K_m(p_1, p_2, \ldots, p_m)$ be the part of the result that lies in $H^{4m}_{\mathrm{DR}}(M)$. Hirzebruch's theorem says that

$$\varphi(M^{4m}) = K_m(p_1, p_2, \ldots, p_m)[M^{4m}].$$

Strict Multiplicativity. Like any genus, the signature satisfies $\sigma(M^n \times N^k) = \sigma(M^n)\sigma(N^k)$. It follows from a theorem of S. S. Chern, F. Hirzebruch, and J.-P. Serre that in fact a much stronger kind of multiplicativity holds. Let G be a compact connected Lie group, and let E be a principal G-bundle over a closed oriented manifold B. Let a smooth action of G on a closed oriented manifold V be given. Then one can form the associated bundle $E \times_G V$ over B with fiber V. Assuming that the orientation on $E \times_G V$ is compatible with the orientations of B and V, we have

$$\sigma(E \times_G V) = \sigma(B)\sigma(V),$$

which is often referred to as the *strict multiplicativity* of the signature. As an example, consider a complex vector bundle ξ over B of complex dimension k, and let $\mathbb{C}P(\xi)$ be the associated projective bundle. The fiber of $\mathbb{C}P(\xi)$ over a point $b \in B$ is the projective space $\mathbb{C}P(\xi_b) \cong \mathbb{C}P^{k-1}$, and strict multiplicativity implies

$$\sigma(\mathbb{C}P(\xi)) = \sigma(B)\sigma(\mathbb{C}P^{k-1}).$$

In particular, if k is even, $\sigma(\mathbb{C}P(\xi)) = 0$ for dimension reasons.

Elliptic Genera. A multiplicative genus φ is an *elliptic genus* if it vanishes on manifolds of the form $\mathbb{C}P(\xi)$, where ξ is an even-dimensional complex vector bundle over a closed oriented manifold B. The origin of the term "elliptic" is in the following theorem, which features an elliptic integral:

Theorem 1. *A genus φ is elliptic if and only if its logarithm $g(u)$ satisfies*

$$g(u) = \int_0^u \frac{dt}{\sqrt{1 - 2\delta t^2 + \varepsilon t^4}},$$

for some constants $\delta, \varepsilon \in \Lambda$.

Notice that for $\Lambda = \mathbb{C}$ and $\delta^2 \neq \varepsilon \neq 0$ (i.e., when the polynomial under the square root has four distinct roots), $g^{-1}(u)$ is the expansion at 0 of an odd elliptic function s. When $\delta^2 = \varepsilon$ or $\varepsilon = 0$, the elliptic genus is called degenerate. The two main examples are the signature ($\delta = \varepsilon = 1$) and the $\hat{A}$-genus ($\delta = -1/8, \varepsilon = 0$).

The projective space $\mathbb{C}P^{k-1}$ (k even) is an example of a *spin manifold*. A manifold V^n is a spin manifold if the structural group of its tangent bundle can be reduced to the group $\mathrm{Spin}(n)$, the two-fold cover of $\mathrm{SO}(n)$. Alternatively, V^n is a spin manifold if its tangent bundle can be trivialized over the 2-skeleton of any triangulation of V^n. The following theorem is equivalent to the *Rigidity Theorem* of R. Bott and C. Taubes:

Theorem 2. *Let G be a compact connected Lie group, let E be a principal G-bundle over a closed oriented manifold B, and let V be a closed spin manifold with a smooth G-action. Then for every elliptic genus φ, we have*

$$\varphi(E \times_G V) = \varphi(B)\varphi(V).$$

Modularity. Consider a non-degenerate elliptic genus φ over $\mathbb{C}$ with parameters $\delta, \varepsilon \in \mathbb{C}$. It is well-known that the Jacobi quartics

$$Y^2 = X^4 - 2\delta X^2 + \varepsilon$$

can be parametrized by points τ in the upper half-plane $H = \{\tau \in \mathbb{C} \mid \mathrm{Im}(\tau) > 0\}$. With this parametrization, δ and ε become level 2 modular forms for a certain subgroup $\Gamma_0(2)$ of the group of Möbius transformations of H. Since the values $\varphi(M^{4m})$ are polynomials in δ and ε, they are modular forms themselves and one can think of φ as an elliptic genus over the ring $\Lambda = M_*(\Gamma_0(2))$ of modular forms for $\Gamma_0(2)$.

Loop Spaces. Elliptic genera have a beautiful interpretation, due to E. Witten, in terms of elliptic operators on the *free loop space* $\mathcal{L}M$ of M, i.e., the infinite-dimensional manifold of smooth loops $S^1 \longrightarrow M$. Such operators play an important role in quantum field theory. The mathematical theory of such operators is still being developed, but conjectural extension of index theory to these operators has resulted in some remarkable insights. The Dirac operator on $\mathcal{L}M$ commutes with a natural circle action on $\mathcal{L}M$, and its index is an infinite-dimensional representation of S^1. Witten showed that the character of this representation can be naturally identified with the $M_*(\Gamma_0(2))$-valued elliptic genus of M.

Further Reading

Elliptic genera first appeared in [1]. The proceedings of the 1986 Princeton conference [3] contain, among many others, a paper by Witten that provides the physics interpretation of elliptic genera. The proof of the rigidity theorem is given in [4]. Finally, [2] is an elegant detailed introduction to the subject.

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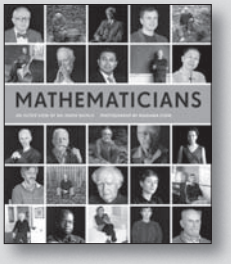

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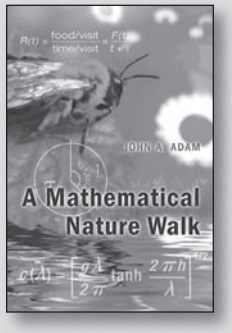

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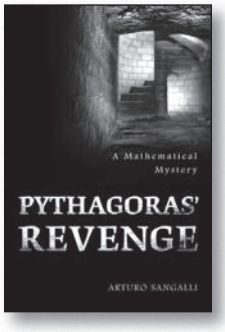

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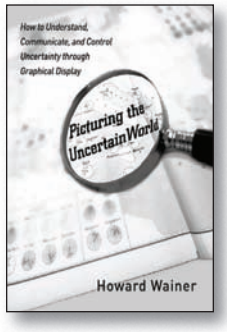

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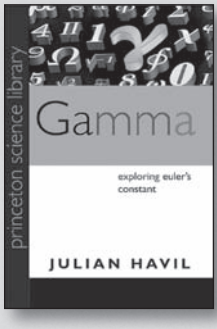

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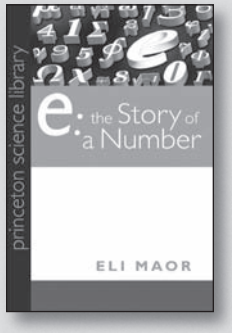

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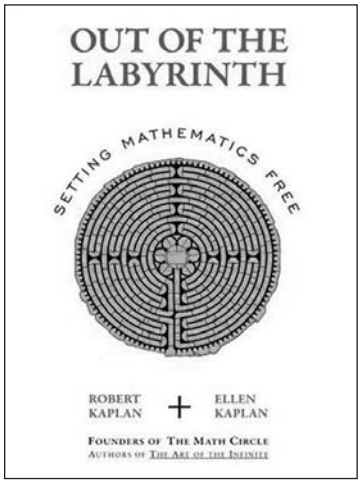

Out of the Labyrinth

Reviewed by Jesse Johnson

Out of the Labyrinth: Setting Mathematics Free
Robert Kaplan and *Ellen Kaplan*
Oxford University Press, USA, 2008
US$15.95, 256 pages
ISBN-13: 978-0195368529

Imagine that you are one of my students. You are 14, maybe 15, and you have never been asked to memorize your multiplication tables. It's unlikely that you have ever been asked to do homework. The word "fraction" and the sight of more than a sentence of words make you groan. You have lived in New York City your whole life. It's unlikely that you have a family member who has gone to college, but you definitely want to go. You have liked math at some point in the past, but your math teachers have never had more than two years of teaching experience, and your classmates are so distracting that you have long since decided that the best thing about math class is text messaging with your friends down the hall. Whether you think you are good or bad at math, learning it in class is difficult, as though you're walking in flip flops through snow up to your belly. When you do engage with mathematics, inevitably frustration, fear, insecurity, anger, disappointment, boredom, discouragement, or self-loathing get the better of you, and you check out.

Now, imagine that this fall, you walk into a different sort of classroom. There are only a few other kids, maybe five or ten, and you all have made the choice to be there. The teacher is more of a guide than a leader, and she's asking really interesting questions. You immediately have some ideas about the answer, and you know without any convincing that these questions matter. You feel excited, interested, engaged, thoughtful. You don't care that you could be playing video games now instead of being here in this classroom. You are working together with these other kids, none of whom is smarter or stupider than you. You are part of a group mind, like an athletic team, except that the other team is really on your side. No one cares who is talking, so long as you are collectively making headway in figuring out this problem. The answer starts to gel. You are happy, exhilarated—but only for a minute, because you're already moving on to the next question, asking how to extend this now completely obvious truth, to discover something else. It's absolutely riveting. This is the Math Circle.

Teaching mathematics is considered an exceptionally difficult task because so many kids come to math without enjoying it or believing they are good at it. Students and their families are comfortable dismissing fluency in mathematics as a worthwhile or necessary pursuit save as a means to get into college or graduate from high school. As a teacher, I have tried to join the ranks of amazing curriculum writers and educators who use modeling, discovery, application, and investigation to shine a light on the beauty, joy, and usefulness of mathematics. But it is a difficult, bewildering task.

In Robert and Ellen Kaplan's Math Circle, however, this task seems to be not only the central purpose but also the Circle's great success. They have written an excellent book about how math circles work, the context in which the circles have been successful, and why they are distinct from typical classroom structures.

The Math Circle is the Kaplans's contribution to improving the way kids experience mathematics. *Out of the Labyrinth* is the Kaplans' contribution

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to transforming the way educators and mathematicians alike think about math education. It has inspired my approach to teaching high school math in New York City, and I recommend it highly to mathematics educators as well as mathematicians who want to share their love of mathematics with others.

The Rise of Math Circles in the U.S.

The tradition of math circles originated in Eastern Europe and Russia during the twentieth century. These informal meetings of students were led by mathematicians and focused on providing substantive, creative engagement with mathematical ideas outside of the usual topics taught in schools. By stimulating bright young minds, these circles inculcated life-long love of mathematics and the sciences and provided a breeding ground for many of the great scientists from that part of the world. The Kaplans's Math Circle, begun in Cambridge, Massachusetts, in 1994, was the first to be established in the United States; another one was launched in Berkeley in 1998. The success of these two circles inspired others in the San Francisco Bay Area and across the country to start up circles of their own. (Robert Kaplan wrote an article, "The Math Circle", which appeared in the September 1995 issue of the *Notices*; see also "Math Circles and Olympiads. MSRI Asks: Is the U.S. Coming of Age?", by James Tanton, in the February 2006 *Notices*.)

According to the Mathematical Sciences Research Institute (MSRI) in Berkeley, which has carried out several programs to foster math circles, there are over forty active circles in the United States in such locations as San Diego, CA; Mobile, AL; Flint, MI; Salt Lake City, UT; St. Louis, MO; and Albany, NY. As the MSRI website explains, math circles vary greatly in style. Some are very informal, with the learning proceeding through games and stories; others are more traditional enrichment classes. Some prepare students for Olympiad competitions, while others eschew competition. No matter what the style, all math circles share the goal of getting students to enjoy learning mathematics and provide a social context in which that learning happens.

MSRI is developing a website (`http://www.mathcircles.org/`) for math circles, with the aim of eventually developing a National Association of Math Circles. In April 2009 MSRI held a workshop called "Great Circles", which attracted over eighty participants. In addition, the Mathematical Association of America now has a SIGMAA (Special Interest Group) on Circles, for those working in or interested in starting math circles.

—Allyn Jackson

What Is the Math Circle?

The Math Circle is a small extracurricular mathematics workshop in which students discuss deep mathematical content in a lively context, the result of which is to "waken in everyone first an awareness of, then a love for, and finally the power to do mathematics" (page 159). Every participant in a math circle has chosen to be there. Most of the classes are made up of five to fifteen students of approximately the same age, with the occasional parent or janitor. The Math Circle has students who range in age from five to seventeen and study mathematical topics atypical for their ages: set theory for elementary schoolers, taxicab geometry for middle schoolers, and combinatorial geometry for high schoolers are just a few examples. They meet for an hour each week for ten weeks to discuss and investigate a particular problem, during which time they explore the problem from an intuitive and later a more formal and rigorous perspective.

Math Circle courses evolve and adjust to the specific needs and interests of the students present. There is no homework assigned because Circle facilitators know that the problem will percolate of its own accord in students' minds. There is no shame in the Math Circle, both because the leaders don't make space for it to grow, and because the students are so engaged they forget whatever shame they might have come in with. They abandon ego, the myth of talent, and the idea that the goal is to be the best in the class or even best as a group in some competition. The facilitator asks questions that are open-ended and interesting, accessible and significant. The questions invite problem solving while always building up a deeper and larger sense of the whole mathematical context. The students and facilitator work together on one problem over the course of the ten weeks, deepening their understanding, developing their arguments, and generalizing their own procedures—in short, learning mathematics through doing. For the students, the facilitator is just one of many footholds along their way. The Kaplans charge, "You learn math by inventing or discovering it yourself" (page 204).

Out of the Labyrinth

Before getting into the nitty-gritty of the Math Circle, the Kaplans spend a lot of time analyzing what makes mathematicians who love math different from the rest of the world. What is it that we enjoy? Why is this joy such a rarity in our communities? The Kaplans believe that it isn't anything particularly special about us. They argue that all people are capable and pretty much ready at any moment, whatever their histories, of

having great experiences doing math. They reason that our definitely human architectural instinct, which drives mathematical thought, is as natural and necessary to our existence as breathing. "The passion for order, the delight in symmetrical balance and asymmetrical tension, the sense that the whole, which is greater than all its parts is the whole *of* those parts—all these are expressions of this instinct" (page 76).

Lacking models in both school and home that respond to momentary failure in mathematics with resiliency and persistence, most people have no reason to believe they can be successful at math if they have instead experienced failing and then giving up. Our society subscribes to a cultural belief in natural talent that, combined with teachers who are afraid of math, negative stereotypes about what it means to be a mathematician, and the utter inaccessibility of mathematical language and symbols, makes it almost impossible for many people even to conceive of the idea of loving math.

The first 140 pages of the book are devoted to the Kaplans's analysis of the joys, struggles, and demands of doing mathematics. They consider people who have had discouraging experiences with mathematics, as well as those who have had great experiences. The premise of the book, in large part, is to understand the gap between these two ends of the spectrum and suggest what might connect them. Reading this book is a bridge for those of us who love math to understand the experience of those who don't. The Kaplans offer the Math Circle as a bridge in the other direction.

So what is necessary to do mathematics? I'd love to read your lists. Robert and Ellen say: be stubborn, risk becoming enthralled, learn to step back. Much of what they suggest amounts to something that sounds a lot like meditation. On page 74, there's a quotation of C. J. Keyser about Sophus Lie, whose answer was: "Imagination, Energy, Self-Trust, Self-Doubt." The authors add to this list fearlessness and risk-taking. "It is like falling in love" (page 34). I wonder how many people have felt this about anything, much less mathematics? Is it possible my students could be blissful in math class?

Out of the Labyrinth offers an illuminating description of the qualities we develop when we do mathematics: stubbornness, a high threshold of frustration, attention without tension, precision, an ability to break things apart, playfulness, experimental fervor, architectural instinct. The Kaplans describe the many cultural, educational, language, and social barriers to developing these qualities that explain why we don't all love math. They summarize the long global history of mathematics education, critiquing the "cookbook math" that has been found in most math classrooms since ancient Egypt.

Finding the Math Circle in the Classroom

This book helped me to understand what it is I do when I do math and why I like it so much, and this understanding clarified how important it is for my students to enjoy doing math. It is a challenge to share the wealth not just of my knowledge but also of my joy and the meditative, transcendent experience of doing math. How I can offer more enjoyment to my students is still a problem, addressed only in part by the Kaplans in this volume.

"It would be ideal were today's hurdles removed and understanding math made the goal, rather than passing tests on the names of things and the application of rules" (page 185). The Math Circle approach is a critique of and a response to contemporary and historical models of mathematics education. I do wish that the Kaplans would bring their brilliance into the classroom. I wish they would bring their immense eloquence and experience to writing a book that is much more rigorous in describing teaching techniques, rich problems, and subtleties of facilitating group collaboration and discussion. The Math Circle may not be a perfect model for classroom teaching, and the students' self-selection distinguishes Math Circles from a typical classroom. Nevertheless all of the ideological elements of the Math Circle structure are adaptable for classroom teaching. As a result of reading this book, I have introduced more problem solving, open-ended exploration, and discussion into my classes. I am more attuned to the experience of my students, whether they meet me loving math or not, and I put a high priority on cultivating the excitement the Kaplans identify as necessary for feeding interest and enjoyment of mathematics. This year most of my students do enjoy math class and feel comfortable asking deep questions and probing for the answers themselves. To ice the cake, I have two freshman girls who asked for my help in pursuing degrees in mathematics.

I believe that if it is indeed possible for anyone in a Math Circle to enjoy learning mathematics, then it must also be possible to teach math educators how to provide opportunities for students to enjoy learning mathematics. I want to know how to come up with those meaningful questions within the state curriculum and create a classroom where my students feel capable and engaged. However difficult it may be to teach these things, I hope the Kaplans choose to take this on in more detail in their next book.

The Math Circle gives kids the experience of discovery and allows them to develop confidence in their own abilities to question and understand the world. If the capacity to enjoy mathematics is within reach of all people, what is getting in the way? I believe this is arguably the most important question we mathematicians can be thinking about, and I tip my hat to the Kaplans for their help in both answering the question and closing the gap.

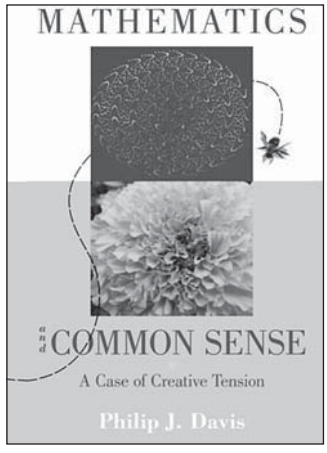
Book Review

Mathematics and Common Sense: A Case of Creative Tension

Reviewed by Chelluri C. A. Sastri

Mathematics and Common Sense: A Case of Creative Tension
Philip J. Davis
A K Peters Ltd., 2006
US$39.00, 242 pages
ISBN-13: 978-1568812700

A common theme of several recent books about mathematics and mathematicians is an exploration into the nature of mathematics, the motivations of mathematicians, and modes of mathematical thought. Besides the book under review, the ones that come to mind are those by Ivar Ekeland (*The Best of All Possible Worlds: Mathematics and Destiny*) and David Ruelle (*The Mathematician's Brain: A Personal Tour through the Essentials of Mathematics and Some of the Great Minds Behind Them*).[1] What distinguishes them from one another is mainly the audience to which each book is addressed. The one by Davis has a leitmotif: common sense—the extent to which mathematics is informed by it and the ways in which mathematics transcends it. The book begins with an exchange of letters between Davis and Christina, a real person with a fictitious name, who is intelligent and curious and whose mathematical background is somewhat above that of a high school graduate. Thus it is safe to assume that the book is aimed at



people like her. The first questions that Christina asks are the basic ones: What is mathematics? What is the nature of mathematical talent? Why should one study mathematics as opposed to, say, literature, art, history, or, for that matter, physics? Davis answers them well, but he could do even better. This was a golden opportunity for him to make the best and most effective use of his pedagogic and storytelling abilities—he *has* written some interesting fiction—to convince the lay reader that studying mathematics at least to some extent, say, at the college level, not only is necessary for becoming a well-informed citizen but can be great fun. In addition, he could make a case for the usefulness, discovered in unexpected ways sometimes, of such study, even if the student never again looks at a math book. Unfortunately, by being succinct and implicit rather than explicit, Davis doesn't take full advantage of this opportunity.

Let us consider the first question, which is actually very difficult. Davis gives a good answer, pointing out the salient features of mathematics, particularly of the pure variety, including its logical structure, beauty, and usefulness. He does mention applied mathematics but avoids getting drawn into the controversy surrounding the relative merits of pure and applied mathematics, which is unfortunate, since he is very well qualified, being a

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[1]*Editor's Note: Both books have been reviewed in the* Notices. The Best of All Possible Worlds *was reviewed by Hector Sussman in the March 2009 issue, and* The Mathematician's Brain *was reviewed by David Corfield in the November 2008 issue.*

well-known applied mathematician, to delve into that difficult subject. On the question of mathematical talent, he doesn't draw a distinction between the ability to learn, understand, and use mathematics and the ability to create new mathematics. The distinction is an important one, for while people with the latter ability form a relatively small group of talented individuals, people with the other type of ability are essential for teaching, clarifying, and, in general, exegesis.

The book is divided into thirty-three chapters, each dealing with a different topic. Some of the topics discussed are difficult and thorny, but Davis deals with them deftly and in a balanced way. The interplay between common sense and mathematics comes into focus early in a chapter provocatively titled "Why Counting Is Impossible". In it, Davis shows that although the laws of arithmetic are precise and simple, when the numbers are large enough, counting becomes impossible if absolute precision is demanded. He uses two interesting examples—the 2000 presidential election and Bertleson's number (the number of prime numbers less than 10^9)—to illustrate this and then describes methods for arriving at satisfactory estimates once a preset level of accuracy is agreed upon. In another chapter he discusses the deductive method, starting with the common-sense understanding of axioms as self-evident truths. He constructs an example with a set of axioms and proves a theorem. The proof, though, involves not just a formalism but also human interaction. This interaction between formalism and human beings is a topic Davis discusses at some length, making a plausible argument that it is unlikely in the foreseeable future that mathematics will be done entirely by computers. Throughout the book, Davis hews to the theme of a creative tension between mathematics and common sense.

The most interesting chapters are the ones on logic, inconsistency, ambiguity, and randomness, all very well done. Concerning proof, an example Davis cites is the work of Thomas Hales on Kepler's sphere-packing conjecture. He tells the story of how, in spite of the herculean efforts of a team of twelve referees, Hales's proof could not be completely checked and concludes that there will be more such instances in the future. In the discussion about logic, he describes examples of strange objects to which the study of logic sometimes leads. Included among them is what is generally called the Banach-Tarski paradox. (Davis calls it the Banach-Tarski-Hausdorff paradox.) He gives a convincing resolution of the paradox by pointing out that a mathematical object is not the same as a physical one even when the mathematical description of the two objects is the same, thus making their images in our minds the same, and by alluding to the notion of nonmeasurability. This is one of the occasions when a lay reader might benefit by referring to a glossary, if there were one. In the discussion about probability, Davis explains how difficult it is to come up with a proper definition of randomness and muses on the reasons why people gamble even when they know their chances of winning are extremely small. In this connection, he mentions two examples, the first of which trips people up because they don't know or understand the monotonic nature of probability (if $A \subset B$, then $P(A) \leq P(B)$), while the second one causes trouble because in it a single event is described in two different ways, leading to the misperception that two distinct events are being referred to. However, his assertion that "in most applications of probabilistic reasoning, it is necessary to make independence assumptions that, to a common-sense understanding, are not even close to true but are wildly fantastic when taken literally" cannot go unchallenged. There are many examples where such an assumption makes perfect sense. The Poisson process is one that comes to mind right away.

Davis spends some time talking about the "chipification" of mathematics and remarks on how tasks that required a lot of time and effort in the past are now accomplished with ease and speed but doesn't say too much about the negative effects. We know that chipification certainly hides the mathematics behind a gadget, device, or procedure, thus allowing the public to persist in its lack of awareness of the truth—namely, that mathematics underpins the developments in question—and in its thinking that mathematics is an arcane and useless discipline. This is a situation that calls for intervention by mathematicians, specifically by communicating mathematical ideas and their importance to the public as well as to the powers that be, for without such communication, support for mathematics would dry up. Chipification also fosters a tendency in the younger generation not to bother with "rote" skills, making it harder to train people to maintain and improve upon the technology or make new discoveries.

In his discussion of mathematics, war, and entertainment, Davis suggests that mathematics is ambiguous as far as values are concerned. It is true, of course, that mathematics, like other human activities and creations, can be used for good as well as for evil. However, there is one value that is paramount in mathematics, indeed in all of science—namely, truth. The high status it is accorded seems to yield some beneficial byproducts, such as honesty and the willingness to admit error. In a recent review of a book in the *American Mathematical Monthly*, the mathematician Ed Nelson wonders why it is that we mathematicians are so nice: by and large, we are honest, quick to say "sorry", and willing to give the other guy the benefit of the doubt. Why, though? A guess would be that these are natural consequences of the importance attached to truth. One may argue that other sciences

value truth equally highly; does it follow that scientists in general are nice? Maybe, but the process appears simpler in mathematics, for all it takes for a mathematical conjecture or belief to be falsified is a single counterexample! In any case, there are many instances in which a young, unknown, and clearly vulnerable mathematician comes up with a good idea or technique, and the adviser or senior mathematician bends over backwards to give credit to the younger person. Isn't it the epitome of civilization to be fair and kind to someone over whom one has power? The more absolute the power, the harder it is to be fair. That mathematicians are decent is certainly something to cheer about. It doesn't follow, however, that there are no charlatans or crooks among mathematicians; of course there are, but the overwhelming majority appear to be honest. This is obviously a consequence of the high status truth occupies, and it goes to show that mathematics is far from being value-free. Unfortunately, Davis doesn't point this out. In another chapter he wonders if there are racial and gender differences in being hard wired for mathematics but doesn't pursue the question further. It would be interesting if he did, even though, or perhaps because, it is an explosive issue.

The question as to whether mathematicians are prone to eccentricity or weirdness, or even downright mental illness, doesn't get much attention in the book. It is of course a very difficult question to answer. What is obvious is that since mathematics is a highly cerebral activity, it would be good for a mathematician to have an interest or a hobby that engages her physically and thus balances her life. Anecdotal evidence seems to indicate that *certain* types of mental illness such as obsessive-compulsive disorder and bipolar disorder may be more prevalent among mathematicians and others who engage in similar activities than in the general population. However, a thorough scientific study of the problem would be needed to either substantiate or refute such a claim. At any rate, the matter is too important to be ignored.

It is surprising and disappointing that a book such as this, addressed to a lay audience, lacks a glossary as well as an index. The absence of an index is actually frustrating, because Davis touches upon several important and difficult questions and, for further reading, gives a wealth of excellent references at the end of each chapter. If one forgets a particular reference, one has to make quite an effort to find it again. Occasional discussions of technical examples—involving complex integration or splines, for example—make one wonder whether a glossary of some sort wouldn't have made the book much more attractive to a lay person. It is true that if there were to be a glossary, the author would have to face the vexing problem of deciding where to begin and where to end, but clearly *some* help is better than none at all.

Davis has written several books, some with collaborators and others by himself. In particular, his fiction reads well. Unfortunately, one cannot say that of the book under review. The reason is that it abounds in not just typos, but stylistic errors and downright bad constructions—misplaced modifiers and dangling participles are common. Now, cleaning up the prose does not mean that it has to be formal and pedantic—witness the writings of Bertrand Russell, Peter Medawar, and Freeman Dyson, for example. Finally, there are instances where what Davis says sounds like something one knows but one isn't sure of the connection. For example, on page 68 he refers to what is called the Weber-Fechner Principle, which says $S = k \log R$, where S = Sensory Response and R = Stimulus; k is presumably a constant. This looks a lot like Boltzmann's formula for entropy: $S = k \log W$, where S is the entropy, k the Boltzmann constant, and W the number of microstates corresponding to a given configuration. Is there a connection?

Here is a sample of the typos and other errors:

p. xxi, paragraph 3, line 5: no single group that is predominates (predominant)

p. xxiv, paragraph 2, line 2: Hilbert's reputation and influence was so great (were)

p. xxv, paragraph 3, line 1: Mathematics can and has flourished (can flourish and has)

p. xxxvii, paragraph 1, line 6: As a young researcher in mathematics, one of my professors gave me (misplaced modifier)

p. xliii, paragraph 3, line 1: Having said all this, Christina, it occurs to me (dangling participle)

p. 3, The volume of a sphere of radius r is $4\pi r^3$ ($\frac{4}{3}\pi r^3$)

p. 44, paragraph 4, line 3: Having written the book, my curiosity was saturated (dangling participle)

p. 213, paragraph 1, line 4: the principle motivation (principal)

In summary, this is a book whose content is very good and well organized. If a second edition is issued with the typos corrected and the prose cleaned up and with changes somewhat along the lines indicated, it would be not just a very good book but an excellent one and would be a welcome addition to the library of books on mathematics and mathematicians.

Acknowledgments

It is a pleasure to thank David Boyd, Rob Noble, and Heydar Radjavi for helpful comments.

William Benter Prize in Applied Mathematics

Call for NOMINATIONS

The William Benter Prize in Applied Mathematics has been set up by the Liu Bie Ju Centre for Mathematical Sciences (LBJ Centre) of City University of Hong Kong in honor of Mr. William Benter for his dedication and generous support to the enhancement of the University's strength in mathematics.

The Prize

The prize recognizes outstanding mathematical contributions that have had a direct and fundamental impact on scientific, business, finance and engineering applications.

It will be awarded to a single person for a single contribution or for a body of related contributions of his/her research or for his/her lifetime achievement.

The prize will be given once every two years. The prize amount is US$100,000.

Nominations

The right to nominate is open to everyone. Nominations should not be made known to the nominee and self-nominations are not acceptable.

Nominations, with justifications and CVs of the nominees as well as two supporting letters, should be sent to:

Selection Committee
c/o Liu Bie Ju Centre for Mathematical Sciences
City University of Hong Kong
Tat Chee Avenue
Kowloon
Hong Kong

Or **by email to: mclbj@cityu.edu.hk**

Deadline for nominations: 30 September 2009

Presentation of Award

The LBJ Centre will present the prize at an international conference at City University of Hong Kong in June 2010. The prize winner is expected to attend the award ceremony and to present a lecture at the conference .

The Liu Bie Ju Centre for Mathematical Sciences was established in 1995 with the aim of conducting first-class research in applied mathematics and in computational mathematics. As a leading research centre in the Asia-Pacific region, its basic objective is to strive for excellence in applied mathematical sciences. For more information, visit ***http://www6.cityu.edu.hk/rcms/***

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Gromov Receives 2009 Abel Prize

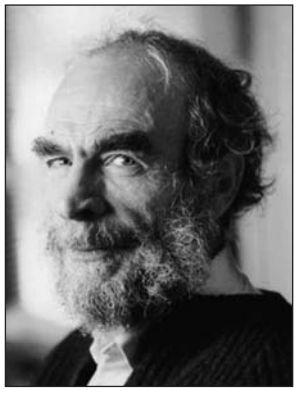


Photo from http://www.abelprisen.no/en/.

Mikhail L. Gromov

The Norwegian Academy of Science and Letters has decided to award the Abel Prize for 2009 to the Russian-French mathematician MIKHAIL L. GROMOV for "his revolutionary contributions to geometry". The Abel Prize recognizes contributions of extraordinary depth and influence to the mathematical sciences and has been awarded annually since 2003. It carries a cash award of 6,000,000 Norwegian kroner (approximately US$950,000). Gromov will receive the Abel Prize from His Majesty King Harald at an award ceremony in Oslo, Norway, on May 19, 2009.

Biographical Sketch

Mikhail Leonidovich Gromov was born on December 23, 1943, in Boksitogorsk, USSR. He obtained his master's degree (1965) and his doctorate (1969) from Leningrad University, where he also completed his postdoctoral thesis (1973). He was an assistant professor at Leningrad University from 1967 to 1974.

Since 1982 Gromov has been a permanent professor at the Institut des Hautes Études Scientifiques, Bures-sur-Yvette, France. He has been a French citizen since 1992. He is currently also Jay Gould Professor of Mathematics at the Courant Institute of Mathematical Sciences, New York University.

Gromov has received many distinguished international awards, including the Kyoto Prize in Basic Sciences (2002), the Balzan Prize (1999), the AMS Leroy P. Steele Prize (1997), the Lobatchewski Medal (1997), and the Wolf Prize (1993). He is a foreign member of the U.S. National Academy of Sciences and of the American Academy of Arts and Sciences, and a member of the Académie des Sciences of France.

Citation

Geometry is one of the oldest fields of mathematics; it has engaged the attention of great mathematicians through the centuries but has undergone revolutionary change during the last fifty years. Mikhail Gromov has led some of the most important developments, producing profoundly original general ideas, which have resulted in new perspectives on geometry and other areas of mathematics.

Riemannian geometry developed from the study of curved surfaces and their higher-dimensional analogues and has found applications, for instance, in the theory of general relativity. Gromov played a decisive role in the creation of modern global Riemannian geometry. His solutions of important problems in global geometry relied on new general concepts, such as the convergence of Riemannian manifolds and a compactness principle, which now bear his name.

Gromov is one of the founders of the field of global symplectic geometry. Holomorphic curves were known to be an important tool in the geometry of complex manifolds. However, the environment of integrable complex structures was too rigid. In a famous paper in 1985 he extended the concept of holomorphic curves to J-holomorphic curves on symplectic manifolds. This led to the theory of Gromov-Witten invariants, which is now an extremely active subject linked to modern quantum field theory. It also led to the creation of

More on Gromov in the *Notices*

For more on the work of Mikhail Gromov, see "Encounter with a geometer", by Marcel Berger, which appeared in two parts in the February and March 2000 issues of the *Notices*.

One of Gromov's celebrated discoveries is described in "WHAT IS... a pseudoholomorphic curve?", by Simon Donaldson, in the October 2005 issue of the *Notices*.

All *Notices* material going back to 1995 is freely available online at `http://www.ams.org/notices`.

symplectic topology, and gradually penetrated and transformed many other areas of mathematics.

Gromov's work on groups of polynomial growth introduced ideas that forever changed the way in which a discrete infinite group is viewed. Gromov discovered the geometry of discrete groups and solved several outstanding problems. His geometrical approach rendered complicated combinatorial arguments much more natural and powerful.

Mikhail Gromov is always in pursuit of new questions and is constantly thinking of new ideas for solutions of old problems. He has produced deep and original work throughout his career and remains remarkably creative. The work of Gromov will continue to be a source of inspiration for many future mathematical discoveries.

About the Prize

The Niels Henrik Abel Memorial Fund was established in 2002 to award the Abel Prize for outstanding scientific work in the field of mathematics. The prize is awarded by the Norwegian Academy of Science and Letters, and the choice of Abel Laureate is based on the recommendation by the Abel Committee consisting of five internationally recognized mathematicians.

Previous recipients of the Abel Prize are: Jean-Pierre Serre (2003), Michael Atiyah and I. M. Singer (2004), Peter Lax (2005), Lennart Carleson (2006), S. R. S. Varadhan (2007), and John G. Thompson and Jacques Tits (2008).

—From Announcements of the Norwegian Academy of Science and Letters

Ask Professor Nescio

Editor's Note: Graduate students, early career faculty, and other mathematicians may have professional questions that they are reluctant to pose to colleagues, junior or senior. The *Notices* advice column, "Ask Professor Nescio", is a place to address such queries. Nomen Nescio is the pseudonym of a distinguished mathematician with wide experience in mathematics teaching, research, and service. Letters to Professor Nescio are redacted to eliminate any details which might identify the questioner. They are also edited, in some cases, to recast questions to be of more general interest and so that all questions are first person. Some letters may be edited composites of several submitted questions. Query letters should be sent to `notices@math.ou.edu` with the phrase "A question for Professor Nescio" in the subject line.

—Andy Magid

Dear Professor Nescio,

My spouse and I are finishing graduate school in math this year and will both be looking for academic positions. We have different last names. Would it be to our advantage or disadvantage to let people know in our cover letter about our two-body problem?

—Married and Looking

Dear Married and Looking,

This is a thorny problem and one for which Professor Nescio must confess uncertainty since his experience here is lacking. Perhaps no one has sufficient experience with this situation to give counsel, let alone wisdom. Therefore Professor Nescio's first piece of advice is to treat any profession of expertise on this matter with skepticism. Even the experience of another married couple that has faced this challenge should be regarded cautiously as there is no guarantee that what they encountered is typical. In fact, my belief is that the great variation in human behavior that manifests itself in all matters will extend to this as well. (Why wouldn't it?)

How to answer your question? My instincts tell me there is no advantage in proclaiming this two-body problem in your cover letter, perhaps even a disadvantage. Let us reason together. There are some creative departments that have used their ability to offer a solution to this problem to great advantage, but this is rare. Some departments will have multiple open positions in the same year, but most will not; so stating in the cover letter the need for two positions might result in your application's being dismissed as impossible. Even if you are willing to share a position you should initially keep this to yourself, as asking a search committee to solve this is creating an unnecessary complication before they even know who you are.

All applicants for an academic position should try to understand the recruiting process from the point of view of the recruiting committee, but this goes double for you (pun intended). The first task of any applicant is to make the committee or chair fall in love with you. Only then will they be willing to seek a creative solution for your problem. So why create a problem for them before they fall in love.

On the other hand, if getting an appointment together is the only way you will consider an offer, you should certainly reveal this in the letter. However Professor Nescio believes imposing that initial condition on the solution of your problem would be a grave mistake. Therefore Professor Nescio has arrived at the conclusion that there is no advantage to revealing your relationship in the cover letter. If you heed this advice, when do you reveal it? That is something you should assess when you see the circumstances. If the department has multiple open jobs, then it would seem that letting them know earlier is better. If there is only one slot to be filled, wait until they have been exposed to your great research accomplishments, your wit, your clear superiority in the classroom, your obvious charm and sparkling personality—all of which guarantee you will be a spectacular colleague.

The exact moment to make the revelation depends on too many extra conditions to give any universally applicable advice. After the offer is made? Are you the first person they offered the position to? Have two others turned down the offer before they offered it to you and therefore they might be willing to go the extra mile to get you signed? On the other hand if you wait until they make you an offer, this might be a problem. You

don't want them to feel as though they are victims of a bait and switch approach. As you see, there are too many variables in this to expect a unique solution. So be flexible and judge the personalities you are dealing with and the particular circumstances.

As you are clearly aware and this discussion reveals, the two-body problem is a difficult one to solve; it is even difficult to approach. An even more difficult version of the two-body problem occurs when the bodies are in different disciplines (like mathematics and engineering), since such a problem involves more than one department, perhaps more than one college within a university. Professor Nescio knows of several couples who have solved it, even the more difficult version, though he knows of none who found the solution straight out of graduate school. Thus the first advice on this matter is to be flexible. Be prepared at this stage to only find an approximate solution—one that permits periodic rendezvous. Of course if the period is too long, this may not be a solution at all. On the other hand Professor Nescio's strongly romantic personality sees the potential here for great excitement—frequent reunions, candlelit dinners, a shared bottle of wine, and pent up love suddenly reignited.

You did not raise the issue of children, which will complicate the issue and make the problem even more difficult to solve satisfactorily. Professor Nescio long ago learned not to stick his nose into people's personal business. Indeed he has often resented the attempts of others to tell him how to live. He understands the issues and forces that determine the course of peoples' lives and that no one knows these better than the principals. Nevertheless he feels he would fail his public if he were not to say anything on this topic. Children are marvelous creatures who walk the earth in a state of wonderment and enrich our lives in ways incalculable. They teach us things we might never otherwise learn. Nevertheless the wise postpone having them until circumstances are right. Getting through graduate school is hard work and a full-time job; children are best left to life after you have a degree. This applies to all, but especially to those who will have to solve a two-body problem.

—Good luck and good hunting,
Professor Nescio

Dear Professor Nescio,

I am a third-year graduate student. I started working with an advisor last year, but now find another faculty member's research more interesting. How do I explore the possibility of changing advisors without causing any hurt feelings?

—Thinking of Switching

Dear Switching,

Professor Nescio salutes your concern for the thesis advisor's feelings. He frequently laments the lack of such concern in our profession. Nevertheless, understand that what is at stake outweighs someone's feelings and if you must upset your current professor, that's the way it goes. Your need to pursue the research that most interests you has higher priority.

The relation between a student and thesis advisor is a complicated one, perhaps more so than between two collaborators and less so than between a married couple. But severing the relation between advisor and student, if initiated by the student, is probably easier than severing the relationship in the other two examples. The student's interests take precedence over other matters and so when you switch advisors, all should acknowledge your right to do this and all should continue with their lives. Of course for certain personalities this might present a challenge. Understand that any objective mathematician will say you have a right to make this change—that's not in question. However, as you seem to fully realize, in the real world there are additional considerations like egos and the fact that a senior faculty member may have already invested time in your development and he/she may now regard this as wasted time.

Given your description of the circumstances it sounds as though you have not obtained any "significant" results with the first advisor. If you had, this would present a more difficult situation. If I were you I would first discuss the impending switch with the new advisor, who is likely to know the old advisor better and will be better situated to see a potential problem. However this is a situation where Professor Nescio believes the direct approach is the optimal one. After getting the new professor's agreement to be your advisor, very quickly go to the old advisor and deliver the message. In the meantime, discuss this with *no one else*. You do not want the old advisor to get the news from another party.

Professor Nescio has had many doctoral students and he also had one who worked with him for a year and then left his tutelage. This was a disappointment as the student was talented, but he accepted it with the same grace that can be expected of any adult. In working with this student Professor Nescio was a bit more disturbed than usual about his lack of progress; quite possibly the student was upset by this as well. Sometimes things just don't work out between student and advisor. Professor Nescio never held any resentment toward the student and he doesn't believe his reaction was unusual in the profession. In fact he knows of no incidents where such a divorce, at the early stage you are discussing, led to serious problems.

If you have obtained a good result while working with the original advisor, things are more complicated but the same basic approach is advised. You might complement this by asking the first advisor if he believes the result should be included in a short paper; you should say you will write the paper and add his name as a co-author. Again I would clear all this with the new advisor. (By the way, if this is the first paper you have written, expect this to take a fair amount of time. Most students have to learn this part of the profession and if the first advisor is in any way demanding—which he has a right to be—this will take double or triple the time you budget for it.)

—Good luck,
Professor Nescio

Dear Professor Nescio,

I am currently a fourth-year graduate student in math at a prestigious school. During my second and third years, there was a postdoc in our department whose work I found very interesting. This postdoc has now moved on to a much less prestigious university but I am very interested in working on this line of research. Unfortunately, no one at my university is able to advise me on this line of research, and I am not interested in the areas where they can offer expertise. I do not particularly want to change schools this late in my graduate career, but would this be the best option?

—Dreaming of Following

Dear Dreaming,

This is a version of the classic conflict between the head and the heart. The head will tell you that graduating from a more prestigious school will be more to your benefit than writing a dissertation under the direction of a rather unknown assistant professor at a lesser school. On the other hand when the heart is fully engaged in a research project, better results follow. Professor Nescio understands why there is a question as to which course you should follow. Let's think about this.

Perhaps there are some questions you should answer and that may help clarify the issue. First, have you approached the ex-postdoc about writing a dissertation under his/her direction? If I were advising the ex-postdoc I would counsel him/her to avoid having a Ph.D. student. At the beginning stage of their development mathematicians have a sufficiently difficult problem getting their own research in shape and should not undertake starting someone else on a career. In addition advising a student is a psychological burden: there is the worry that they won't succeed, the worry that the problem may not work out, and then, should the student succeed, the worry of getting the student a job. All this is to be carried out by someone without tenure, reputation, or an established research program? No, no. Professor Nescio does not approve. But just as there are teenagers who have babies, there are mathematicians who fail to heed Professor Nescio's advice and then take on doctoral students before they are fully equipped for such an endeavor.

Second, is there really no research at your current institution that attracts you? Frankly this perplexes Professor Nescio. Presumably there was some faculty member who was sufficiently attracted to the work of the postdoc to get him/her the position. Isn't that person's research area close enough to what attracts you? Changing schools is going to delay your graduation and even though a lot of your course work will transfer, your Ph.D. exams will not and the new university will insist that you take some additional course work. It seems clear that you need a middle course to bring you through this conundrum.

I would suggest that you talk to the senior professor at your present institution who sponsored the postdoc, explain the situation, and ask him/her to be, at the least, a formal advisor while the postdoc supplies the research problem. This would relieve the postdoc of much of the pressure and responsibility and permit you to stay where you are. The concept of a formal advisor who signs the thesis but is less identified with the dissertation is not unknown and arises for many reasons. In addition, having an external thesis examiner is a rather common occurrence and the postdoc can serve in that capacity. Your current institution might even have some funds available to support your occasional travel to the postdoc's university to consult with him/her.

Professor Nescio finds your changing institutions after investing three years in its graduate program too disruptive and probably not in your best interest. This is especially so when I believe a far less disruptive solution is likely. But if you insist you must work in the postdoc's area even though it means postponing graduation, maybe it would be better to work with the advisor of the postdoc. There, at least, you have the benefit of a senior advisor and one who has a track record of placing his/her students in good positions.

—Good luck,
Professor Nescio

Mathematics Programs that Make a Difference

Students working together in the NCSU computer lab.

NCSU photographs by Marc Hall.

Each year the AMS Committee on the Profession (CoProf) selects outstanding mathematics department programs to be designated as *Mathematics Programs that Make a Difference*. For 2009 the honored programs are the DEPARTMENT OF STATISTICS AT NORTH CAROLINA STATE UNIVERSITY, and the DEPARTMENT OF MATHEMATICS AT THE UNIVERSITY OF MISSISSIPPI.

CoProf created the Mathematics Programs that Make a Difference designation in 2005 as a way to bring recognition to outstanding programs that successfully address the issue of underrepresented groups in mathematics. Each year CoProf identifies two exemplary programs that:

1) aim to bring more individuals from underrepresented minority backgrounds into some portion of the pipeline beginning at the undergraduate level and leading to an advanced degree in mathematics, or retain them in the pipeline;

2) have achieved documentable success in doing so; and

3) are replicable models.

Previously designated Mathematics Programs that Make a Difference are: the graduate program at the University of Iowa and the Summer Institute in Mathematics for Undergraduates/Research Experience for Undergraduates at Universidad de Puerto Rico, Humacao (2006); Enhancing Diversity in Graduate Education (EDGE) and the Mathematical Theoretical Biology Institute (2007); and the Mathematics Summer Program in Research and Learning (Math SPIRAL) at the University of Maryland and the Summer Undergraduate Mathematical Science Research Institute at Miami University (Ohio) (2008).

The selection committee for the 2009 Mathematics Programs that Make a Difference consisted of: Alejandro Adem (chair), Dennis Davenport, Susan Loepp, Francis Su, Vasant Waikar, and Leon Woodson.

Below are CoProf's citations, followed by brief descriptions of the programs prepared by *Notices* staff.

Citation: North Carolina State University

Be it resolved that the American Mathematical Society and its Committee on the Profession recognize the Department of Statistics, North Carolina State University, for its significant efforts to encourage students from underrepresented groups to continue in the study of mathematics and statistics.

In the past ten years the department has graduated fifteen minority students with master's degrees in statistics or biomathematics and two with Ph.D. degrees in statistics. The department actively recruits in order to attract minority students to its programs and to create diversity within its faculty and staff. The department is committed to providing the mentoring and support resources needed to guarantee that students succeed in its programs, and has received several grants to support these efforts.

The AMS commends the faculty and staff members of the Department of Statistics at North Carolina State University for their high level of commitment and their successful efforts to improve the diversity of the profession of the mathematical sciences in the United States.

Description of Program: NCSU

The Department of Statistics at North Carolina State University (NCSU) has made diversity of students and faculty a top priority. Out of forty faculty in the department, eleven are female, three are African American, and two are Hispanic. In the past ten years, fifteen minority students have received master's degrees and two have received Ph.Ds. The department has about 160 graduate

A sampling of the North Carolina State University Department of Statistics graduate students and their mentors.

Harry Briscoe, University of Mississippi Imaging Services.

The faculty and some of the graduate students, University of Mississippi Mathematics Department.

students, including nine African-Americans and four Hispanics; over fifty percent are female.

The department's approach includes communication with faculty at other institutions, active and sustained recruiting of minority students, and careful mentoring. NCSU has cultivated ties to other institutions, in particular historically black colleges and universities, as well as to organizations such as the Society for the Advancement of Chicanos and Native Americans in Science (SACNAS). Through such connections, NCSU has reached undergraduate students interested in advanced work in statistics and provided them with information to decide whether NCSU is a good fit for them for graduate school. A co-director of graduate programs, Pam Arroway, travels extensively to various small colleges and summer programs to recruit students and to network and maintain strong relationships with their mentors.

Once students are recruited into the graduate program, they benefit from extensive mentoring from faculty advisors. Each new student is also assigned to a more advanced student who acts as a mentor, or "stat buddy". A key figure in the department's mentoring efforts has been faculty member Kimberly Weems, who organizes many social activities for minority students and meets individually with them to ensure their successful progress through the program. Setting the student-centered tone is department head Sastry Pantula, who has twice been selected for a university diversity award. Other department faculty have received similar recognition, including Weems and Jackie Hughes-Oliver. Recently a graduate student in the department, Anthony Franklin, received a university diversity award for his support of students and for recruiting new students of all backgrounds.

This dynamic department has pursued and received many grants, including two National Science Foundation VIGRE grants that proved crucial in supporting minority students. Recently the department received an S-STEM (Scholarships in Science, Technology, Engineering, and Mathematics) grant from the NSF, which will provide scholarships for United States undergraduate and graduate students with financial need. The department participates in many existing diversity programs, workshops, and conferences, and also designs and hosts some of its own. Some of the more recent such events include StatFest, Infinite Possibilities Conference, a Pipeline Workshop for Faculty of Women's Colleges and Minority Institutions, and Building Future Faculty. NCSU's long-term commitment, with strong support from its administration, is making a difference in diversity in the mathematical sciences.

Citation: University of Mississippi

Be it resolved that the American Mathematical Society and its Committee on the Profession recognize the Department of Mathematics, University of Mississippi, for its significant efforts to encourage students from underrepresented groups to continue in the study of mathematics.

The department's exceptional commitment to its students includes research guidance, mentoring, and professional development opportunities in addition to financial support provided by grant funding. In one outstanding year, 2006, the department graduated six African American Ph.D.s in mathematics, over one-third of all African Americans who received Ph.D.s nationally that year. The department at Ole Miss has made, and continues to make, a remarkable contribution to the national effort to produce more minority Ph.D.s in the mathematical sciences.

The AMS commends the members of the Department of Mathematics at the University of Mississippi for their high level of commitment and their

successful efforts to improve the diversity of the profession of mathematics in the United States.

Description of Program: University of Mississippi

The southern United States is home to many of the nation's African-Americans, and yet the universities in that part of the country have not historically been large producers of African-American Ph.D.s in mathematics. But the University of Mississippi (UM) has started to reverse this trend, becoming a national leader in nurturing and mentoring African-Americans in doctoral study. Over the past decade, eleven African-Americans have received mathematics doctorates from Ole Miss. That the university was once a symbol of educational segregation in the United States gives this success story special importance.

Since 2001 the UM mathematics department has received two GAANN (Graduate Assistance in Areas of National Need) grants from the U.S. Department of Education; the grants provide fellowships for graduate study. The fellowships proved to be transformational for the department, allowing it to quadruple the number of graduate students and to ensure that they are financially well supported. At the same time the department worked diligently to provide more careful nurturing of its graduate student population, both in research and in professional development.

Contributions to these achievements were made by the entire UM mathematics department, including ten faculty who have served as GAANN dissertation advisors. Among the key leaders have been the co-principal investigators of the GAANN grants, Gerard Buskes and Donald Cole. As an African-American faculty member and assistant to the chancellor for multicultural affairs, Cole has been a role model and mentor for the African-American graduate students, while Buskes serves as advisor and mentor to the GAANN students. Buskes eloquently described the department's efforts in an article, "Mississippi mathematics renaissance", which appeared in the January 2007 issue of the *Notices*. This article celebrated a high point in the department's efforts, the awarding of Ph.D.s to six African-Americans in 2006, which is the largest cohort of African-American mathematics Ph.D.s ever produced at any university in the United States.

Philip Kutzko of the University of Iowa, in his letter of nomination for the award, summed up the achievements of the mathematics department of the University of Mississippi: "By the work that it has done in welcoming and nurturing minority students as well as in building ties to nearby communities, the department is unique, as far as I know, nationally, in providing minority students with a place where they can do advanced mathematics without 'leaving home'."

Mathematics People

2009–2010 AMS Centennial Fellowship Awarded

The AMS has awarded its Centennial Fellowship for 2009–10 to ANTONIO MONTALBÁN of the University of Chicago. The fellowship carries a stipend of US$75,000, an expense allowance of US$7,500, and a complimentary Society membership for one year.

Antonio Montalbán

Antonio Montalbán got his bachelor's degree at the Universidad de la República, which is in Uruguay, where he grew up. He then got his Ph.D. in 2005 from Cornell University under the supervision of Richard A. Shore. Montalbán was a Dickson Instructor at the University of Chicago for a year and also did a one-year postdoc at the University of Victoria Wellington. Since 2007 he has been an assistant professor at the University of Chicago.

Montalbán's research field is logic, more specifically computability theory. In general, he is interested in measuring the complexity of proofs and constructions from classical mathematics. He plans to use his fellowship to visit Berkeley, among other places, and to work on finding the proof-theoretic strength of Laver's theorem and other theorems that seem to require proofs of particularly high complexity.

Please note: Information about the competition for the 2010–11 AMS Centennial Fellowships will be published in the "Mathematics Opportunities" section of an upcoming issue of the *Notices*.

—Allyn Jackson

Sloan Fellowships Awarded

The Alfred P. Sloan Foundation has announced the names of the recipients of the 2009 Sloan Research Fellowships. Each year the foundation awards 118 fellowships in the fields of mathematics, chemistry, computational and evolutionary molecular biology, computer science, economics, neuroscience, and physics. Grants of US$50,000 for a two-year period are administered by each fellow's institution. Once chosen, fellows are free to pursue whatever lines of inquiry most interest them, and they are permitted to employ fellowship funds in a wide variety of ways to further their research aims.

Following are the names and institutions of the 2009 awardees in mathematics: GERARD AWANOU, Northern Illinois University; FRANCESCO CALEGARI, Northwestern University; IZZET COSKUN, University of Illinois; CIPRIAN DEMETER, University of Indiana; JULIEN DUBÉDAT, Columbia University; JUSTIN A. HOLMER, Brown University; CHIU-YEN KAO, Ohio State University; THOMAS LAM, Harvard University; ROBERT LIPSHITZ, Columbia University; DAN MARGALIT, Tufts University; ALINA MARIAN, University of Illinois, Chicago; YOICHIRO MORI, University of Minnesota; JESSE PETERSON, Vanderbilt University; JIAN SONG, Rutgers University; LUIS E. SILVESTRE, University of Chicago; JULIANNA TYMOCZKO, University of Iowa; LAUREN K. WILLIAMS, Harvard University; and WOTAO YIN, Rice University.

—From a Sloan Foundation announcement

NSF Graduate Fellowships Announced

The National Science Foundation (NSF) has awarded a number of Graduate Research Fellowships for fiscal year 2009. Further awards may be announced later in the year. This program supports students pursuing doctoral study in all areas of science and engineering and provides a stipend of US$30,000 per year for a maximum of three years of full-time graduate study. Following are the names of the awardees in the mathematical sciences selected so far in 2009, followed by their undergraduate institutions (in parentheses) and the institutions at which they plan to pursue graduate work.

BORIS ALEXEEV (Massachusetts Institute of Technology), Princeton University; CARLOS EDUARDO ARRECHE

(Princeton University), University of Chicago; JOSHUA D. BATSON (Yale University), Massachusetts Institute of Technology; DORIS DOBI (Massachusetts Institute of Technology), University of California, Berkeley; ARTHUR J. FRIEND (Georgia Institute of Technology), Massachusetts Institute of Technology; MAXWELL J. GRAZIER G'SELL (California Institute of Technology), Stanford University; RUSSELL E. HOWES (Brigham Young University), University of California, Los Angeles; TYLER L. KELLY (University of Georgia), Columbia University; SARAH KHASAWINAH (Bryn Mawr College), Oxford University; SAM J. LEWALLEN (Harvard University), Princeton University; SAMUEL LICHTENSTEIN (Harvard University), Princeton University; AARON MAZEL-GEE (Brown University), Harvard University; GREGORY T. MINTON (Harvey Mudd College), Massachusetts Institute of Technology; ANDREW N. NILES (University of Rochester), University of California, Berkeley; NATHAN K. PFLUEGER (Stanford University), Massachusetts Institute of Technology; ANATOLY PREYGEL (Harvard University), Massachusetts Institute of Technology; STEVEN V. SAM (University of California, Berkeley), Massachusetts Institute of Technology; HAKAN ALI-JOHN SEYALIOGLU (College of William and Mary), University of California, Los Angeles; SHRENIK N. SHAH (Harvard University), Princeton University; Samuel S. Watson (University of Mississippi), Stanford University; JAMES E. WEIGANDT (Purdue University), Purdue University; and ERIC R. WOFSEY (Washington University), Harvard University.

—From an NSF announcement

Li Receives ONR Young Investigator Award

The Office of Naval Research (ONR) has announced fifteen aspiring researchers as award recipients of the U.S. Navy's 2009 Young Investigator Program (YIP). Award recipients were selected from 193 proposals submitted for the highly competitive program. Winners will receive a three-year research grant up to US$510K.

The 2009 YIP winning recipients include PING LI of the Department of Statistical Science, Cornell University, whose project title is "Processing Massive Data; Fundamental Techniques and Applications".

YIP has been in place at ONR since 1985 and seeks to identify and support academic scientists and engineers who have received a doctorate or equivalent degree within the past five years and who show exceptional promise for doing cutting-edge research. YIP's objectives are to attract outstanding faculty members of institutions of higher education to the Department of the Navy's research program, support their research, and encourage their teaching and research careers.

—From an ONR News Release

2009 Clay Research Awards

The 2009 Clay Research Awards were presented at the Clay Research Conference, held May 4–5, 2009, at Harvard University.

The awards were presented "to JEAN-LOUP WALDSPURGER for his work in p-adic harmonic analysis, particularly his contributions to the transfer conjecture and the fundamental lemma. This work, combined with that of others, makes it possible to finally resolve important, long-standing parts of the Langlands program"; and "to IAN AGOL and to DANNY CALEGARI and DAVID GABAI for their solutions of the Marden Tameness Conjecture, and, by implication through the work of Thurston and Canary, of the Ahlfors Measure Conjecture."

The Langlands program is a collection of conjectures and theorems that unify the theory of automorphic forms, relating it intimately to the main stream of number theory, with close relations to harmonic analysis on algebraic groups as well as arithmetic algebraic geometry. Since its origins in the winter of 1966–67, when it was laid out in a letter from Langlands to André Weil, it has served as the basis of much deep work, including applications to many famous problems in number theory, e.g., Artin's conjectures on L-functions, Fermat's Last Theorem, and the behavior of Hasse-Weil zeta functions.

The tameness conjecture asserts that a hyperbolic 3-manifold with finitely-generated fundamental group is homeomorphic to the interior of a compact 3-manifold (possibly with boundary). The Ahlfors conjecture asserts that the limit set of a finitely generated Kleinian group (i.e., the minimal invariant set on the Riemann sphere, which is the boundary at infinity of hyperbolic 3-space) has either full or zero measure, and in the former case the action of the group on it is ergodic.

Recipients of the Clay Research Award are named as Clay Research Scholars, and receive flexible research support for a period of one year. They also receive the bronze sculpture *Figureight Knot Complement VII/CMI* by Helaman Ferguson.

Previous recipients of the award are Clifford Taubes and Claire Voisin (2008), Alex Eskin, Christopher Hacon, James McKernan, Michael Harris, and Richard Taylor (2007), Manjul Bhargava and Nils Dencker (2005), Ben Green and Gérard Laumon and Bao-Châu Ngô (2004), Richard Hamilton and Terence Tao (2003), Oded Schramm and Manindra Agrawal (2002), Edward Witten (2001), Alain Connes and Laurent Lafforgue (2000), and Andrew Wiles (1999). Please see `http://www.claymath.org` for more information.

—Clay Mathematics Institute Announcement

Browning Awarded 2009 Balaguer Prize

The Ferran Sunyer i Balaguer Foundation has awarded the Ferran Sunyer i Balaguer Prize for 2009 to TIM BROWNING

of Bristol University, United Kingdom, for his monograph *Quantitative Arithmetic of Projective Varieties.* According to the prize citation, the monograph deals with "computing asymptotic estimates for the number of rational points in algebraic varieties defined over Q that have infinitely many rational points. This is done using methods coming from analytic number theory (like the Hardy-Littlewood circle method) and some techniques coming from arithmetic algebraic geometry (the universal torsor, for instance)." The monograph features "a detailed discussion of the conjectures in the subject, like Manin conjectures and the dimension growth conjecture."

The Ferran Sunyer i Balaguer Foundation of the Institut d'Estudis Catalans (IEC) awards this international prize every year to honor the memory of Ferran Sunyer i Balaguer (1912–1967), a self-taught Catalan mathematician who gained international recognition for his research in mathematical analysis despite the serious physical disabilities with which he was born. The prize carries a cash award of €15,000 (approximately US$19,800); the winning monographs are published by Birkhäuser Verlag.

—From a Ferran Sunyer i Balaguer Foundation announcement

Kelly Awarded John von Neumann Theory Prize

The 2008 John von Neumann Theory Prize, the highest prize given in the field of operations research and management science, has been awarded to FRANK P. KELLY of the University of Cambridge "for his profound contributions to the mathematical theory of stochastic networks, and for applications of these theories to the understanding, performance evaluation, and design of telecommunications networks." The award, which is presented by the Institute for Operations Research and the Management Sciences (INFORMS), carries a cash award of US$5,000.

—From an INFORMS announcement

CMS Prizes Awarded

The Canadian Mathematical Society (CMS) has announced the awarding of several major prizes.

LIA BRONSARD of McMaster University has been awarded the 2010 Krieger-Nelson Prize, which recognizes outstanding research by a woman mathematician. Bronsard specializes in the study of singular limits of solutions of partial differential equations. According to the prize citation, "her research brings rigorous methods of analysis to bear on problems arising in the physical sciences, and in particular those involving singular geometrical structures such as vortices, phase transition layers, and grain boundaries."

MIKHAIL LYUBICH of Stony Brook University and the University of Toronto has been named recipient of the 2010 Jeffery-Williams Prize, which recognizes mathematicians who have made outstanding contributions to mathematical research. According to the prize citation, "Lyubich is a leader in the field of dynamical systems. He is one of the founders of modern real and complex one-dimensional dynamics, having in many ways shaped the development of the field."

PATRICK BROSNAN of the University of British Columbia has been honored with the 2009 Coxeter-James Prize, which recognizes young mathematicians who have made outstanding contributions to mathematical research. The prize citation calls Brosnan "a young mathematician of unusual breadth, depth and scope; his work has had significant impact in several areas of mathematics, including motives, algebraic cycles, Hodge theory, algebraic groups, algebraic combinatorics, analytic number theory, and mathematical physics."

—From a CMS announcement

Miermont Awarded Rollo Davidson Prize

GREGORY MIERMONT of Ecole Normale Supérieure, Paris, has been awarded the 2009 Rollo Davidson Prize for his "original contributions to the understanding of random trees and large random planar maps."

The Rollo Davidson Trust was founded in 1975 and awards an annual prize to young mathematicians working in the field of probability.

—University of Cambridge announcement

Prizes of the CRM

The Centre de Recherches Mathématiques (CRM) in Montreal has awarded several prizes for 2009.

The 2009 André-Aisenstadt Mathematics Prize has been awarded to VALENTIN BLOMER of the University of Toronto. The prize, consisting of C$3,000 (approximately US$2,500) and a medal, recognizes achievements in research by young Canadian mathematicians. According to the prize citation, Blomer solved "a deep and difficult problem of Paul Erdős" that "revolved around getting precise estimates for the number of integers up to a given point represented by a given binary quadratic form, where that point is small enough that the coefficients of the form will have significant impact on the shape of the solution." His recent work has focused on the subconvexity problem for automorphic L-functions.

The CRM and the Statistical Society of Canada (SSC) have awarded the 2009 CRM-SSC Prize in Statistics to HUGH CHIPMAN of Acadia University. According to the prize citation, "his contributions to computational data analysis and especially to nonparametric Bayesian modeling have had an important impact in statistics and bioinformatics. He has made outstanding contributions to the application of Bayesian statistical inference for data analysis. His work on Bayesian variable selection in experimental design, on a Bayesian paradigm for nonparametric

wavelet regression, and on a Bayesian approach to CART (Classification and Regression Tree) modeling is seminal. His papers are widely cited and have a profound impact on the development of computer-intensive nonparametric data analysis." The prize, which includes a cash award of C$3,000 (approximately US$2,500), is given to a Canadian citizen or a permanent resident of Canada whose research was carried out primarily in Canada.

The CRM and the Canadian Association of Physicists (CAP) have awarded the 2009 CAP-CRM Prize in Theoretical and Mathematical Physics to HONG GUO of McGill University "for his pioneering work on the ab initio theory of transport in nanoscale systems, including the theory of circuits in which current flows through molecules." The annual prize is given jointly in recognition of exceptional achievements in theoretical and mathematical physics. It carries a cash award of C$2,000 (approximately US$1,600).

—From a CRM announcement

Scott and Shafarevich Awarded Gold Medals of the Sobolev Institute

DANA SCOTT of Carnegie Mellon University and IGOR SHAFAREVICH have been awarded the 2009 Gold Medals for Great Contributions in Mathematics by the Sobolev Institute of Mathematics in Novosibirsk. The Gold Medal was established in 2007 to mark the fiftieth anniversary of the Institute. Previous recipients of the medal have been V. G. Vizing, Yu. I. Zhuravlev, V. L. Makarov, G. I. Marchuk, and L. V. Ovsyannikov (2007), and I. M. Gel'fand and S. M. Nikolskii (2008).

—From a Sobolev Institute announcement

Humboldt Foundation Awards Given

The Alexander von Humboldt Foundation has given several awards for 2008 and 2009 to researchers in the mathematical sciences.

The Alexander von Humboldt Professorship honors researchers from outside of Germany who are internationally recognized leaders in their fields and allows them to spend five years conducting research at German universities. The award is valued at up to five million euros (approximately US$6,500,000) and is endowed by the Federal Ministry of Education and Research. MARC LEVINE of Northeastern University has been selected to receive this award in 2009. He works in the field of algebraic geometry and has made "outstanding, innovative contributions to his subject, not least his recent theory of algebraic cobordism."

The Humboldt Research Award for Senior U.S. Scientists includes a monetary grant and support for research at a German university. PREDRAG CVITANOVIĆ of the Georgia Institute of Technology has received a Research Award for 2009 for his body of work in chaos and turbulence theory. His research interests include nonlinear dynamics, chaos, quantum chaos, quantum field theory, statistical mechanics, and group theory. MARK STRIKMAN of Pennsylvania State University has received a 2009 Humboldt Research Award "for his academic achievements and his successful collaborations with German scientists during his previous visits to Germany." He has created mathematical models of novel collisions involving large transfers of energy and momentum. TOSHIYUKI KOBAYASHI of the University of Tokyo received a 2008 Humboldt Research Award "for his pioneering contributions to geometric analysis, in particular to the theory of lattices for homogeneous spaces and representation theory."

—Elaine Kehoe

Fulbright Awards Announced

The J. William Fulbright Foundation and the United States Department of State, Bureau of Educational and Cultural Affairs, have announced the names of the recipients of the Fulbright Foreign Scholarships for 2008–09. The U.S. scholars in the mathematical sciences who have been awarded Fulbright scholarships to lecture or conduct research, together with their home institutions and the countries in which they plan to use the awards, are as follows.

AKRAM ALDROUBI (Vanderbilt University), Argentina; RICHARD M. ARON (Kent State University), Ireland; JOHN J. BORKOWSKI JR. (Montana State University, Bozeman), Thailand; JUSTIN J. CORVINO (Lafayette College), Sweden; EDWARD T. DOBSON (Mississippi State University), Slovenia; SONIA M. GARCIA (United States Naval Academy), Ireland; JIE SHEN (Purdue University), Canada; and JOSEPH S. VERDUCCI (Ohio State University, Columbus), Ireland.

—From a Fulbright Awards announcement

Guggenheim Fellowships Awarded

The John Simon Guggenheim Memorial Foundation has announced the names of 180 artists, scholars, and scientists from the United States, Canada, and the United Kingdom who were selected as Guggenheim Fellows for 2009. Guggenheim Fellows are appointed on the basis of distinguished achievement in the past and exceptional promise for future accomplishment.

The names of the awardees whose work involves the mathematical sciences, together with their affiliations and areas of research interest, are: SALLY BLOWER, University of California, Los Angeles: mathematical modeling of infectious diseases; JIANQING FAN, Princeton University: feature selection and statistical learning in ultrahigh-dimensional space; A. S. FOKAS, University of Cambridge: boundary value problems, integrability, and medical imaging; WILHELM SCHLAG, University of Chicago: blowup and longtime

existence for nonlinear hyperbolic equations; and SHOU-WU ZHANG, Columbia University: topics in arithmetical algebraic geometry.

—From a Guggenheim Foundation news release

Putnam Prizes Awarded

The winners of the sixty-ninth William Lowell Putnam Mathematical Competition have been announced. The Putnam Competition is administered by the Mathematical Association of America (MAA) and consists of an examination containing mathematical problems that are designed to test both originality and technical competence. Prizes are awarded to both individuals and teams.

The five highest ranking individuals, listed in alphabetical order, were: BRIAN R. LAWRENCE, California Institute of Technology; SEOK HYEONG LEE, Stanford University; ARNAV TRIPATHY, Harvard University; BOHUA ZHAN, Massachusetts Institute of Technology; and YUFEI ZHAO, Massachusetts Institute of Technology. Each received a cash award of US$2,500.

Institutions with at least three registered participants obtain a team ranking in the competition based on the rankings of three designated individual participants. The five top-ranked teams (with team members listed in alphabetical order) were: Harvard University (Zachary Abel, Iurie Boreico, Arnav Tripathy); Princeton University (Peter Z. Diao, John V. Pardon, Adrian I. Zahariuc); Massachusetts Institute of Technology (Qingchun Ren, Xuancheng Shao, Yufei Zhao); Stanford University (Young Hun Jung, Nathan K. Pflueger, Jeffrey Wang); and the California Institute of Technology (Jason C. Bland, Zarathustra E. Brady, Brian Lawrence).

The first place team receives an award of US$25,000, and each member of the team receives US$1,000. The awards for second place are US$20,000 and US$800; for third place, US$15,000 and US$600; for fourth place, US$10,000 and US$400; and for fifth place, US$5,000 and US$200.

The Elizabeth Lowell Putnam Prize is awarded periodically to a woman whose participation in the Putnam Competition is deemed particularly meritorious. This prize was awarded to VIKTORIYA KRAKOVNA, University of Toronto. The prize carries a cash award of US$1,000.

—From a Putnam announcement

Intel Science Talent Search Winners Announced

A young mathematician has received the top scholarship award in the 2009 Intel Science Talent Search. ERIC LARSON, a seventeen-year-old student from Eugene, Oregon, received a US$100,000 scholarship from the Intel Foundation for his research project classifying mathematical objects called fusion categories. Larson's work describes these in certain dimensions for the first time.

Two other students with mathematics projects received awards in the competition. NOAH ARBESFELD, a seventeen-year-old student from Lexington, Massachusetts, was awarded sixth place and a US$25,000 scholarship for his work seeking to understand a fundamental structure underlying all of algebra, with potential impact for string theory. NILESH TRIPURANENI, an eighteen-year-old student from Fresno, California, received the ninth-place award of a US$20,000 scholarship for formulating a set of hydrodynamic equations that may provide a potential method of better understanding the first movements of the universe and that could aid in the development of a quantum theory of gravity.

—From an Intel Corporation announcement

Mathematics Opportunities

AMS Department Chairs Workshop

The annual workshop for department chairs will be held a day before the start of the Joint Mathematics Meetings in San Francisco, California, on Tuesday, January 12, 2010, from 8:00 a.m. to 6:30 p.m. This one-day session for mathematical sciences department chairs is organized in a workshop format so as to stimulate discussion among attendees. Sharing ideas and experiences with peers creates an environment that enables attending chairs to address departmental challenges from new perspectives. Past workshop sessions have focused on a range of issues facing departments today, including personnel issues (staff and faculty), long-range planning, hiring, promotion and tenure, budget management, assessments, outreach, stewardship, junior faculty development, communication, and departmental leadership.

There is a registration fee for the workshop, which is in addition to and separate from the Joint Meetings registration. An invitation to attend the workshop will be sent to department chairs this fall. Information will also be posted on the AMS website. For further information, please contact the AMS Washington Office at 202-588-1100 or amsdc@ams.org.

—AMS Washington Office

Call for Nominations for Popov Prize

The Vasil Popov Prize is awarded every three years for outstanding research contributions in fields related to the work of Vasil A. Popov, who is best known for his contributions to approximation theory. Candidates must have received the Ph.D. degree within the six years prior to the nomination.

Nominations should include a brief description of the relevant work and a vita of the candidate. The deadline for nominations is **November 1, 2009.** Nominations should be sent to Pencho Petrushev, Chair, Popov Prize Selection Committee, Department of Mathematics, University of South Carolina, Columbia, South Carolina 29208; email: popov@math.sc.edu. For further information, visit the website http://www.math.sc.edu/~popov/.

—Pencho Petrushev, University of South Carolina

Call for Nominations for Parzen Prize

To promote the dissemination of statistical innovation, the Emanuel and Carol Parzen Prize for Statistical Innovation is awarded in even-numbered years to North American statisticians who have made outstanding and influential contributions by developing innovative statistical methods. Candidates must have received the Ph.D. degree more than twenty-five years before the nomination. The prize consists of an honorarium of US$1,000 and travel expenses to College Station, Texas, to present a lecture at the prize ceremony. Nominations for the 2010 Parzen Prize should be submitted by **October 15, 2009,** to Thomas Wehrly, Department of Statistics, 3143 TAMU, Texas A&M University, College Station, Texas 77843-3143.

—From a Texas A&M announcement

Call for Nominations for SASTRA Ramanujan Prize

The Shanmugha Arts, Science, Technology Research Academy (SASTRA) invites nominations for the 2009 SASTRA Ramanujan Prize. The prize carries a cash award of US$10,000, and the winner will be invited to give a

talk at the SASTRA conference in December 2009. The deadline for nominations is **August 15, 2009**. For more information, email: sastraprize@math.ufl.edu, or see the website http://www.math.ufl.edu/sastra-prize/nominations-2008.html.

—Krishnaswami Alladi, University of Florida

Call for Nominations for ICTP Ramanujan Prize

The Abdus Salam International Centre for Theoretical Physics (ICTP) invites nominations for the 2009 Ramanujan Prize for young mathematicians from developing countries. The prize, funded by the Niels Henrik Abel Memorial Fund, carries a cash award of US$15,000 and an allowance to visit ICTP to deliver a lecture.

The prize is awarded annually to a researcher from a developing country who is under forty-five years of age on December 31 of the year of the award and who has conducted outstanding research in a developing country. Researchers working in any branch of the mathematical sciences are eligible. The deadline for receipt of nominations is **July 31, 2009**. For further information, see the website http://prizes.ictp.it/Ramanujan/.

—From an ICTP announcement

Call for Nominations for Heineman Prize

The American Physical Society (APS) and the American Institute of Physics (AIP) are seeking nominations for the 2009 Dannie Heineman Prize for Mathematical Physics. The prize recognizes outstanding publications in the field of mathematical physics. The prize carries a cash award of US$10,000, an award certificate, and travel expenses to the meeting at which the prize is given. The deadline for nominations is **July 1, 2009**. For more information, see the APS website at http://www.aps.org/programs/honors/prizes/heineman.cfm.

—From an APS announcement

For Your Information

Kichoon Yang Named Next NCTM Executive Director

Kichoon Yang of Northwest Missouri State University has been named executive director of the National Council of Teachers of Mathematics (NCTM), effective July 1, 2009.

Yang is provost and professor at Northwest Missouri State, where he has been since 2005. He served as dean of the College of Natural Sciences and professor of mathematics at the University of Northern Iowa from 2001 through 2004. He was also a program director in the Division of Mathematical Sciences at the National Science Foundation for three years. Earlier in his career he served for twelve years on the mathematics faculty at Arkansas State University. Yang earned a B.S. in mathematics from the University of North Carolina and a Ph.D. in mathematics from Washington University in St. Louis.

Yang will succeed Jim Rubillo, who has been NCTM executive director since 2001. Rubillo announced his retirement last year and will continue in the position until Yang begins on July 1, 2009.

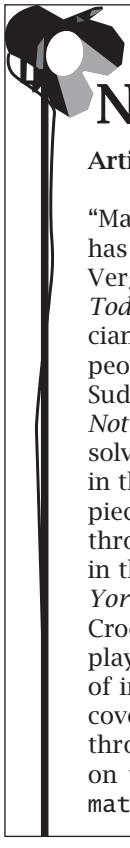
The National Council of Teachers of Mathematics is a public voice of mathematics education, providing vision, leadership, and professional development to support teachers in ensuring mathematics learning of the highest quality for all students. It has more than 100,000 members and 230 affiliates and is the world's largest organization dedicated to improving mathematics education from prekindergarten through grade 12.

—From an NCTM announcement

Mathematics Film Receives Prize

The film *The Spell of the Poincaré Conjecture* has received the Pierre Gilles de Gennes Prize of the Pariscience International Science Film Festival. The film was directed by Masahito Kasuga and produced by the Japanese television station NHK. The de Gennes Prize is awarded by the Centre National de la Recherche Scientifique for research and spreading of scientific knowledge through the uncommon scenario of a film. The prize carries a cash award of €3,000 (approximately US$3,900).

—Allyn Jackson



Noticed

Article Hits the Headlines

"Math has helped place a man on the moon and has counted the genes in our DNA," writes Dan Vergano in the March 16, 2009, issue of *USA Today*. "But never mind all that. A mathematician says he has finally produced something that people really care about: a foolproof way to beat Sudoku puzzles." Vergano was referring to the *Notices* article "A pencil-and-paper algorithm for solving Sudoku puzzles", by J. F. Crook, which ran in the April 2009 issue. News of Crook's *Notices* piece circled the globe, with stories appearing through United Press International, as well as in the *Toronto Star*, the *Daily Mail*, and the *New York Daily News*. The algorithm presented in Crook's article is used intuitively by many Sudoku players, but the way Crook encapsulated it was of interest to many. Find out more about media coverage of this and other math-related stories through the "Math Digest", a monthly feature on the AMS website at `http://www.ams.org/mathmedia/mathdigest`.

Inside the AMS

AMS Announces Congressional Fellow

The American Mathematical Society (AMS) is pleased to announce that KATHERINE CROWLEY of Washington and Lee University has been chosen as the AMS Congressional Fellow for 2009–10.

The AMS will sponsor Crowley's fellowship through the Congressional Fellowship Program administered by the American Association for the Advancement of Science (AAAS). 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.

Katherine Crowley

Fellows spend a year on the staff of a member of Congress or a congressional committee, working as a special legislative assistant in legislative and policy areas requiring scientific and technical input. The fellowship program includes an orientation on congressional and executive branch operations and a year-long seminar series on issues involving science, technology, and public policy.

Katherine Crowley was chosen from among several very competitive applicants. She earned her Ph.D. in mathematics from Rice University after completing her thesis, titled *Discrete Morse Theory and the Geometry of Nonpositively Curved Simplicial Complexes.*

For more information on the AAAS Congressional Fellowship Program, visit the website `http://www.fellowships.aaas.org`.

—AMS Washington Office

AMS Announces Mass Media Fellowship Award

The American Mathematical Society (AMS) is pleased to announce that BALDUR HEDINSSON has been awarded its 2009 Mass Media Fellowship. Hedinsson is a Ph.D. student in mathematics at Boston University. He will be working at the *Milwaukee Journal Sentinel* for ten weeks over the summer under the sponsorship of the AMS.

The Mass Media Fellowship program is organized by the American Association for the Advancement of Science (AAAS) and is intended to strengthen the connections between science and the media, to improve public understanding of science, and to sharpen the ability of the fellows to communicate complex scientific issues to nonspecialists. The program is available to college or university students (in their senior years or on any graduate or postgraduate level) in the natural, physical, health, engineering, computer, or social sciences or mathematics with outstanding written and oral communication skills and a strong interest in learning about the media. It is a highly competitive program, and the AMS wishes to congratulate Baldur Hedinsson on his accomplishment.

Baldur Hedinsson

The program is in its thirty-fifth year and has supported more than five hundred fellows.

—AMS Washington Office

AMS Testifies Before House Appropriations Subcommittee

American Mathematical Society Past President James Glimm testified on April 2, 2009, before the House Appropriations Subcommittee on Commerce, Justice, Science and Related Agencies. The testimony was part of a joint statement by the American Mathematical Society, the American Chemical Society, the American Physical Society, and the Federation of American Societies for Experimental Biology urging a federal investment of $7 billion for the National Science Foundation (NSF) for fiscal year 2010.

James Glimm

Glimm emphasized that this level of support "would allow the NSF to continue innovative and transformational scientific research that fuels the American economy,

upholds national security, maintains our global competitiveness, and improves health and quality of life for millions of Americans." The full text of the testimony can be read at http://www.ams.org/government/testimony-approp-april2009.pdf.

—AMS Washington Office

Erdős Memorial Lecture

The Erdős Memorial Lecture is an annual invited address named for the prolific mathematician Paul Erdős (1913–1996). The lectures are supported by a fund created by Andrew Beal, a Dallas banker and mathematics enthusiast. The Beal Prize Fund, now US$100,000, is being held by the AMS until it is awarded for a correct solution to the Beal Conjecture (see http://www.math.unt.edu/~mauldin/beal.html). At Beal's request, the interest from the fund is used to support the Erdős Memorial Lecture.

The Erdős Memorial Lecturer for 2009 was Jeffrey Lagarias of the University of Michigan. He delivered a lecture titled "From Apollonian Circle Packings to Fibonacci Numbers" at the Spring Central Section Meeting at the University of Illinois at Urbana-Champaign in March 2009. In 2008 the Erdős Memorial Lecturer was William Timothy Gowers of the University of Cambridge, who spoke on "Decomposing Bounded Functions" at the Courant Institute of Mathematical Sciences, New York University, during the Spring Northeast Section Meeting in March 2008.

—AMS announcement

AMS Sponsors Exhibit on Mathematical Modeling

David Hiebeler of the University of Maine represented the AMS at the fifteenth annual Coalition for National Science Funding (CNSF) Exhibition on Capitol Hill held March 24, 2009. Hiebeler's research, funded by the National Science Foundation, was presented to members of Congress, congressional staff, administration representatives, and members of the scientific community in an exhibit titled "Modeling Outbreaks in Agricultural Systems, Human Communities and Computer Networks".

Hiebeler's exhibit used information and computer simulations to describe his work in three different areas: (1) determining the best strategy for applying pesticides or other measures to control invasive insect species in Maine's agriculture while using fewer chemicals; (2) using epidemiological models to explore the implications of clustering within certain socioeconomic groups of people who choose not to be vaccinated or to have their children vaccinated against infectious diseases; and (3) modeling the effectiveness of new biological dispersal strategies in the spread of computer viruses and "worms" by malicious software and also exploring methods for helping to control such outbreaks.

David Hiebeler with Rep. Rush Holt (NJ-12).

The annual CNSF exhibition highlights research made possible through funding by the National Science Foundation. The 2009 exhibition included thirty-four exhibit booths displaying a wide range of scientific research and education projects. For more information, see http://www.ams.org/government/cnsfex09.html.

—Anita Benjamin, AMS Washington Office

AMS Holds Workshop for Department Chairs

The AMS hosted its annual one-day workshop for mathematical sciences department chairs at the 2009 Joint Mathematics Meetings in Washington, D.C. This session is organized in a workshop format so as to stimulate discussion among attendees. The workshop focused on mentoring faculty through the professional life cycle; on the mission of the mathematics department within the context of the institution's mission; on positioning the mathematics department for the future in an environment of budget cuts; and on creating a productive, positive collegial environment.

Workshop leaders included Guillermo Ferreyra, dean of the College of Arts and Sciences, Louisiana State University; Lawrence Gray, former head and director of undergraduate studies at the School of Mathematics, University of Minnesota; and Stephen Robinson, chair, Department of Mathematics, Wake Forest University.

The Department Chairs Workshop is an annual event hosted by the AMS prior to the start of the Joint Meetings. Past workshop sessions have focused on a range of issues facing departments today, including personnel issues (staff and faculty); long-range planning; hiring, promotion, and tenure; budget management; assessments; outreach; stewardship; junior faculty development; communication; departmental leadership; and undergraduate and graduate education.

If you are interested in attending a future workshop, please look for registration information sent out in advance of the Joint Meetings or contact the AMS Washington Office at amsdc@ams.org.

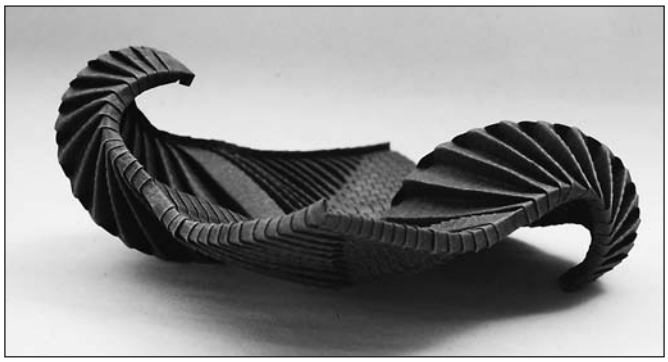
—Anita Benjamin, AMS Washington Office

From the AMS Public Awareness Office

• **AMS Graduate Student Blog**. The AMS Graduate Student Blog is a new blog by and for math graduate students, managed by Frank Morgan, AMS vice-president and professor of mathematics at Williams College. "Graduate students are the future of the AMS, and they have a lot to talk about," says Morgan. The Graduate Student Editorial Board members are Asher Auel, Adam Boocher, Diana Davis, Daniel Erman, Fernando Galaz, Brian Katz, Alex Levin, Kathryn Lindsey, Andrew Obus, David Shea Vela-Vick, Clay Shonkwiler, Annalies Z. Vuong, and Tom Wright, and Morgan hopes that more grad students from around the country will be interested in joining the board. The blog entries to date concern organizing a reading seminar, how to give a good mathematics talk, advice for beginning teaching assistants, navigating seminars, and finding an advisor—topics of great importance to graduate students, who are all are invited to join the community by posting comments, questions and advice on the blog. The American Mathematical Society encourages all graduate students in the mathematical sciences to visit and use the AMS Graduate Student Blog, hosted by Williams College, at `http://mathgradblog.williams.edu/`.

• **Math in the Media**. Recent media coverage of mathematics and mathematicians includes the winner of the 2009 Intel Science Talent Search competition (Eric Larson of Eugene, Oregon "for his classification of new fusion categories, a type of algebraic structure with applications in string theory and quantum computation"); a profile of Ken Golden ("Cold Equations," by Dana Mackenzie, *Science*, April 3); the 2009 Abel Prize awarded to Mikhail Gromov; a series of articles on mathematics by Arvind Gupta (MITACS) published in the *Vancouver Sun*. View the most recent issue of Math in the Media and explore the archive of "Tony Phillips' Take" and Math Digest summaries at `http://www.ams.org/mathmedia/`.

• ***2009 Mathematical Art Exhibition*** **album on Mathematical Imagery**. The Mathematical Art Exhibition held at the 2009 Joint Mathematics Meetings in Washington, DC, included 49 works in various media by 36 artists. Images of these works—which can be sent as e-postcards—are now posted as an album on Mathematical Imagery. Robert Fathauer was the curator of the exhibition, and the exhibition was juried by Fathauer, Anne Burns, Nat Friedman, and Reza Sarhangi. The album includes winners of the inaugural Mathematical Art Exhibition Prizes: first prize to Goran Konjevod, for his origami work, "Wave (32)", 2006 (pictured here); second prize to Carlo Séquin, for his sculpture, "Figure-8 Knot", 2007; and third prize to Robert Fathauer, for "Twice Iterated Knot No. 1", 2008. The prize "for aesthetically pleasing works that combine mathematics and art" was established in 2008 through an endowment provided to the AMS by an anonymous donor who wishes to acknowledge those whose works demonstrate the beauty and elegance of mathematics expressed in a visual art form. See `http://www.ams.org/mathimagery/thumbnails.php?album=22`.



"Wave (32)", by Goran Konjevod, 2006.

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

Deaths of AMS Members

VLADO CIGIC, professor, Strojarski Fakultet, Bosnia-Herzegovina, died on November 22, 2008. Born on August 21, 1946, he was a member of the Society for 7 years.

KARL WALTER GRUENBERG, professor, Queen Mary University of London, died on October 10, 2007. Born on June 3, 1928, he was a member of the Society for 50 years.

JOHN R. KUCHER, from Quincy, MA, died on July 28, 2008. Born on September 28, 1946, he was a member of the Society for one year.

JACK LORELL, professor, Caltech, died on March 13, 2008. Born on October 7, 1916, he was a member of the Society for 68 years.

CHARLES E. RICKART, from North Branford, CT, died on April 17, 2002. Born on June 28, 1913, he was a member of the Society for 63 years.

ANDREW J. TERZUOLI, from Brooklyn, NY, died on January 23, 2008. Born on October 5, 1914, he was a member of the Society for 60 years.

EUGENE R. TOMER, from San Francisco, CA, died on July 2, 2007. Born on June 15, 1932, he was a member of the Society for 47 years.

BENNIE B. WILLIAMS, University of Texas at Arlington, died on September 9, 2007. Born on January 16, 1922, he was a member of the Society for 40 years.

RHODA WOOD, from Pasadena, CA, died on June 22, 2006. Born on July 2, 1912, she was a member of the Society for 67 years.

Reference and Book List

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

Contacting the *Notices*

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

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

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

Information for *Notices* Authors

The *Notices* welcomes unsolicited articles for consideration for publication, as well as proposals for such articles. The following provides general guidelines for writing *Notices* articles and preparing them for submission.

***Notices* readership.** The *Notices* goes to about 30,000 subscribers worldwide, of whom about 20,000 are in North America. Approximately 8,000 of the 20,000 in North America are graduate students who have completed at least one year of graduate school. All readers may be assumed to be interested in mathematics research, but they are not all active researchers.

***Notices* feature articles.** Feature articles may address mathematics,

Where to Find It

A brief index to information that appears in this and previous issues of the *Notices*.

mathematical news and developments, mathematics history, issues affecting the profession, mathematics education at any level, the AMS and its activities, and other such topics of interest to *Notices* readers. Each article is expected to have a large target audience of readers, perhaps 5,000 of the 30,000 subscribers. Authors must therefore write their articles for nonexperts rather than for experts or would-be experts. In particular, the mathematics articles in the *Notices* are expository. The language of the *Notices* is English.

Most feature articles, including those on mathematics, are expected to be of long-term value and should be written as such. Ideally each article should put its topic in a context, providing some history and other orientation for the reader and, as necessary, relating the subject matter to things that readers are likely to understand. In most cases, articles should progress to dealing with contemporary matters, not giving only historical material. The articles that are received best by readers tend to relate different areas of mathematics to each other.

By design the *Notices* is partly magazine and partly journal, and authors' expository styles should take this into account. For example, many readers want to understand the mathematics articles without undue effort and without consulting other sources.

Mathematics feature articles in the *Notices* are normally six to nine pages, sometimes a little longer. Shorter articles are more likely to be read fully than are longer articles. The first page is 400 or 500 words, and subsequent pages are about 800 words. From this one should subtract an allowance for figures, photos, and other illustrations, and an appropriate allowance for any displayed equations and any bibliography.

Form of articles. Except with very short articles, authors are encouraged to use section headings and subsection headings to help orient readers. Normally there is no section heading at the beginning of an article. Despite the encouraged use of internal headings, the assigning of numbers to sections and subsections is not permitted in any article.

The bibliography should be kept short. In the case of mathematics articles, bibliographies are normally limited to about ten items and should consist primarily of entries like books in which one may do further reading. To help readers who might want lists of recent literature, an author might include a small number of recent publications with good bibliographies.

Editing process. Most articles that are destined to be accepted undergo an intensive editing process. The purposes of this process are to ensure that the target audience is as large as practicable, that the content of the article is clear and unambiguous, and that the article is relatively easy to read. Usually it is the members of the editorial board who are involved in this process. Sometimes outside referees are consulted.

Preparation of articles for submission. The preferred form for submitted articles is as electronic files. Authors who cannot send articles electronically may send the articles by fax or by postal mail.

Articles with a significant number of mathematical symbols are best prepared in TEX, LATEX, or $\mathcal{A}\mathcal{M}\mathcal{S}$-TEX. There is no style file for distribution to authors, but upon request, the editor can make available a simple TEX header that simulates the *Notices* two-column format. Since the *Notices* is set in narrow columns, keeping displayed formulas relatively short helps to minimize adjustments during the production process; avoiding nonstandard supplementary files and complex sequences of definitions also helps. For the handling of figures and other illustrations, please consult the editor.

Articles without a significant number of mathematical symbols may be prepared as text files or in Microsoft Word. In the case of files prepared in Microsoft Word, it is advisable to send both the source Word file and a PDF.

Instructions for Authors of "WHAT IS…?" Columns

The purpose of the "WHAT IS…?" column is to provide brief, nontechnical descriptions of mathematical objects in use in current research. The target audience for the columns is first-year graduate students.

Each "WHAT IS…?" column provides an expository description of a single mathematical object being used in contemporary research. Thus "WHAT IS M-Theory?" would be too broad, but "WHAT IS a Brane?" would be appropriate; ideally, "WHAT IS a Brane?" would give a flavor of what M-theory is.

The writing should be nontechnical and informal. The level should be a little higher than the level of popular articles about mathematical developments one finds in magazines like *Science* that are aimed at a general audience.

"WHAT IS…?" columns should be no more than two *Notices* pages (1,400 words with no picture, or 1,200 words with one picture). A list of "Further Reading" should contain no more than three references.

Inquiries and comments about the "WHAT IS…?" column are welcome and may be sent to `notices-whatis@ams.org`.

Upcoming Deadlines

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

July 1, 2009: Nominations for Dannie Heineman Prize for Mathematical Physics. See "Mathematics Opportunities" in this issue.

July 31, 2009: Nominations for ICTP Ramanujan Prize. See "Mathematics Opportunities" in this issue.

August 4, 2009: Letters of intent for NSF Project ADVANCE Institutional Transformation (IT) and Institutional Transformation Catalyst (IT-Catalyst) awards. See `http://www.nsf.gov/pubs/2009/nsf09504/nsf09504.htm`.

August 4, 2009: Full proposals (by invitation only) for NSF Partnerships for International Research and Education (PIRE). See `http://www.nsf.gov/pubs/2009/nsf09505/nsf09505.htm`.

August 15, 2009: Nominations for SASTRA Ramanujan Prize. See "Mathematics Opportunities" in this issue.

August 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.

September 14, 2009: Full proposals for NSF Integrative Graduate Education and Research Training (IGERT). See http://www.nsf.gov/pubs/2009/nsf09519/nsf09519.htm.

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

October 15, 2009: Nominations for Emanuel and Carol Parzen Prize for Statistical Innovation. See "Mathematics Opportunities" in this issue.

October 21, 2009: Proposals for NSF Postdoctoral Research Fellowships. See http://www.nsf.gov/pubs/2008/nsf08582/nsf08582.htm.

November 1, 2009: Nominations for Vasil Popov Prize. See "Mathematics Opportunities" in this issue.

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

November 12, 2009: Full proposals for NSF Project ADVANCE Institutional Transformation (IT) and Institutional Transformation Catalyst (IT-Catalyst) awards. See 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.

New Journals for 2008

Below is a list of mathematical journals appearing for the first time in 2008 as compiled by *Mathematical Reviews*. This list, as well as the listings for new journals for other years, can be found on the Web at http://www.ams.org/mathweb/mi-newjs.html.

European Journal of Pure and Applied Mathematics. ISSN 1307-5543. Electronic, quarterly. Istanbul, Turkey. Launched January 2008.

Journal of Topology. ISSN 1753-8416. London Mathematical Society, London, UK. US$581 for 4 issues (print and online)/yr. (Free online in its first year.) Launched in 2008.

Tbilisi Mathematical Journal. E-ISSN 1512-0139. National Centre for Science and Technology, Tbilisi, Georgia and Amsterdam University Press. €85 print and online, €20 online only. Launched in 2008.

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.

An Abundance of Katherines, by John Green. Dutton Juvenile Books, September 2006. ISBN-13:978-0-5254-7688-7. (Reviewed October 2008.)

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 Archimedes Codex: How a Medieval Prayer Book Is Revealing the True Genius of Antiquity's Greatest Scientist, by Reviel Netz and William Noel. Da Capo Press, October 2007. ISBN 978-03068-1580-5. (Reviewed September 2008.)

The Best of All Possible Worlds: Mathematics and Destiny, by Ivar Ekeland. University Of Chicago Press, October 2006. ISBN-13: 978-0-226-19994-8. (Reviewed March 2009.)

The Book of Numbers: The Secret of Numbers and How They Changed the World, by Peter J. Bentley. Firefly Books, February 2008. ISBN-13: 978-15540-736-10.

The Calculus Wars: Newton, Leibniz, and the Greatest Mathematical Clash of All Time, by Jason Socrates Bardi. Thunder's Mouth Press, April 2007. ISBN-13: 978-15602-5992-3. (Reviewed May 2009.)

The Cat in Numberland, by Ivar Ekeland. Cricket Books, April 2006. ISBN-13: 978-0-812-62744-2. (Reviewed January 2009.)

Crossing the Equal Sign, by Marion D. Cohen. Plain View Press, January 2007. ISBN-13: 978-18913-866-95.

**Crocheting Adventures with Hyperbolic Planes*, by Daina Taimina. A K Peters, March 2009. ISBN-13: 978-15688-145-20.

Digital Dice, by Paul J. Nahin. Princeton University Press, March 2008. ISBN-13: 978-06911-269-82.

Dimensions, by Jos Leys, Etienne Ghys, and Aurélien Alvarez. DVD, 117 minutes. Available at http://www.dimensions-math.org.

The Drunkard's Walk: How Randomness Rules Our Lives, by Leonard Mlodinow. Pantheon, May 2008. ISBN-13: 978-03754-240-45.

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.

Euclidean and Non-Euclidean Geometries: Development and History, fourth revised and expanded edition, by Marvin Jay Greenberg. W. H. Freeman, September 2007. ISBN-13: 978-0-7167-9948-1.

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.

Fifty Mathematical Ideas You Really Need to Know, by Tony Crilly. Quercus, 2007. ISBN-13: 978-18472-400-88.

Fighting Terror Online: The Convergence of Security, Technology and the Law, by Martin Charles Golumbic. Springer, 2008. ISBN: 978-0-387-73577-1.

Five-Minute Mathematics, by Ehrhard Behrends (translated by David Kramer). AMS, May 2008. ISBN-13: 978-08218-434-82.

Geekspeak: How Life + Mathematics = Happiness, by Graham Tattersall. Collins, September 2008. ISBN-13: 978-00616-292-42.

Geometric Folding Algorithms: Linkages, Origami, Polyhedra, by Erik D. Demaine and Joseph O'Rourke. Cambridge University Press, July 2007. ISBN-13: 978-05218-57574.

Geometric Origami, by Robert Geretschläger. Arbelos, October 2008. ISBN-13: 978-09555-477-13.

The Golden Section: Nature's Greatest Secret (Wooden Books), by Scott Olsen. Walker and Company, October 2006. ISBN-13: 978-08027-153-95.

Group Theory in the Bedroom, and Other Mathematical Diversions, by Brian Hayes. Hill and Wang, April 2008. ISBN-13: 978-08090-521-96. (Reviewed February 2009.)

Guesstimation: Solving the World's Problems on the Back of a Cocktail Napkin, by Lawrence Weinstein and John A. Adam. Princeton University Press, April 2008. ISBN-13: 978-0-6911-2949-5.

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 Math Explains the World: A Guide to the Power of Numbers, from Car Repair to Modern Physics, by James D. Stein. Collins, April 2008. ISBN-13: 978-00612-417-65.

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.

Impossible?: Surprising Solutions to Counterintuitive Conundrums, by Julian Havil. Princeton University Press, April 2008. ISBN-13: 978-0-6911-3131-3.

The Indian Clerk, by David Leavitt. Bloomsbury USA, September 2007. ISBN-13: 978-15969-1040-9. (Reviewed September 2008.)

Irreligion: A Mathematician Explains Why the Arguments for God Just Don't Add Up, by John Allen Paulos. Hill and Wang, December 2007. ISBN-13: 978-0-8090-591-95. (Reviewed August 2008.)

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.

Lewis Carroll in Numberland: His Fantastical Mathematical Logical Life: An Agony in Eight Fits, by Robin Wilson. W. W. Norton & Company, ISBN-13: 978-03930-602-70.

Logic's Lost Genius: The Life of Gerhard Gentzen, by Eckart Menzler-Trott, Craig Smorynski (translator), Edward R. Griffor (translator). AMS-LMS, November 2007. ISBN-13: 978-0-8218-3550-0.

The Map of My Life, by Goro Shimura. Springer, September 2008. ISBN-13: 978-03877-971-44.

Mathematical Omnibus: Thirty Lectures on Classic Mathematics, by Dmitry Fuchs and Serge Tabachnikov. AMS, October 2007. ISBN-13: 978-08218-431-61. (Reviewed December 2008).

The Mathematician's Brain, by David Ruelle. Princeton University Press, July 2007. ISBN-13 978-0-691-12982-2. (Reviewed November 2008.)

**Mathematicians of the World, 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 and Common Sense: A Case of Creative Tension, by Philip J. Davis. A K Peters, October 2006. ISBN 1-568-81270-1. (Reviewed in this issue.)

Mathematics and Democracy: Designing Better Voting and Fair-Division Procedures, by Steven J. Brams. Princeton University Press, December 2007. ISBN-13: 978-0691-1332-01.

Mathematics at Berkeley: A History, by Calvin C. Moore. A K Peters, February 2007. ISBN-13: 978-1-5688-1302-8. (Reviewed November 2008.)

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. ISBN13: 978-06910-918-22.

Mathematics in India, by Kim Plofker. Princeton University Press, January 2009. ISBN-13: 978-06911-206-76.

The Mathematics of Egypt, Mesopotamia, China, India, and Islam: A Sourcebook, by Victor J. Katz et al. Princeton University Press, July 2007. ISBN-13: 978-0-6911-2745-3.

More Mathematical Astronomy Morsels, by Jean Meeus. Willmann-Bell, 2002. ISBN 0-943396743.

Number and Numbers, by Alain Badiou. Polity, June 2008. ISBN-13: 978-07456-387-82.

The Numbers Behind NUMB3RS: Solving Crime with Mathematics, by Keith Devlin and Gary Lorden. Plume, August 2007. ISBN-13: 978-04522-8857-7. (Reviewed March 2009.)

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.

One to Nine: The Inner Life of Numbers, by Andrew Hodges. W. W. Norton, May 2008. ISBN-13: 978-03930-664-18.

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, to appear April 2009. ISBN-13: 978-07710-169-67.

Out of the Labyrinth: Setting Mathematics Free, by Robert Kaplan and Ellen Kaplan. Oxford University Press, January 2007. ISBN-13: 978-0-19514-744-5. (Reviewed in this issue.)

A Passion for Discovery, by Peter Freund. World Scientific, August 2007. ISBN-13: 978-9-8127-7214-5.

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.

Professor Stewart's Cabinet of Mathematical Curiosities, by Ian Stewart. Basic Books, December 2008. ISBN-13: 978-0-465-01302-9.

Pursuit of Genius: Flexner, Einstein, and the Early Faculty at the Institute for Advanced Study, by Steve Batterson. A K Peters, June 2006. ISBN 1-56881-259-0. (Reviewed August 2008.)

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.

Reminiscences of a Statistician: The Company I Kept, by Erich Lehmann. Springer, November 2007. ISBN-13: 978-0-387-71596-4.

Rock, Paper, Scissors: Game Theory in Everyday Life, by Len Fisher. Basic Books, November 2008. ISBN-13: 978-04650-093-81.

Roots to Research: A Vertical Development of Mathematical Problems, by Judith D. Sally and Paul J. Sally Jr. AMS, November 2007. ISBN-13: 978-08218-440-38. (Reviewed December 2008.)

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.

Super Crunchers: Why Thinking-by-Numbers Is the New Way to Be Smart, by Ian Ayres. Bantam, August 2007. ISBN-13: 978-05538-054-06. (Reviewed April 2009.)

Symmetry: The Ordering Principle (Wooden Books), by David Wade. Walker and Company, October 2006. ISBN-13: 978-08027-153-88.

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.

The Wraparound Universe, by Jean-Pierre Luminet. A K Peters, March 2008. ISBN 978-15688-130-97. (Reviewed December 2008.)

Zeno's Paradox: Unraveling the Ancient Mystery behind the Science of Space and Time, by Joseph Mazur. Plume, March 2008 (reprint edition). ISBN-13: 978-0-4522-8917-8.

From the AMS Secretary

Report of the AMS First-Year Task Force

James Lewis and Alan Tucker

Introduction

What grade has your department earned this year for that portion of its mission that is focused on teaching? More specifically, what grade would you give your department for its pursuit of excellence in teaching first-year students?

The first-year experience for collegiate mathematics instruction comprises the greatest part of the teaching and student contact for a typical mathematics department. Success with this mission thus plays a large role in the perceptions of university administrators and of students regarding mathematics, mathematicians, and their institution's mathematics department. Does your institution view your department as a pump or a filter?

First-year mathematics instruction at research universities. The AMS report, *Towards Excellence*, argues: "To ensure their institution's commitment to excellence in mathematics research, doctoral departments must pursue excellence in their instructional programs." Of special importance is the teaching and learning of mathematics in first-year mathematics courses. For many students, the only mathematics they study in college is at the freshman level. For others, the lack of success in freshman level courses serves as a barrier to mathematical-based careers in science, engineering, economics, teaching, etc. Because mathematics education plays a critical and growing role in our society, more than ever it is essential that mathematics departments pursue excellence in freshman-level mathematics.

Mathematics departments whose mission places a heavy emphasis on research and graduate education often face unique challenges in ensuring the quality of freshman mathematics instruction while maintaining the department's commitment to research and graduate education. This can be an especially difficult challenge in large state universities. According to *Towards Excellence*, public doctoral-granting departments report that over 60% of their course registrations are in first-year calculus, precalculus, or remedial courses. Combining this with some share of the instruction classified as "other undergraduate courses", i.e., courses for nonmajors, it is reasonable to estimate that over two-thirds of the mathematics instruction in these departments is at the first-year level.

Task Force charge. Concern for this issue led AMS President James Glimm to appoint the AMS Task Force on the First-Year Mathematics Experience and to charge it to:

- Identify the most significant challenges departments face as they pursue excellence in freshman mathematics instruction.
- Collect and analyze information about the diverse strategies doctoral mathematics departments are using to respond to these challenges.
- Produce a report for use by mathematics departments and university administrations with recommendations for maximizing the effectiveness of freshman mathematics instruction while maintaining their commitment to mathematics research and doctoral education.

The charge to the task force was to examine changes which can yield an improvement in such matters. Consistent with the views expressed in *Towards Excellence*, we believe that this can be done in ways that contribute to a department's research and doctoral education programs. Thus, in so far as is practical, the task force was asked to identify those steps which promise

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significant improvement while being relatively easy or practical to implement.

Factors in students' success. Of course it is very difficult to seek significant improvement in any area if one does not have a fairly clear image of what constitutes achievement at a high level. So let us pose a hypothetical question. Suppose you randomly choose a class (e.g., calculus, college algebra, etc.) that is taken largely by first-year students. Perhaps you are the instructor. Perhaps the course is taught by a colleague, a graduate student, or a lecturer hired by your institution. The students in this class have met your institution's admission requirements and have either passed a prerequisite course or have "placed" into the course based on your institution's placement test. If the instructor does a good job teaching the course, what percent of the students who start the course will complete it with a grade of C or better?

If you are anything like our friends and colleagues, you are reluctant to offer an answer to this question. You hasten to point out that "it depends." You explain that students at your university are often unprepared for the expectations of a college mathematics class, even though your institution has decided that your students meet the prerequisites for the course. You explain that many students don't come to class regularly and even those who do attend don't do enough hard work to learn the material.

To some degree, this is all true. But if this argument is presented to someone in your university administration, it will be heard as if you are arguing that the instructor is the only constant in this equation. They will interpret your comments as implying that the instructor's ability as a teacher, the energy and effort (s)he puts into teaching the course, and the pedagogical approach used to teach the class are, at most, unimportant variables. Such an argument is unlikely to be successful in an institution that is concerned with its "freshmen retention rate" or one that enters the conversation suspecting that their mathematics department devotes insufficient attention to its undergraduate teaching mission.

Low passing rates are a serious problem for departments. At a recent meeting of the AMS Committee on Education (CoE), several participants commented on their institution's "success rate", the percent of students initially enrolled in a course who complete it with a grade of C or better, in college algebra and calculus. The figure 70% was mentioned as the success rate in college algebra at several state universities, but we also heard of places where the success rate is in the mid-60s or mid-50s. At the same time, some university representatives indicated that they were criticized by their university administration because their success rate was not higher. Few parents would agree to send their children to universities if they knew the chance for success was so low and few state legislatures would willingly support a mathematics department that was producing such results. At least one person at the CoE meeting indicated that their department had a success rate in the range of 75%–80% in Calculus I. We suspect that many departments would be quite pleased if they could increase their success in calculus to this level.

We offer our congratulations to those mathematics departments that have already focused attention on first-year instruction and have achieved the significant improvement necessary to make their department an institutional showcase for excellence in teaching first-year students. We believe that many more departments will enhance their standing in their universities and be more successful at competing for university resources if they are able to achieve similar success in teaching first-year students. And, we stress that departments should seek to do this without diminishing their commitment to research and graduate education. Thus, our suggestions emphasize approaches that should be relatively easy or practical to implement but which have the potential to yield significant improvement.

Task Force focus. Taking a "first things first" approach to our pursuit of excellence in first-year instruction, we wish to advance three areas in this report that we believe merit a department's initial attention. Depending on the environment at your institution, you may choose different actions around which to focus your efforts. Our suggestions are:

- Harness the power of technology to improve teaching and learning;
- Leadership matters—success in this area depends upon the value assigned to it by a department's leadership;
- Invest in teaching graduate students to be good teachers.

Web-based Assessment and Testing Systems (WATS)

In this section, we discuss technology for faculty to help grade homework and tests. A growing number of mathematics departments are now using such technology. Historically such technology was limited to grading multi-choice answers entered as darkened spaces on a machine-readable answer sheet. A more modern example is the MAA Mathematics Placement Test software that uses Maple to check answers. One of the charges of this Task Force was to make recommendations to mathematics departments regarding this technology.

In this section we summarize a Rutgers study that makes a strong case for the value of homework software. Then we discuss the three best-known Web-based Assessment and Testing Systems (WATS) for college mathematics courses,

MapleTA, WebAssign, and WeBWorK. Publishers are beginning to offer Internet-based homework grading options with some textbooks. In particular, Pearson, which owns Prentice-Hall and Addison-Wesley, is now linking many of its low-level college mathematics textbooks with MyMathLab software. Departments should ask about such options when selecting new textbooks. There are two related uses of technology in instruction that will not be discussed here. For courses below calculus, there exist a growing number of programs that provide sophisticated personalized tutoring. To allow interaction with students in a large lecture, some universities have installed small response units at each seat in a classroom with which students can respond to questions posed by the lecturer.

Overview of WATS. The new wave of WATS software accepts as responses expressions in one or more variables. These systems raise the possibility that much of the homework and tests in an introductory mathematics course might be generated and graded by such software. Tests need to be taken in supervised computer classrooms, but homework can be done on the Internet from anywhere. The most widely used mathematics WATS software is free; some of the others require students to pay most of the costs.

It is universally agreed that one learns mathematics by doing mathematics. Homework is the primary venue where students do mathematics. However, many universities lack the resources to grade student homework in large introductory courses. A fallback strategy is to assign homework but not grade it; instead, a weekly quiz on the homework will hopefully motivate students to do the homework. Homework software has the potential to handle the grading of homework at a low cost. While this software has the limitation of requiring a concise answer—an algebraic expression or a multiple-choice response—it also has an important advantage over hand grading. Namely, if a student's answer to a problem is wrong, the student learns of the mistake immediately and can be allowed to try the problem or a similar problem repeatedly until the right answer is obtained. One would expect students would try harder and put more time into their mathematics homework when they get such immediate feedback and are allowed multiple attempts. This should result in better learning. A Rutgers study, cited below, documents this effect.

In the 1970s there was considerable interest in an instructional strategy, often called the Keller Plan, where students could re-take unit tests until they demonstrated "proficiency", say, a score of 70%. The effort required to grade so many tests led to the demise of most such efforts. WATS software makes this mode of testing possible again. For example, such proficiency tests, often called "gateway" tests, can be used to check computational skills, such as the product, quotient, and chain rules in differential calculus, which students are supposed to learn largely on their own, freeing up class time to focus on concepts and applications.

A critical hurdle to the use of WATS software is the substantial effort required by faculty to learn to use it and by a department's computer experts (faculty or staff) to master the installation and maintenance of the software on a server, if the WATS is not run in a server maintained by the software provider. Because of this hurdle and because grading software is relatively new, most mathematics departments have been reluctant to be one of the pioneers to install and use such software.

With the growing use of such software, the Task Force believes that the time has come for all mathematics departments to consider adopting WATS software, especially in large first-year courses where there is often a heavy emphasis on computational skills.

Whether or not the high cost of hand grading is an issue, the immediate feedback from WATS-based homework offers important benefits over hand grading or worse, ungraded homework.

Evidence of improved learning with WATS. We will cite one study with a homework grading system that was undertaken in a calculus course at Rutgers. The situation at Rutgers, where homework had been hand graded, counting for 15% of the course grade, is typical of many freshmen calculus courses. The Rutgers study is available online (C. Weibel and L. Hirsch, 2002, "WeBWorK Effectiveness in Rutgers Calculus", `http://www.math.rutgers.edu/~weibel/webwork.html`).

Rutgers used WeBWorK, a homework-oriented WATS that randomly varies parameters in template problems to create individualized homework sets for each student. If a wrong answer is entered, students can typically re-try a problem as many times as they want up to the deadline for homework submission. In fall 2001 Rutgers's non-science calculus course with 1,300 students started using WeBWorK homework assignments in randomly selected subsets of sections that enrolled 940 students; WeBWorK sections also had several (about eight) word problems, graded by hand, each week. There were quizzes, two common mid-terms, and a common final exam. The study looked at how students' WeBWorK scores correlated with their performances on the final exam. For the purposes of the study, students in all sections were divided into three categories:

I. First-year students,

II. Other non-repeaters (sophomores or higher, taking the course for the first time),

III. Repeaters.

Given the focus of the Task Force, we shall give most attention to first-year students (group I). The average final exam score in WebWorK sections was

slightly better than non-WeBWorK sections in this group, but no group showed a significant difference. However, there was a dramatic bifurcation of grades within WeBWorK sections based on how many WeBWorK exercises students attempted. It was convenient to compare the following two categories (omitting the middle 30%):

a) First-year students who scored 80% or more on the WeBWorK problems; or

b) First-year students who scored less than 50% on the WeBWorK exercises.

Most first-year students (70%) were in category a). Along with good work habits, there is also the likely interpretation for this behavior that once students got engaged in doing some of the problems, they kept on working at them. The average final exam grade in category a) was B+, while the average final exam grade in category b) was C. Remember that WeBWorK was only part—albeit the larger part—of the weekly homework assignments.

A skeptic may question the true impact of doing WeBWorK assignments: smarter students probably are in the habit of doing homework. The Rutgers study tried to account for this effect by using its precalculus-based placement exam scores which had been shown to be significantly correlated with calculus grades. This conditioning actually increased the impact of WeBWorK. For a given score on the precalculus placement exam, a student in category a) had almost a two-letter higher grade on the final exam than a student in category b): B+ versus C-.

When an analysis of variance was performed on final exam grades in WeBWorK sections, the WeBWorK homework score was the most significant predictor of performance, outweighing the placement test score, SAT scores, or high-school rank. While all these factors are mutually correlated, it is still very surprising that the WeBWorK score had higher influence on the final exam performance than measures of innate ability and high-school performance. This finding sends the heartening message that if students try hard in calculus they can do better than traditional indicators for incoming student performance would predict.

The Rutgers study found a very high probability that if a student attempted a WeBWorK problem once then the student would keep working the problem until it was correctly answered. Other studies of homework software have, not unexpectedly, found that same high probability of persistence. Also, one large survey of students found that they self-reported greater effort put into WeBWorK assignments than with hand-graded homework in similar courses (see the survey paper (V. Roth, V. Ivanchenko, and N. Record, 2007, "Evaluating Student Response in WeBWorK", *Computers and Education*, Elsevier, New York, to appear)).

In sum, this Rutgers study strongly confirms one's common sense that students get more out of homework when they get instant feedback if their answers are wrong—they work at the problems longer and they learn more in a course from this effort.

Three WATS for College Mathematics Courses

WeBWorK. WebWorK was designed to be used for homework but now has gateway test capability also. It was developed by Michael Gage and Arnold Pizer, mathematics faculty at the University of Rochester, for use in their big single-variable calculus course. WeBWorK is the only WATS that is free, with open-source code that has been refined by many users. It appears to be the most widely used WATS in calculus courses, with over 100,000 students a year. Problem banks have been developed for other courses. Several major public research universities now use WeBWorK in one of their calculus courses, including Arizona, Indiana, Michigan, Rutgers, Stony Brook, and Virginia. It has an active users group that is closely associated with the Mathematical Association of America.

As noted above, WeBWorK randomly varies constants in a set of template problems to create individualized homework sets for each student. The template problems come from problem banks that users have developed and deposited at the WeBWorK website, supplemented by problems made up by the instructor. Students can re-try an incorrectly answered problem as many times as the instructor specifies.

One of the nice aspects of WeBWorK is that an instructor can modify a problem that students are currently working on to clarify the problem's wording or give a hint. Or the instructor can add prompts for answers at intermediate stages in a multi-step problem to allow students to check that they have these intermediate steps correct. In other WATS, an instructor can create problems but no modifications are possible once students start working problems. While WeBWorK has a user interface for building homework sets, there is none for creating problems. Problems are written in PERL, which is a fairly intuitive language, so that it is possible to modify an existing problem in the ways just mentioned without knowing anything about Perl programming.

WeBWorK checks expressions entered by students by comparing their values at randomly chosen points, typically 4 points between 0 and 1, with the comparable values of the correct expressions. Thus, WeBWorK has no problem with multiple ways of expressing an answer. However, if a specified simplification of an expression is desired, as is often the case in college algebra and precalculus courses, WeBWorK cannot be used.

MapleTA. MapleTA started as eGrade, a WATS developed by John Orr of the University of Nebraska Mathematics Department to generate

questions for gateway tests that students took in supervised computer labs to validate computational skills in calculus, such as standard differentiation and integration techniques. MapleTA offers two ways to randomize problems: i) randomizing parameters in template problems, like WeBWorK, or ii) randomly selecting problems from banks of individually created problems of desired types. In mode ii), if a student gets a problem wrong, (s)he normally gets another problem from the given problem bank rather than the same problem to re-try.

MapleTA permits a very powerful multi-part question which lets one create free-form questions that mix formula, number, multiple-choice, etc. elements in a longer exercise. Because Maple TA grades expressions with the Maple engine, it works well in college algebra and precalculus courses where exercises often ask students to re-write or simplify an expression. Also, Maple enables one to ask more imaginative questions along the lines of "give an example of a function that is concave upward and decreasing on [0,5]," because one can write Maple scripts to check complex criteria.

MapleTA, as the name implies, is now a product of Maplesoft, the company that sells and supports Maple, the popular mathematical software package. A department can either buy a license to run the MapleTA WATS on its own server or use a Maplesoft server, with the cost shared in the latter case by the students and the department. While MapleTA is not as widely used as WebWorK among mathematics departments, it is being used in many other scientific disciplines. The MAA Math Placement Test uses Maple. The strengths of MapleTA listed above along with MapleTA's Maple affiliation make it likely that institution-wide MapleTA adoptions may become common, making it easier and less costly for a mathematics department to use MapleTA. MapleTA has a good user interface for creating problems and building homework sets. There are a number of special features such as links with the Blackboard course administration software and a LaTeX converter.

WebAssign. WebAssign was created by faculty at North Carolina State University. A private company now owns WebAssign. Students and faculty log onto the company's servers to use WebAssign. It claims to have been used by about 800,000 students. Like WeBWorK, it is designed just for homework assignments but it has more extras like tutorials and simulations for students, and good homework record-keeping for teachers. Like MapleTA, it has good user interfaces for creating problems and building homework sets and is used in many scientific disciplines besides mathematics. Indeed, most of its users appear to be in the physical sciences. However, some major mathematics departments use it; for example, the University of Arizona and the University of Maryland use WebAssign in a range of freshman mathematics courses. Fees are paid only by the students.

The AMS has submitted a proposal to NSF to survey mathematics departments about the experience with computer homework software and, for departments not using it, about the level of interest in it.

Departmental Leadership

We are proposing here a role for departmental leadership in improving the quality of mathematics teaching. Departmental leadership is the ability to influence the culture of a department. Typically, department leaders, working with the support of senior faculty, determine the departmental culture.

Value teaching. We believe that a culture which values successful teaching will often be rewarded in tangible and intangible ways by the university administration. Conversely, a department with poor performance may suffer as a consequence. Standards for accountability are increasing across many areas of academic life. These include teaching outcomes, student performance, and student retention. We cite comments from John Marburger, the former Science Advisor to the President, that "In most institutions the engineering departments have little control over how the math and science courses are taught…there needs to be an effective stakeholder input to these service courses" (comments at the 2005 National Science Board conference, "The Engineering of 2020"). Our remarks are directed primarily toward the environment of a research teaching faculty. For this reason, we avoid suggestions which would impede the research productivity of the faculty.

Concern for teaching when hiring. The first recommendation is to pay attention to teaching ability during hiring, tenure, and promotion decisions. Usually good teaching is highly correlated with an open personality and an interest in communicating. Since we are referring to broad distinctions in teaching talent, these distinctions are usually obvious or can be readily ascertained.

Assessment of teaching. Assessment of teacher performance and student satisfaction is our second recommendation. Most universities require such assessments based on student evaluations. The question is, what to do with them? They are a useful tool if used wisely, but potentially pernicious otherwise. What constitutes wise usage? First of all, the data needs to be used sparingly, for example to identify outliers, both positive and negative, and not to make fine distinctions. Secondly, the data needs to be correlated with other, more qualitative measures of teacher performance, such as anomalies in grading practices, student drop rates compared to other classes, attendance (the fraction of enrolled students returning the questionnaire), and student complaints. Usually the outliers, both positive and negative, are more

or less obvious to most department members, and the student evaluations serve to provide a measure of what may already be commonly realized.

When confirmed by other information about teaching, weak teaching evaluations can be used as a tangible basis by department leaders to talk with individual faculty about their teaching. While faculty may disparage student evaluations, junior faculty know that college tenure committees take these evaluations very seriously and tenured faculty know that university administrators take these evaluations into account when dealing with the mathematics departments on budget and hiring decisions. Thus, tenured faculty can be asked to be more sensitive to their teaching evaluations for the sake of the department's standing with the university administration.

Reward good teaching. For the excellent teachers, student evaluations, when confirmed by other information about teaching, can be the basis for rewards for good teaching. Nonfinancial rewards can be very useful, such as personal thanks from the chair or other departmental leaders; public notice, such as a list of the outstanding teachers of the semester displayed in the tea room; or announcements in faculty meetings.

In summary, a culture which values quality teaching can be nurtured by departmental leadership. If maintained consistently over time, this culture can support simple but effective methods to improve the level of student satisfaction by measurable amounts, with positive consequences for relations with the rest of the university, not to mention recruitment of students into the department's major or upper division courses.

TA Training

Forty-two years ago as a graduate student assigned to teach his first course, I (Lewis) was given a class roster and a textbook, and I was told the time and room number where the course was offered. Like many mathematics graduate students before me, and I am sure at least a few who came after me, I learned to teach on the job and on my own. There was no "TA Training" and there was no supervision of the job I did teaching that group of students. Whether this was ever acceptable is debatable, but surely it is not acceptable today. And, hopefully, it is quite rare.

There are two important reasons for a mathematics department to make it a priority to prepare graduate students to be successful teachers. First, it is in our self-interest. Many of our departments support our graduate program by employing graduate students as teaching assistants. While some departments restrict the use of teaching assistants as recitation section leaders and paper graders, there are departments where over one-third of a department's instruction is provided by graduate students who have full responsibility for their own classes. Because courses taught by graduate students are overwhelmingly at the freshman level, a much higher percentage of first-year courses are taught by graduate students. If our institution loses faith in our ability to provide quality mathematics instruction while making significant use of graduate teaching assistants, we may see a shift of instructional dollars to the use of lecturers or other teaching faculty. Without the ability to support graduate students as teachers, many of us would see our graduate program shrink significantly.

Second, it is in our graduate students' self-interest. Scan the job announcements in any issue of the *Notices* and one learns that the vast majority of academic position announcements stress the importance of the successful candidate's potential to be an outstanding teacher. Many job announcements specifically ask for a teaching statement, evidence of successful teaching experience, and indicate that one letter of reference should address teaching. Surely, we should consider efforts to help our graduate students learn to teach part of strengthening our graduate programs.

What follows is a checklist of ways that a department might invest in helping graduate students learn to teach. The suggestions are particularly appropriate for departments that make heavy use of graduate students as instructors in classes where they have complete authority.

TA orientation. Each department should offer an orientation for new teaching assistants prior to their initial teaching duties. A week-long program should offer sufficient time to introduce new graduate students to each other, the department, and to their teaching duties. This is an important opportunity for the department to communicate the importance it assigns to good performance in the classroom and to help new graduate students appreciate the need to balance their duties as a graduate student and their duties as a teaching assistant.

Super TA. Departments that use TAs to conduct recitation sections to supplement instruction offered using a large lecture format have an opportunity to use faculty lecturers to serve as teaching mentors for their recitation instructors. In addition, some departments identify an experienced and successful senior graduate student and make it part of their appointment as a TA to mentor new teaching assistants. The duties of such a position might include observing recitation sections taught by new TAs, offering feedback to the TAs, and providing feedback to the department about problems that TAs encounter but are reluctant to discuss directly with the faculty.

Careful supervision. Once graduate students are given their own class to teach, departments must make decisions as to how much independent authority the graduate student instructor should

have. Some departments report that for multi-section courses, exams are written by a course coordinator and that grading is done in group grading sessions so that more experienced graders can offer advice to those less experienced. We see this as indicative of the close supervision that can help with "on the job training" and can help a department offer students consistent grading across many sections of the same course.

Teaching seminar. One way that a department can help graduate students learn to teach is to offer a teaching seminar that graduate students take the first year that they teach their own courses. The seminar might be offered for graduate credit and an outstanding teacher in the department should be assigned to teach the seminar as part of her/his teaching duties for that semester. As part of the seminar, TAs can be offered help with a wide variety of issues from classroom management to creating a syllabus and writing exams. *Teaching Mathematics in Colleges and Universities: Case Studies for Today's Classroom*, by Solomon Friedberg et. al., and *You're the Professor, What Next?*, MAA Notes #35, edited by Bettye Anne Case, are valuable resources for use in such a seminar.

Teaching mentors. TA instructors normally have a supervising faculty member, typically the person in charge of the course in which the TA teaches. Such a supervisor should serve as a general teaching mentor as well as a course coordinator. Some departments assign each TA instructor a separate teaching mentor for the first year of classroom contact. Ideally, such a teaching mentor would be a faculty member who is recognized as an outstanding teacher and who is willing to work one-on-one with a graduate student, observing her/his teaching and offering advice as the graduate student grapples with the issues that we all face as teachers.

In addition to specific steps a department can take to help graduate students develop their ability to teach, the place that quality teaching occupies in the value system of a department will contribute significantly to the energy and effort that graduate students put into their teaching. Are outstanding teachers honored by the department? Does a graduate student risk a less attractive teaching assignment, a reduction in their appointment, or even the termination of their TA appointment if they do a poor job in the classroom? By making teaching a very public activity within our department, we will contribute to a culture that values teaching and in which everyone strives to improve.

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/ .

June 2009

1–3 **Second Global Conference on Power Control and Optimization (PCO-2009)**, Bali, Indonesia. (Jan. 2009, p. 71)

1–5 **2nd Chaotic Modeling and Simulation International Conference (CHAOS2009)**, MAICh Conference Center, Chania, Crete, Greece. (Dec. 2008, p. 1449)

* 1–5 **Affine Algebraic Geometry: A Conference in Honour of Peter Russell**, Centre de Recherches Mathématiques, Université de Montréal, Canada.
Description: This five-day conference will celebrate the contributions of Peter Russell to the area of affine algebraic geometry, as well as to problems in characteristic p geometry. It assembles participants working in such topics as algebraic group actions on affine spaces, the cancellation problem, embeddings of affine spaces and the theory of open surfaces. It will provide perspectives on the latest work in the area as well as directions for future work.
Information: `http://www.crm.umontreal.ca/Russellfest09/index_e.php`.

1–5 **Fifth Summer School in Analysis and Applied Mathematics**, Department of Mathematics, Sapienza, Universita' di Roma, Rome, Italy. (Feb. 2009, p. 309)

1–5 **Geometry & Topology at Muenster 2009**, University of Muenster, Muenster, Germany. (Jan. 2009, p. 71)

* 1–5 **Hypercyclicity and Chaos for Linear Operators and Semigroups**, Universidad Politecnica de Valencia, Valencia, Spain.
Description: Over the last two decades, the study of hypercyclicity and linear chaos has developed into a very active research area. In the past few years several long-standing problems have been solved, and a number of landmark results have been obtained. Our intention is to combine plenary and short talks about recent work and open problems in this highly active area. Contributions at the frontier of hypercyclicity are encouraged, especially semigroups of linear operators and their applications to PDEs.
Scientific Committee: R. Aron, J. Bès, K. Grosse-Erdmann, A. Peris.
Information: `http://www.hypercyclic.upv.es/`.

1–5 **i-MATH School on Derived Algebraic Geometry**, University Institute for Fundamental Physics and Mathematics (IUFFyM), University of Salamanca, Spain. (Apr. 2009, p. 521)

1–28 **Statistical Genomics**, Institute for Mathematical Sciences, National University of Singapore, Singapore. (Jan. 2009, p. 71)

1–October 31 **i-MATH Trimester on Derived Algebraic Geometry**, University Institute for Fundamental Physics and Mathematics (IUFFyM), University of Salamanca, Spain. (Apr. 2009, p. 521)

2–5 **Holomorphically symplectic varieties and moduli spaces**, Laboratoire Paul Painlevé at the University of Lille 1, Lille, France. (May 2009, p. 654)

2–6 **The 29th Great Planes Operator Theory Symposium (GPOTS 2009)**, Department of Mathematics, University of Colorado at Boulder, Colorado. (May 2009, p. 654)

3–5 **Conference on Character Theory of Finite Groups in honor of Martin Isaacs**, Universitat de Valencia, Spain. (Sept. 2008, p. 1031)

3–15 **Interactions Between Hyperbolic Geometry, Quantum Topology and Number Theory Workshop**, Columbia University, New York, New York. (Oct. 2008, p. 1134)

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/`.

4–6 **Lehigh University Geometry and Topology Conference**, Lehigh University, Bethlehem, Pennsylvania. (May 2009, p. 654)

7–12 **35th International Conference: Applications of Mathematics in Engineering and Economics (AMEE'09)**, The Black Sea resort of Sozopol, Bulgaria. (May 2009, p. 654)

8–11 **25th Nordic and 1st British-Nordic Congress of Mathematicians**, University of Oslo, Oslo, Norway. (Jan. 2009, p. 71)

8–11 **Analysis, Inequalities and Homogenization Theory (AIHT 2009)**, Lulea University of Technology, Lulea, Sweden. (May 2009, p. 654)

8–11 **MAMERN09: 3rd International Conference on Approximation Methods and Numerical Modeling in Environment and Natural Resources**, University of Pau, Pau, France. (Dec. 2008, p. 1449)

8–11 **The 2nd International Conference on Mathematical Modelling and Computation and The 5th East Asia SIAM Conference**, Universiti Brunei Darussalam, Bandar Seri Begawan, Brunei. (Feb. 2009, p. 309)

8–12 **Computational Methods and Function Theory 2009**, Bilkent University, Ankara, Turkey. (Jun./Jul. 2008, p. 742)

8–12 **Geometrie Algebrique en Liberte**, Lorents Center, Leiden, Netherlands. (Mar. 2009, p. 413)

8–12 **Recursion structures in topological string theory and enumerative geometry**, American Institute of Mathematics, Palo Alto, California. (Apr. 2009, p. 521)

* 8–12 **The U.S.-Asian Workshop on Random Dynamical Systems**, S.S. Chern Institute of Mathematics, Nankai University, Tianjin, China.
Information: `http://www.iit.edu/~duan/Nankai2009.htm`.

8–13 **Disordered Systems: Spin Glasses**, Centre de recherches mathématiques, Université de Montréal, Pavillon André-Aisenstadt, 2920, Chemin de la tour, 5th floor, Montréal, Québec, H3T 1J4, Canada. (Apr. 2009, p. 521)

8–13 **Workshop on Disordered Systems: Spin Glasses**, Centre de recherches mathématiques, Université de Montréal, Montréal, Québec, Canada. (Jan. 2008, p. 78)

8–19 **Geometry and Arithmetic around Galois Theory**, Galatasaray University, Istanbul, Turkey. (Dec. 2008, p. 1449)

8–19 **Recent Developments in Dynamic Equations on Time Scales**, University of Wyoming, Laramie, Wyoming. (Jan. 2009, p. 71)

10–12 (NEW DATE) **Sixth Advanced Course in Operator Theory and Complex Analysis**, Seville, Spain. (May 2009, p. 654)

11–13 **Representation Theory**, Institut de Recherche Mathématique Avancée, Université de Strasbourg, 7 rue René Descacrtes, Strasbourg, France. (Dec. 2008, p. 1449)

13–17 **Symposium on Biomathematics and Ecology Research and Education**, Izmir University of Economics, Izmir, Turkey. (Mar. 2009, p. 413)

14–18 **QTRF5 - Quantum Theory: Reconsideration of Foundations-5**, Vaxjo University, Vaxjo, Sweden. (Apr. 2009, p. 521)

* 14–19 **2009 USENIX Annual Technical Conference (USENIX '09)**, Town & Country Resort and Convention Center, 500 Hotel Circle, North San Diego, California.
Description: USENIX Annual Tech has always been the place to present groundbreaking research and cutting-edge practices in a wide variety of technologies and environments. USENIX '09 will be no exception. USENIX '09 will feature an extensive Training Program, covering crucial topics and led by highly respected instructors, as well as Technical Sessions, including the Refereed Papers Track, Invited Talks, and a Poster Session. Join the community of programmers, developers, and systems professionals in sharing solutions and fresh ideas.
Information: `http://www.usenix.org/events/usenix09/`.

14–20 **47th International Symposium on Functional Equations**, Gargnano, Italy. (Dec. 2008, p. 1449)

14–20 **The Interplay of Algebra and Geometry**, Cortona, Italy. (Apr. 2009, p. 521)

14–27 **ESI workshop on large cardinals and descriptive set theory**, Esi, Vienna, Austria. (Oct. 2008, p. 1134)

* 15–16 **Colloquia on the Occasion of F. L. Bauer 85 Years – F. L. Bauer-Prize 2009, 50 Years Numerische Mathematik**, Bayerische Akademie der Wissenschaften, Plenarsaal, Munich, Germany.
Location: Monday location: Munich. Tuesday location: Leibniz Supercomputing Centre, Lecture Hall, Boltzmannstrasse 1, 85748 Garchin.
Information: `http://www5.in.tum.de/Bauer85_Numerisch-eMathematik50/index.html`.

15–18 **The 5th International Conference "Dynamical Systems and Applications"**, "Ovidius" University of Constantza, Constantza, Romania. (Nov. 2008, p. 1319)

15–18 **SIAM Conference on Mathematical & Computational Issues in the Geosciences**, Leipziger Kubus Conference Center, Helmholtz - Centre for Environmental Research - UFZ, Leipzig, Germany. (Dec. 2008, p. 1449)

15–18 **Workshop on Electromagnetic Inverse Problems**, University of Manchester, Manchester, United Kingdom. (Apr. 2009, p. 521)

15–19 **Conference on Harmonic Analysis, Geometric Measure Theory and Quasiconformal Mappings**, CRM: Centre de Recerca Matematica, Bellaterra, Spain. (May 2009, p. 654)

15–19 **International Summer School on Operator Algebras and Applications**, Instituto Superior Tecnico, UTL, Lisbon, Portugal. (May 2009, p. 654)

15–19 **The analytic theory of automorphic forms (at the 65th birthday of Roelof Bruggeman)**, Woudschoten, The Netherlands. (Mar. 2009, p. 413)

15–19 **Waves 2009: The 9th International Conference on Mathematical and Numerical Aspects of Waves Propagation**, Pau, France. (Jun./Jul. 2008, p. 742)

* 15–19 **Workshop on Interacting Particle Systems in honor of Professor Tom Liggett's 65th Birthday**, Peking University, Beijing, China.
Invited Speakers: M. Biskup (UCLA), M. Bramson (Minnesota), L. Chayes (UCLA), M-F Chen (Beijing Normal Univ.), R. Durrett (Cornell), P. A. Ferrari (IMPA), L. Fontes (Univ. Sao Paulo), G. R. Grimmett (Cambridge), S. Lalley (Univ. Chicago), C. Newman (Courant Inst), A. Puha (CSUSM), E. Saada (Univ. Rouen), J. Schweinsberg (UCSD), V. Sidoravicius (CWI), J. Steif (Chalmers), R. Sun (NU Singapore), M. E. Vares (CBPF), and N. Yoshida (Kyoto Univ.)
Information: `http://www.math.pku.edu.cn/teachers/dayue/Homepage/IPS-Workshop.htm`.

15–20 **Strobl09 Conference on Time-Frequency**, Conference center "BIFEB" Strobl, Salzburg, Austria. (Apr. 2009, p. 522)

* 15–21 **VIII International Workshop Lie Theory and its Applications in Physics**, Varna, Bulgaria.
Description: The meeting covers the whole field of Lie Theory in its widest sense together with its applications in many facets of physics. As interface between mathematics and physics the workshop serves as a meeting place for mathematicians and theoretical and mathematical physicists. The first three workshops were organized in Clausthal (1995,1997,1999), the 4th was part of the 2nd Symposium 'Quantum Theory and Symmetries' in Cracow (2001), the 5th was organized in Varna (2003); `http://theo.inrne.bas.bg/~dobrev/LT-5`; the 6th was part of the 4th Symposium 'Quantum Theory and Symmetries' in Varna (2005), but has its own volume of Proceedings; `http://theo.inrne.bas.bg/~dobrev/qts-4`; the 7th was organized in Varna (2007); `http://theo.inrne.bas.bg/~dobrev/LT-7.htm`.
Information: `http://theo.inrne.bas.bg/~dobrev/LT-8.htm`.

15–26 **IMA New Directions Short Course: Applied Algebraic Topology**, Institute for Mathematics and its Applications (IMA), University of Minnesota, Minneapolis, Minnesota. (Apr. 2009, p. 522)

15–July 3 **IMA PI Summer Program for Graduate Students: The Mathematics of Inverse Problems**, University of Delaware, Newark, Delaware. (Apr. 2009, p. 522)

15–July 3 **Summer School and Conference in Geometric Representation Theory and Extended Affine Lie Algebras**, University of Ottawa, Ottawa, Ontario, Canada. (Feb. 2009, p. 309)

* 16–19 **INdAM Workshop: Kähler and Sasakian Geometry in Rome**, Departments of Mathematics of Universita' di Roma La Sapienza and Universita' Roma Tre, Istituto Nazionale di Alta Matematica, Roma, Italy.
Description: This Workshop is a sequel of the intensive research periods Differential Geometry and Topology and Extremal Kähler Metrics and Kähler-Ricci Flow held in Pisa (Fall 2004 and Spring 2008) and of the Conference Geometry and Mathematical Physics held in Albuquerque (October 2008). Kähler and Sasakian Geometry and their interplay are a rapidly spreading research domain. Among the remarkable results of the last years are the existence of Einstein metrics on homotopy and homology spheres, the extension of Hamilton-Perelman's results on the Ricci flow and applications to mathematical models of string theory. This workshop was conceived in memory of Krzysztof Galicki (1958-2007). Kris was a visitor in Italy, with collaborations and students. The members of the organizing and the scientific committees have always felt Kris as a link between European and American Differential Geometry, and this Workshop will be an occasion to continue this link in the same spirit.
Information: email: piccinni@mat.uniroma 1.it; http://www.mat.uniroma1.it/~ksgr.

16–22 **Sixth International Workshop on Optimal Codes and Related Topics: OC 2009**, Varna, Bulgaria. (Feb. 2009, p. 309)

16–25 **International Workshop on Resonance Oscillations and Stability of Nonsmooth Systems**, Imperial College, London, United Kingdom. (May 2009, p. 654)

* 17–21 **Modern Complex Analysis and Operator Theory and Applications, IV**, "Casa E. San José", El Escorial (Madrid area), Spain.
Description: The fourth in a series of analysis meetings; the earlier ones were held in Dublin (2004), El Escorial (2005), and Chapel Hill (2007). The meeting will be held at the residence "Casa E. San José" in El Escorial, a historical town and a UNESCO World Heritage site located about 55 km (35 miles) away from downtown Madrid.
Topics: Spaces of analytic functions, geometric function theory, stochastic Loewner equation, complex dynamics, dynamics of operators, and Toeplitz and composition operators, and applications.
Plenary speakers: A. Aleman, J. Bonet, N. Makarov, D. Marshall, S. Treil. There are 37 invited speakers as well, and possibly also a poster session.
Scientific Committee: M. Contreras, D. Girela, F. Pérez-González, K. Seip, A. Vasil'ev, D. Vukotic.
Information: Room and board for the full duration of the meeting will be available at the conference venue at an affordable price; http://www.uam.es/dragan.vukotic/conf-mecano09.html.

18–19 **2nd IMA International Conference on Mathematics in Sport**, University of Groningen, The Netherlands. (Oct. 2008, p. 1134)

18–20 **Models, Logics and Higher-Dimensional Categories: A tribute to the work of Mihaly Makkai**, Centre de recherches mathématiques, Université de Montréal, Montreal, QC Canada. (May 2009, p. 655)

19–22 **International Conference on Asymptotic Analysis and Infinite-dimensional Dynamical Systems**, City University of Hong Kong, Hong Kong, China. (Mar. 2009, p. 413)

21–27 **Eighth International Conference Symmetry in Nonlinear Mathematical Physics**, Institute of Mathematics, National Academy of Sciences of Ukraine, Kyiv (Kiev), Ukraine. (Nov. 2008, p. 1319)

21–27 **2nd Mile High Conference on Nonassociative Mathematics**, University of Denver, Denver, Colorado. (Jan. 2009, p. 72)

22–25 **Geometric Flows in Mathematics and Theoretical Physics**, Center "Ennio De Giorgi"–Scuola Normale superiore, Pisa, (IT). (May 2009, p. 655)

22–26 (NEW DATE) **5th Asian Mathematical Conference (AMC 2009)**, Penang /Kulalumpur, Malaysia. (Jun./Jul. 2008, p. 742)

22–26 **The 10th European Congress of Stereology and Image Analysis**, University of Milan, 20133 Milan, Italy. (Oct. 2008, p. 1135)

22–26 **Topology of Algebraic Varieties**, Jaca, Spain. (Apr. 2009, p. 522)

22–27 **3rd Nordic EWM Summer School for Ph.D. Students in Mathematics**, University of Turku, Turku, Finland. (Feb. 2009, p. 309)

22–27 **First Conference "Application of Mathematics in Technical and Natural Sciences" (AMiTaNS'09)**, Resort of Sozopol, Bulgaria. (Feb. 2009, p. 309)

22–29 **The Poetry of Analysis (Conference in honour of Antonio Córdoba on the occasion of his 60th birthday)**, Colegio Mayor Juan Luis Vives, Madrid, Spain. (Apr. 2009, p. 523)

22–July 3 **Automorphic forms and L-functions, computational aspects**, CRM, Montreal, Canada. (Feb. 2009, p. 309)

22–July 4 **Renormalization, graph polynomials, Hopf algebras and relations with motives (summerschool) Algebraic geometry and algebra related to renormalization (workshop)**, CIMAT, Guanajuato, Mexico. (Apr. 2009, p. 523)

23–25 **Geometric Topology in 3 and 4 Dimensions**, University of California, Davis, California. (May 2009, p. 655)

23–26 **Sixth Annual International Symposium on Voronoi Diagrams in Science and Engineering (ISVD 2009)**, Technical University of Denmark, Kongens Lyngby, Denmark. (Apr. 2009, p. 522)

23–26 **The 9th Central European Conference on Cryptography (CECC09)**, Trebic, Czech Republic. (Mar. 2009, p. 414)

23–26 **The 33rd Summer Symposium in Real Analysis**, Southeastern Oklahoma State University, Durant, Oklahoma. (Jan. 2009, p. 72)

24–26 **International Workshop on Reliable Methods of Mathematical Modeling (RMMM 2009)**, Humboldt-Universität zu Berlin, Germany. (May 2009, p. 655)

24–26 **Sixth Advanced Course in Operator Theory and Complex Analysis**, Seville, Spain. (May 2009, p. 655)

25–27 **Current Geometry: The X Edition of the International Conference on Problems and Trends of Contemporary Geometry**, Hotel Serino, Via Terminio, 83028 Serino, Avellino, Italy. (Feb. 2009, p. 309)

28–July 2 **20th International Workshop on Combinatorial Algorithms**, Novy Hradec, Czech Republic. (Mar. 2009, p. 414)

28–July 3 **Affine Isometric Actions of Discrete Groups**, The Centro Stefano Franscini, Zurich, Switzerland. (Apr. 2009, p. 522)

28–July 4 **XXVIII Workshop on Geometric Methods in Physics**, Bialowieza, Poland (Organized by the University of Bialystok). (Apr. 2009, p. 522)

28–July 18 **IAS/Park City Mathematics Institute (PCMI) 2009 Summer Session: Arithmetic of L-functions**, Park City, Utah. (Sept. 2008, p. 1032)

28–July 25 **UA VIGRE: Arizona Summer Program 2009**, University of Arizona, Tucson, Arizona. (Jan. 2009, p. 72)

29–July 1 **1st Rapid Modelling Conference**, Neuchâtel, Switzerland. (Dec. 2008, p. 1450)

29–July 3 **Workshop on Stochastic Analysis and Finance**, City University of Hong Kong, Kowloon, Hong Kong. (Apr. 2009, p. 522)

29–July 31 **Special Program: IMA Interdisciplinary Research Experience for Undergraduates**, Institute for Mathematics and its Applications (IMA), University of Minnesota, Minneapolis, Minnesota. (Apr. 2009, p. 522)

July 2009

1–3 **International Conference of Applied and Engineering Mathematics 2009**, Imperial College London, London, United Kingdom. (Oct. 2008, p. 1135)

1–3 **International Conference on Design Theory and Applications**, National University of Ireland, Galway, Ireland. (Apr. 2009, p. 522)

* 1–3 **Techniques and Problems in Graph Theory**, University of Bristol, Bristol, United Kingdom.
Description: A three-day workshop on techniques and problems in graph theory will be held from Wednesday 1st to Friday 3rd July at the University of Bristol. The aim of the workshop is to promote discussion and collaboration between researchers working in graph theory. Particular topics of interest include problems of an extremal nature, algebraic and combinatorial techniques, and the use of computational methods as a tool to gain insight into solving problems. This workshop is supported by the Heilbronn Institute for Mathematical Research.
Information: Please visit: `http://www.maths.bris.ac.uk/~marjw/workshop/` or contact: `tpgt-workshop@bristol.ac.uk`.

* 1–4 **EMMDS 2009: European Workshop on Challenges in Modern Massive Data Sets**, Technical University of Denmark, Copenhagen, Denmark.
Description: The 2009 European Workshop on Challenges in Modern Massive Data Sets (EMMDS 2009) will address algorithmic, mathematical, and statistical challenges in modern statistical data analysis. The goals of EMMDS 2009 are to explore novel techniques for modeling and analyzing massive, high-dimensional, and nonlinearly-structured scientific and Internet data sets, and to bring together computer scientists, statisticians, mathematicians, and data analysis practitioners to promote cross-fertilization of ideas.
Information: `http://mmds.imm.dtu.dk`.

1–August 31 **Mathematical Theory and Numerical Methods for Computational Materials Simulation and Design**, Institute for Mathematical Sciences, National University of Singapore, Singapore, (Jan. 2009, p. 72)

3–7 **International Conference on Mathematical Control Theory and Mechanics**, Suzdal, Russia. (May 2009, p. 655)

5–10 **22nd British Combinatorial Conference**, University of St. Andrews, Fife, Scotland. (Dec. 2008, p. 1450)

5–10 **The Second European Set Theory Meeting: In honor of Ronald Jensen — an ESF-EMS-ERCOM research conference**, Mathematical Research and Conference Center, Bedlewo, Poland. (May 2009, p. 655)

5–18 **39th Probability Summer School**, Saint-Flour, France. (May 2009, p. 655)

6–8 **SIAM Conference on Control and Its Applications**, Sheraton Denver Hotel, Denver, Colorado. (Dec. 2008, p. 1450)

6–10 **2009 SIAM Annual Meeting (AN09)**, Sheraton Denver Hotel, Denver, Colorado. (Feb. 2009, p. 309)

6–10 **26th Journées Arithmétiques**, Université de Saint-Etienne, Saint-Etienne, France. (Jun./Jul. 2008, p. 742)

6–10 **First PRIMA Pacific Rim Congress of Mathematicians**, University of New South Wales, Sydney, Australia. (Jun./Jul. 2008, p. 742)

6–10 **Journées de Géométrie Arithmétique de Rennes**, Institut de Recherche Mathématique de Rennes, Université de Rennes 1, Rennes, France. (Sept. 2008, p. 1032)

6–10 **Workshop on Equivariant Gromov-Witten theory and Symplectic Vortices**, CIRM, Luminy, France. (Mar. 2009, p. 414)

6–11 **Conference on Algebraic Topology CAT'09**, University of Warsaw, Warsaw, Poland. (Jan. 2009, p. 72)

6–11 **International Conference on Semigroups and Related Topics**, Faculty of Sciences of the University of Porto, Porto, Portugal. (Nov. 2008, p. 1319)

6–11 **International Conference on Topology and its Applications, ICTA 2009**, Hacettepe University, Ankara, Turkey. (Mar. 2008, p. 415)

9–13 **The 3rd International Workshop on Matrix Analysis and Applications**, Hangzhou (Lin'An), China. (Mar. 2008, p. 415)

10–12 **Ninth International Conference on Mathematical Knowledge Management**, Grand Bend, Ontario, Canada. (Apr. 2009, p. 523)

* 12–21 **International Seminar on Low-Dimensional Homotopy Theory and Combinatorial Group Theory**, Wallowa Lake Lodge in Joseph, Oregon.
Description: This meeting focuses on unsolved problems in low-dimensional homotopy theory and combinatorial group theory. These include Whitehead's Asphericity Conjecture, the Andrews-Curtis Conjecture, Wall's Domination Problem in dimension two, the relation gap problem, and the Eilenberg-Ganea Conjecture. This seminar is in succession to similar conferences held in Luttach (Italy), the Pacific Northwest, and Russia. The workshop format emphasizes detailed discussion of ideas in progress and collaboration of the participants, from advanced graduate students to early-career researchers to senior experts. The National Science Foundation has been asked for support.
Organizers: F. Rudolf Beyl, `beylf@pdx.edu`, Portland State University, and Jens Harlander, `jensharlander@boisestate.edu`, Boise State University.
Information: If interested, please contact the organizers by May 1, 2009. Available space is limited. Graduate students are requested to provide a reference familiar with their work.

13–16 **MULTICONF-09**, Orlando, Florida. (Jan. 2009, p. 72)

13–17 **9th International Conference on Finite Fields and Applications**, University College Dublin, Dublin, Ireland. (Jun./Jul. 2008, p. 742)

13–17 **Permutation Patterns 2009**, Dipartmento di Sistemi e Informatica, Università di Firenze, Firenze, Italy. (Jan. 2009, p. 72)

13–18 **7th International ISAAC Congress**, Imperial College, London, United Kingdom. (Jan. 2009, p. 72)

13–31 **IMA Summer Program: Nonlinear Conservation Laws and Applications**, Institute for Mathematics and its Applications (IMA), University of Minnesota, Minneapolis, Minnesota. (Apr. 2009, p. 523)

14–24 **The 19th International Conference on Banach algebras**, Bedlewo, Poland. (Oct. 2008, p. 1135)

15–20 **Dobrushin International Conference**, Institute for the Information Transmission Problems, RAS, Moscow, Russia. (May 2009, p. 655)

16–31 **XII Diffiety School — on Geometry of Partial differential Equations and Secondary Calculus**, Santo Stefano del Sole, Avellino, Italy. (Feb. 2009, p. 309)

20–22 **Future Models for Energy and Water Management— AMSI/MASCOS/UNESCO Industry workshop and short course: Future Models for Energy and Water Management under a Regulated Environment**, Queensland University of Technology, Brisbane, Queensland 4000 Australia. (May 2009, p. 656)

* 20–24 **Research experiences for undergraduate faculty**, American Institute of Mathematics, Palo Alto, California.
Description: This workshop, sponsored by AIM and the NSF, will introduce undergraduate faculty to research opportunities in graph theory, algebra, combinatorics, and linear algebra that will equip them with the tools to mentor students in undergraduate research in mathematics.
Information: http://aimath.org/ARCC/workshops/relant2.html.

20–24 **Vibration and Structural Acoustics Analysis: in conjunction with 3rd International Conference on Integrity, Reliability & Failure**, FEUP/INEGI, University of Porto, Porto, Portugal. (May 2009, p. 656)

20–24 **21st International Conference on Formal Power Series & Algebraic Combinatorics**, Research Institute for Symbolic Computation, Hagenberg, Austria. (Dec. 2008, p. 1450)

20–24 **AIP (Applied Inverse Problems)**, Vienna, Austria. (Nov. 2008, p. 1319)

20–24 **Equadiff 12**, Brno, Czech Republic. (Aug. 2008, p. 872)

20–31 **2009 ESSLLI Student Session**, Bordeaux, France. (Jan. 2009, p. 72)

20–December 18 **Non-Abelian Fundamental Groups in Arithmetic Geometry**, Isaac Newton Institute for Mathematical Sciences, Cambridge, England. (Aug. 2008, p. 872)

* 21–24 **Workshop on Automorphic Representations, Geometry, and Arithmetic**, National Taiwan University, Taipei, Taiwan.
Description: Many celebrated advances in number theory in the last few decades involve mysterious yet systematic relations among subjects of entirely disparate natures. Knowledge of analytically defined objects, via approaches coming from geometry, have provided information not obtained otherwise about arithmetic. The main theme of this workshop is to understand some of the latest developments along these lines. We have invited many promising researchers over the world, mostly young ones, to share their results, ideas, and ways of thinking. We hope to create a pleasant atmosphere that would encourage questions and discussions inspiring future progresses in these subjects. Researchers and students interested in number theory or arithmetic geometry are especially welcome to attend.
Information: http://www.tims.ntu.edu.tw/workshop/Automorphic_Representations/index.htm.

* 26–August 1 **Nearrings 2009, 21st International Conference on Near-rings, Near-fields, and related topics**, Abbey Vorau, Styria, Austria.
Description: There will be invited one-hour survey lectures and short (20-minute) presentations of recent research results. The survey lectures will be partially devoted to areas outside (but in vicinity of) nearring theory.
Invited speakers: Gary Birkenmeier, Lafayette, USA; Nico Groenewald, Port Elizabeth, South Africa; Laszlo Marki, Budapest, Hungary; Stuart Scott, Auckland, New Zealand; Stefan Veldsman, Muscat, Oman; Robert Wisbauer, Dusseldorf, Germany.
Information: http://nearrings09.asc.tuwien.ac.at/.

27–30 **The Society for Mathematical Biology Annual Meeting**, University of British Columbia, Vancouver, Canada. (Nov. 2008, p. 1319)

27–31 **33rd Conference on Stochastic Processes and their Applications**, Berlin, Germany. (May 2008, p. 636)

* 28–30 **Berlin hp-Workshop on Implementation Aspects**, Berlin, Germany.
Description: Berlin hp-Workshop on Implementation Aspects will focus on the implementation aspects of hp-FEM. Different application fields like elasticity and Maxwell equations will be discussed. The aim of the workshop is to bring together leading experts and young researchers.
Information: http://www.math.hu-berlin.de/~bhp09.

29–July 24 **The Cardiac Physiome Project**, Isaac Newton Institute for Mathematical Sciences, Cambridge, England. (Aug. 2008, p. 872)

* 29–August 2 **Spectral Theory and Geometric Analysis (in honor of the 65th birthday of Mikhail Shubin)**, Northeastern University, Boston, Massachusetts.
Description: The conference will facilitate cooperation between researchers working in different areas of geometric analysis and spectral theory. It will last five days. During four days there will be five 50-minute talks. One day will have three 50-minute talks and a two-hour discussion session, where the leading mathematicians will share their vision of the future development of the field with graduate students and other junior participants. This schedule will leave ample time for discussion and problem sessions. A poster session will also be arranged.
Information: http://www.math.neu.edu/~braverman/ShubinConference/shubinconference.html.

31–August 2 **3rd Jairo Charris Seminar—Symmetries of differential and difference equations**, Universidad Sergio Arboleda, Bogotá, Colombia. (Feb. 2009, p. 310)

August 2009

1–15 **Groups St Andrews 2009 in Bath**, University of Bath, Bath, United Kingdom. (May 2009, p. 656)

3–5 **SNC2009: The 3rd International Workshop on Symbolic-Numeric Computation**, Hotel "CO-OP INN Kyoto", Kyoto, Japan. (Mar. 2009, p. 415)

3–7 **Chern-Simons Gauge Theory: 20 years after**, Max Planck Institute for Mathematics, Bonn, Germany. (Apr. 2009, p. 523)

3–8 **7th Pan African Congress of Mathematicians (PACOM) 2009**, Yamoussoukro, Ivory Coast. (Apr. 2009, p. 523)

3–8 **XVI International Congress on Mathematical Physics (ICMP09)**, Clarion Congress Hotel Prague, Prague, Czech Republic. (Jan. 2009, p. 73)

3–14 **Pan-American Advanced Studies Institute (PASI): In Commutative Algebra and its connections to Geometry**, Olinda, Brazil. (Feb. 2009, p. 310)

4–10 **International Conference of Mathematical Sciences (ICMS Istanbul 2009)**, Maltepe University, Marmara Egitim Koyu, TR 34857 Maltepe, Istanbul, Turkey. (Apr. 2009, p. 523)

* 5–7 **19th Capricornio Mathematical Congress (COMCA 2009)**, Universidad Catolica del Norte, Antofagasta, Chile.
Description: The congress will provide an opportunity for the presentation and exchange of the latest research by those mathematicians interested in topics such as matrix theory, graph theory, control theory, algebra, geometry, industrial statistics, physical mathematics, applied mathematics, dynamical systems, and others. The congress is organized in short courses, talks, special invited sessions, and paper presentations. See website for list of confirmed speakers. Authors are kindly invited to submit abstracts before June 30, 2009. See website for submission information.
Information: http://www.comca2009.ucn.cl.

* 5–14 **Mathematical Modeling in Industry XIII - A Workshop for Graduate Students**, Institute for Mathematics and its Applications (IMA), University of Minnesota, Minneapolis, Minnesota.
Description: The IMA is holding a 10-day workshop on Mathematical Modeling in Industry. The workshop is designed to provide graduate students and qualified advanced undergraduates with first hand experience in industrial research. Students will work in teams of up to 6 students under the guidance of a mentor from industry. The mentor will help guide the students in the modeling process, analysis, and computational work associated with a real-world industrial problem. A progress report from each team will be scheduled during the period.

In addition, each team will be expected to make an oral final presentation and submit a written report at the end of the 10-day period.
Information: See http://www.ima.umn.edu/2008-2009/MM8.5-14.09/.

9–14 **Model Theory: ESF Mathematics Conference in Partnership with EMS and ERCOM**, Mathematical Research and Conference Center, Bedlewo, Poland. (Apr. 2009, p. 523)

9–15 **Reconnect Conference 2009: Reconnecting Teaching Faculty to the Mathematical Sciences Enterprise and Exposing Researchers in Government and Industry to Relevant Current Research, Visual Analytics and its Applications.**, DyDAn Center, Rutgers University, Piscataway, New Jersey. (May 2008, p. 656)

9–22 **Summer School: Structures in Lie Representation Theory, Crystals, Derived Functors, Harish-Chandra Modules, Invariants, Quivers**, Jacobs University, Bremen, Germany. (Apr. 2009, p. 523)

10–12 **Continuing Statistics Education Workshop**, Statistics Online Computational Resource (SOCR), University of California, Los Angeles, California. (Dec. 2008, p. 1450)

10–12 **Workshop on Technology-Enhanced Probability and Statistics Education Using SOCR Resources**, Statistics Online Computational Resource (SOCR), University of California, Los Angeles, California. (Dec. 2008, p. 1451)

10–14 **Nonlinear problems for p-Laplace and Laplace**, Linköping, Sweden. (May 2008, p. 656)

10–14 **Topological complexity of random sets**, American Institute of Mathematics, Palo Alto, California. (Jan. 2009, p. 73)

* 10–20 **International Conference and Young Scientists School "Theory and Computational Methods for Inverse and Ill-posed Problems"**, Novosibirsk, Russia.
Description: Scientific program covers: Theory of inverse and ill-posed problems and regularization methods; Computational methods for solution of inverse problems in acoustics, electrodynamics, tomography, electrical survey, seismology, gravimetry, transport theory and other fields of science; New information technologies; Parallel computations; Visualization; Non-distractive control.
Lectures/Talks: Scientific program consists of lectures by members of the International Program Committee, talks by invited speakers and young scientists' presentations.
Languages: Russian and English.
Information: http://math.nsc.ru/conference/onz09/engl.html.

12–14 **18th USENIX Security Symposium**, Le Centre Sheraton Hotel Montreal, 1201 Boulevard Rene-Levesque, West Montreal, Quebec H3B 2L7 Canada. (Jan. 2009, p. 73)

12–December 18 **Dynamics of Discs and Planets**, Isaac Newton Institute for Mathematical Sciences, Cambridge, England. (Aug. 2008, p. 872)

15 **Workshop on Logical Aspects of Fault Tolerance (LAFT) co-located with LICS 2009**, University of California, Los Angeles, California. (Apr. 2009, p. 523)

17 **Symplectic and Contact Geometry and Topology**, Mathematical Sciences Research Institute, Berkeley, California. (Sept. 2008, p. 1033)

17–19 **Measurement, Design, and Analysis Methods for Health Outcomes: Research Offered by the Harvard School of Public Health Center for Continuing Professional Education**, Boston, Massachusetts. (May 2009, p. 656)

17–21 **International Conference on Complex Analysis and Related Topics**, University of Turku, Turku, Finland. (Feb. 2009, p. 310)

17–21 **Modular forms on noncongruence groups**, American Institute of Mathematics, Palo Alto, California. (Aug. 2008, p. 872)

* 17–21 **PDE & Mathematical Finance III**, Royal Institute of Technology, Stockholm, Sweden.
Description: The goal of the workshop is to present the state of the art of applications of partial differential equations to finance. The event is a follow up on conferences in PDE and Finance held at KTH, Stockholm in 2005 and 2007.
Information: http://www.math.kth.se/pdefinance/2009/.

* 17–22 **Brain Activity Modeling: From Fine to Coarse Scale**, Centre de recherches mathématiques, Université de Montréal, Montréal, Québec, Canada.
Description: The interpretation of brain functional signals (fMRI, EEG, MEG, Optical imaging) necessitates models of the neuronal bioelectrical activity and the metabolic processes. It is by now essential to confront models with the various type of data that allows one to explore more accurately temporal and spatial distribution of brain activity. These models consist, for instance, in coupled PDE's and other nonlinear equations that represent, at various scales of the processes, the electrophysiology in relationship with vascular and hemodynamic. The workshop will make the point on the current avenues in modeling with respect to the various modalities in non-invasive functional brain imaging.
Information: http://www.crm.umontreal.ca/Brain09/index_e.php.

17–December 18 **Tropical Geometry**, Mathematical Sciences Research Institute, Berkeley, California. (Sept. 2008, p. 1033)

* 22–26 **FM2009 Conference Functional Methods in Approximation Theory and Operator Theory III, dedicated to the memory of V. K. Dzyadyk (1919-1998)**, Camp Hart, Village Svityaz, Shatskyi Region, Volyn, Ukraine.
Topics: Algorithms for approximation, applications of approximation theory, applications of operator theory in mathematical physics, boundary problems and complex approximation, multivariate approximation, nonlinear approximation, operator-differential equations, polynomial and spline approximation, shape preserving approximation, spectral problems, wavelets, widths.
Information: http://www.imath.kiev.ua/~funct/fm2009/.

23–25 **Salford Data Mining Conference 2009 (SALFORD 2009)**, San Diego, California. (May 2009, p. 657)

24–26 **2009 Workshop for Young Researchers in Mathematical Biology (WYRMB)**, Mathematical Biosciences Institute, The Ohio State University, Columbus, Ohio. (May 2009, p. 656)

* 24–26 **The 34th Sapporo Symposium on Partial Differential Equations**, Department of Mathematics, Hokkaido University, Sapporo, Japan.
Description: The Sapporo Symposium on Partial Differential Equations has been held annually to present the latest developments on PDE with a broad spectrum of interests not limited to the methods of a particular school.
Financial Support: Limited amount of financial support for local expenses is available to non-resident visitors who are interested in the meeting. Please make inquiry to cri@math.sci.hokudai.ac.jp by April 30, 2009.
Information: http://www.math.sci.hokudai.ac.jp/sympo/sapporo/program_en.html.

24–28 **Relative trace formula and periods of automorphic forms**, American Institute of Mathematics, Palo Alto, California. (Sept. 2008, p. 1033)

24–28 **Mal'tsev Meeting**, Sobolev Institute of Mathematics SB RAS, Novosibirsk, Russia. (May 2009, p. 657)

* 24–29 **Inverse Problem in Brain Imaging and Multimodal Fusion**, Centre de recherches mathématiques, Université de Montréal, Montréal, Québec, Canada.

Description: The interpretation of brain functional signals (fMRI, EEG, MEG, Optical imaging) necessitates models of the neuronal bioelectrical activity and the metabolic processes. It is by now essential to confront models with the various type of data that allows one to explore more accurately temporal and spatial distribution of brain activity. These models consist, for instance, in coupled PDE's and other nonlinear equations that represent, at various scales of the processes, the electrophysiology in relationship with vascular and hemodynamic. The workshop will make the point on the current avenues in modeling with respect to the various modalities in non-invasive functional brain imaging.
Information: `http://www.crm.umontreal.ca/Inverse09/index_e.php`.

27–29 **Ukrainian Mathematical Congress 2009 (Dedicated to the Centennial of Nikolai N. Bogoliubov)**, Institute of Mathematics of NASU, Kiev (Kyiv), Ukraine. (Jan. 2009, p. 73)

30–31 **Oded Schramm Memorial Conference in Probability and Geometry**, Microsoft Research, Redmond, Washington. (May 2009, p. 657)

30–September 4 **Algebraic Groups and Invariant Theory**, Centro Stefano Franscini, Ascona, Switzerland. (Jan. 2009, p. 73)

31–September 4 **GF2009 International Conference on Generalized Functions**, University of Vienna, Vienna, Austria. (Apr. 2009, p. 523)

31–September 6 **International School on Geometry and Quantization**, Mathematics Research Unit, University of Luxembourg, Luxembourg. (Apr. 2009, p. 524)

September 2009

2–4 **Workshop in nonlinear elliptic PDEs**, Université Libre de Bruxelles, Brussels, Belgium. (Feb. 2009, p. 310)

* 2–6 **The 9th Balkan Conference on Operational Research (BALCOR 2009)**, Constanta, Romania.
Description: The University of Bucharest, Naval Academy Mircea cel Batran Constanta, The Romanian Academy, The Technical University of Civil Engineering Bucharest, are honored to invite everyone engaged in research, teaching, business, or public services related to Operational Research to attend. The general aim of the conference is to facilitate the exchange of scientific and technical information related to Operational Research and to promote international co-operation especially among the Balkan countries.
Information: `http://civile.utcb.ro/balcor/`.

* 3–5 **Complex and Harmonic Analysis 2009**, Archanes, Crete, Greece.
Description: At the Department of Mathematics of the University of Crete we are organizing a small meeting in the broad areas of Complex and Harmonic Analysis. The meeting will take place in the village of Archanes, 15km southeast of the city of Iraklio. We are hoping that a similar meeting will be taking place every two years alternating in Greece and Spain.
Invited Speakers: Dimitris Betsakos, Univ. of Thessaloniki; Oscar Blasco, Univ. de Valencia; Joaquim Bruna, Univ. Autonoma de Barcelona; Daniel Girela, Univ. de Malaga; Antonios Melas, Univ. of Athens; Vassilis Nestoridis, Univ. of Athens; Artur Nicolau∗, Univ. Autonoma de Barcelona; Aristomenis Siskakis, Univ. of Thessaloniki; Dragan Vukotic. Univ. Autonoma de Madrid. ∗ Beyond the invited speakers there will be some shorter contributed talks. Financial support: there will be some support for junior participants.
Information: `http://fourier.math.uoc.gr/ch2009`.

3–5 **International Conference on Modern Mathematical Methods in Science and Technology (M3ST '09)**, Poros Image Hotel, Poros Island, Greece. (May 2009, p. 657)

3–6 **International Conference on Theory and Applications in Mathematics and Informatics**, "1 Decembrie 1918" University of Alba Iulia, Alba Iulia, Romania. (May 2009, p. 657)

4–9 **2nd Dolomites Workshop on Constructive Approximation and Applications (DWCAA09)**, Alba di Canazei, Trento, Italy. (Jan. 2009, p. 73)

* 5–10 **9th Conference on Geometry and Applications**, Hotel Joliot Curie, resort St. Constantine and Helena, Varna, Bulgaria.
Organizer: The Geometrical Society Bojan Petkanchin in Bulgaria.
Topics: The following fields are included: Differential geometry, finite groups and inzident geometries, application of computer methods in geometry, algebra and analysis, school geometry.
Information: `http://www.fmi.uni-sofia.bg`.

7–8 **CETL-MSOR Conference 2009**, Open University, Milton Keynes, England. (Apr. 2009, p. 524)

* 7–10 **A Harmonic Map Fest**, University of Cagliari, Italy.
Description: This conference is in honour of Prof. John C. Wood, on the occasion of his 60th birthday and 35 years of involvement in harmonic maps. While the scientific content will undoubtably reflect J. C. Wood's predilection for harmonic maps and harmonic morphisms and be a good opportunity to review the state of the art, other topics in Differential Geometry will be most welcome.
Main speakers: P. Baird (Brest), F. Burstall (Bath), S. Dragomir (Potenza), F. Helein (Paris), D. Kotschick (Munich), E. Musso (Aquila), Y. Ohnita (Osaka), L. Ornea (Bucharest), F. Pedit (Tuebingen and Amherst), M. Rigoli (Milan) and H. Urakawa (Tohoku. There will also be some 30 minute talks.
Information: `http://www.matematik.lu.se/JCW-60/`.

7–11 **Third International Conference on Geometry and Quantization GEOQUANT**, Mathematics Research Unit, University of Luxembourg, Luxembourg. (Apr. 2009, p. 524)

* 7–11 **XXIst Rolf Nevanlinna Colloquium**, Kyoto University, Kyoto, Japan.
Information: To join the mailing list for further information, please send an empty mail to: `join@nevanlinna.jp`; Contact address: `http://www.nevanlinna.jp`.

7–12 **Advanced School on Homotopy Theory and Algebraic Geometry**, Mathematical Research Institute, University of Sevilla (IMUS), Sevilla, Spain. (May 2009, p. 657)

8–12 **IV International Conference on Mathematical Analysis in Andalucia**, University of Cadiz, Jerez de la Frontera, Spain. (May 2009, p. 657)

8–December 11 **Long Program: Combinatorics: Methods and Applications in Mathematics and Computer Science**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California. (Jan. 2009, p. 73)

9–16 **Combinatorics: Methods and Applications in Mathematics and Computer Science, Tutorials**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California. (Jan. 2009, p. 73)

10–12 **Quantum topology and Chern-Simons theory**, Institut de Recherche Mathématique Avancée, Université de Strasbourg, 7 rue René Descartes, Strasbourg, France. (Jan. 2009, p. 73)

11–13 **Algebra and Topology in Interaction**, University of California, Davis, California. (May 2009, p. 657)

11–17 (NEW DATE) **Models in Developing Mathematics Education**, Dresden University of Applied Sciences, Dresden, Germany. (Apr. 2007, p. 498)

* 14–18 **2009 Workshop on Algebraic Geometry and Physics: Representations, Lie Theory and Physics**, Maresias Beach Hotel, Maresias, Brazil.
Description: The workshop will bring together mathematicians and physicists working on several aspects of Lie theory (Lie groups, Lie algebras, algebraic groups, representations) and their applications (including gauge theory, deformation theory, automorphic representations, partial differential equations, integrable systems, symmetries

in physics, among others). The programme will include minicourses by A. Kleshchev, D. E. Diaconescu, R. Donagi, and about 15 one-hour talks by invited speakers. It is possible to submit a proposal of a communication; please send a title and a short abstract. Inclusion into the programme will be decided by the scientific committee. If you are interested in participating, please write to: jardim@ime.unicamp.br, futorny@ime.usp.br or henrique@impa.br by April 30, 2009.
Information: http://people.sissa.it/~bruzzo/wagp09/index.htm.

14–18 **IMA Workshop: Flowing Complex Fluids: Rheological Measurements and Constitutive Modeling**, Institute for Mathematics and its Applications (IMA), University of Minnesota, Minneapolis, Minnesota. (Apr. 2009, p. 524)

* 14–19 **Dictionary of Atoms: New Trends in Advanced Signal Processing in Functional Brain Imaging**, Centre de recherches mathématiques, Université de Montréal, Montréal, Québec, Canada.
Description: During the last decade, sparse representations of signals have been intensively studied in the domain of functional brain imaging and electrophysiology. This workshop will present various aspects of this "wavelet heritage" in this domain of signal processing, applied in fMRI and electrophysiological signals. Analysis of signals and inverse problems in sparse representations will be highly focussed during the week.
Information: http://www.crm.umontreal.ca/Atoms09/index_e.php.

15–18 **Bogolyubov Kyiv Conference: "Modern Problems of Theoretical and Mathematical Physics"**, Bogolyubov Institute for Theoretical Physics, Kyiv, Ukraine. (Nov. 2008, p. 1319)

21–25 **Convex algebraic geometry, optimization and applications**, American Institute of Mathematics, Palo Alto, California. (Apr. 2009, p. 524)

* 24–26 **Variational and Topological Methods in Nonlinear Analysis**, University of Texas at San Antonio (UTSA).
Description: International conference dedicated to the 60th birthday of Vieri Benci.
Information: http://www.dm.uniba.it/nonlinear09/.

24–30 **6th International Conference on Functional Analysis and Approximation Theory -FAAT 2009**, Acquafredda di Maratea, Italy. (Apr. 2009, p. 525)

27–29 **Symposium on Engineered & Natural Complex Systems**, Toronto, Ontario, Canada. (May 2009, p. 658)

October 2009

5–8 **2009 SIAM/ACM Joint Conference on Geometric Design and Solid & Physical Modeling**, Hilton San Francisco Financial District, San Francisco, California. (Dec. 2008, p. 1451)

5–9 **Combinatorics: Probabilistic Techniques and Applications**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California. (Dec. 2008, p. 1451)

5–9 **International Conference "Kolmogorov readings. General control problems and their applications (GCP-2009)"**, Tambov State University named after G.R. Derzhavin, Institute of Mathematics, Physics, and Computer sciences, Tambov, Russia. (May 2009, p. 658)

* 5–9 **Rational curves and A^1-homotopy theory**, American Institute of Mathematics, Palo Alto, California.
Description: This workshop, sponsored by AIM and the NSF, will be devoted to studying recent interactions between rational connectivity and the newly developing theory of A^1-algebraic topology.
Information: http://aimath.org/ARCC/workshops/a1homotopy.html.

9–11 **SIAM Conference on Mathematics for Industry: Challenges and Frontiers (MI09)**, Hilton San Francisco Financial District, San Francisco, California. (Feb. 2009, p. 310)

* 9–11 **Southeastern Lie Theory Workshop on Combinatorial Lie Theory and Applications**, North Carolina State University, Raleigh, North Carolina.
Description: The main focus of this workshop will be on combinatorial representation theory, both algebraic and geometric. Professor Masaki Kashiwara will give a series of three lectures at this workshop. This is the first of three annual workshops on Lie Theory to be held in the southeastern region of USA, funded by the National Science Foundation; organized by Kailash Misra (email: misra@math.ncsu.edu), Daniel Nakano, and Brian Parshall. Partial support would be available to junior researchers and graduate students. Please see the conference web page for further details. Priority for funding will be given to applicants from minority and underrepresented groups.
Information: http://www.math.virginia.edu/lieworkshops/.

12–14 **The 6th annual International New Exploratory Technologies Conference (NEXT 2009)**, Fudan University, Shanghai, China. (May 2009, p. 658)

12–16 **Algebra, Geometry, and Mathematical Physics**, The Bedlewo Mathematical Research and Conference Center, Bedlewo, Poland. (Dec. 2008, p. 1451)

12–16 **IMA Workshop: Flowing Complex Fluids: Fluid Mechanics-Interaction of Microstructure and Flow**, Institute for Mathematics and its Applications (IMA), University of Minnesota, Minneapolis, Minnesota. (Apr. 2009, p. 524)

14–16 **The 9th Conference Shell Structures Theory and Applications**, Neptun Hotel, Hel Peninsula, Baltic Sea, Jurata, Poland. (Dec. 2008, p. 1451)

14–17 **Integers Conference 2009**, University of West Georgia, Carrollton, Georgia. (Apr. 2009, p. 524)

* 16–17 **Twenty-Ninth Southeastern Atlantic Regional Conference on Differential Equations (SEARCDE)**, Mercer University, Macon, Georgia.
Plenary Speakers: Howard (Howie) Weiss (Georgia Institute of Technology), H.T. Banks (North Carolina State University), Irena Lasiecka (University of Virginia). In addition to the plenary speakers, there will be sessions of twenty-minute contributed talks. Pending funding from the National Science Foundation, travel support funds will be available for advanced graduate students and recent Ph.D. recipients (2004 or later). Women and minorities are especially encouraged to participate in this conference and to apply for support.
Deadline: For abstracts in contributed session is October 2, 2009.
Information: http://www.mercer.edu/math/searcde/ for information on registration, lodging, submission of abstracts, and application for support.

16–18 **AMS Central Section Meeting**, Baylor University, Waco, Texas. (Aug. 2008, p. 872)

19–22 **International Conference "Discrete Mathematics, Algebra, and their applications" (DIMA09)**, Belarus State University, Minsk, Belarus. (May 2009, p. 658)

19–23 **Combinatorics: Combinatorial Geometry**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California. (Dec. 2008, p. 1451)

19–23 **Higher Reidemeister Torsion**, American Institute of Mathematics, Palo Alto, California. (Dec. 2008, p. 1451)

20–22 **International Conference in Modeling Health Advances 2009**, UC Berkeley, San Francisco Bay Area, California. (Mar. 2009, p. 416)

21–23 **The 4th International Conference on Research and Education in Mathematics 2009 (ICREM09)**, Kuala Lumpur, Malaysia. (Apr. 2009, p. 525)

22–24 **Partial Differential Equations and Applications International Workshop for the 60th birthday of Michel Pierre**, Club Med, Vittel, France. (Apr. 2009, p. 525)

24–25 **AMS Eastern Section Meeting**, Pennsylvania State University, University Park, Pennsylvania. (Aug. 2008, p. 872)

* 25–30 **Mathematical Methods in Emerging Modalities of Medical Imaging**, Banff International Research Station, Banff, Canada.
Description: The workshop will assemble researchers from mathematics, physics, engineering and medicine interested in developing and implementing mathematical methods of novel medical diagnostic imaging. Among the techniques to be discussed are, in particular, optical tomography, electron tomography, phase contrast CT, thermo/photoacoustic tomography, elastography, ultrasound modulated optical tomography, and acousto-electric tomography. These new modalities of imaging involve challenging problems on crossroads of mathematics, physics, and engineering. The goal is to formulate the mathematical problems that must be resolved to meet outstanding challenges of this young and fast developing area and to assess and facilitate the current progress in these directions.
Information: `http://www.birs.ca/birspages.php?task=displayevent&event_id=09w5017`

26–28 **SAGA 2009, Fifth Symposium on Stochastic Algorithms, Foundations and Applications**, Hokkaido University, Sapporo, Japan. (May 2009, p. 658)

26–30 **Implementing algebraic geometry algorithms**, American Institute of Mathematics, Palo Alto, California. (May 2009, p. 658)

26–31 **Autumn School: "Towards a p-adic Langlands Correspondence"**, Mathematical Research Institute, University of Sevilla (IMUS), Sevilla, Spain. (May 2009, p. 658)

30–November 1 **AMS Southeastern Section Meeting**, Florida Atlantic University, Boca Raton, Florida. (Aug. 2008, p. 872)

November 2009

1–6 **23rd Large Installation System Administration Conference (LISA '09)**, Baltimore Marriott Waterfront, 700 Aliceanna Street, Baltimore, Maryland. (Mar. 2009, p. 416)

1–December 31 **Financial Mathematics**, Institute for Mathematical Sciences, National University of Singapore, Singapore. (Jan. 2009, p. 73)

2–6 **Combinatorics: Topics in Graphs and Hypergraphs**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California. (Jan. 2009, p. 74)

2–6 **The Cuntz Semigroup**, American Institute of Mathematics, Palo Alto, California. (Apr. 2009, p. 525)

* 6–10 **XV International Conference on Mathematics, Informatics and Related Fields**, Hotel Energetyk, Naleczow, Poland.
Topics: Mathematical analysis, probability and statistics, computer science, applied mathematics and mathematical didactics.
Scientific Committee: Bogdan Bojarski, Theodor Bulboaca, Stanisława Kanas, Jacek Kluska, Józef Korbicz, Piotr Liczberski, Dariusz Partyka, Wiesław Pleśniak, Arkadiusz Płoski, Dymitr Prokhorov, Zdzisław Rychlik, Józef Siciak, Hari M. Srivastava, Jan Stankiewicz, Toshiyuki Sugawa, Zbigniew Suraj, Józef Zajc, Jarosław Zemanek.
Organizing Committee: Stanisława Kanas, Beata Fałda, Zdzisław Rychlik, Anna Szpila, Katarzyna Wilczek.
Information: `http://ptm.prz.rzeszow.pl/konferencja/`.

7–8 **AMS Western Section Meeting**, University of California, Riverside, California. (Aug. 2008, p. 872)

9–13 **Cyclic homology and symplectic topology**, American Institute of Mathematics, Palo Alto, California. (Apr. 2009, p. 525)

19–21 **2nd meeting on Optimization Modelization and Approximation Moma 2009**, Hassania School, Public Works Département de Mathématiques et Informatique Km 7, Route d'El Jadida, B.P 8108, Oasis-Casablanca, Morocco. (May 2009, p. 658)

* 23–27 **Mathematics and Astronomy: A Joint Long Journey**, CSIC, Madrid, Spain.
Description: Mathematics and Astronomy walked together for thousands of years. Ptolemy, Copernicus, Galileo, Kepler, Newton are good examples of this fruitful interaction between both disciplines. In medieval educational theory, the "quadrivium" consisted of arithmetic, geometry, music, and astronomy, which prove their common past in the development of science. More recently, the extraordinary works by Einstein with the General Theory of Relativity give new insights to our vision of the universe, in a wonderful cooperation of geometry and physics. The proposed symposium wants to show and stress these links with the occasion of the celebration of the International Year of Astronomy IYA2009.
Information: `http://www.astromath2009.com`.

29–December 4 **Southern Right Delta ($\Sigma P\Delta$'09) Conference on the Teaching and Learning of Undergraduate Mathematics and Statistics**, Gordon's Bay, Western Cape, South Africa. (Feb. 2009, p. 310)

December 2009

1–4 (NEW DATE) **Combinatorics: Analytical Methods in Combinatorics, Additive Number Theory and Computer Science**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California. (Dec. 2008, p. 1452)

7–9 **SIAM Conference on Analysis of Partial Differential Equations (PD09)**, Hilton Miami Downtown, Miami, Florida. (Feb. 2009, p. 310)

7–11 **IMA Workshop: Microfluidics: Electrokinetic and Interfacial Phenomena**, Institute for Mathematics and its Applications (IMA), University of Minnesota, Minneapolis, Minnesota. (Apr. 2009, p. 525)

14–18 **Brownian motion and random matrices**, American Institute of Mathematics, Palo Alto, California. (May 2009, p. 659)

16–18 **The 4th Indian International Conference on Artificial Intelligence: (IICAI-09)**, Tumkur (near Bangalore), India. (Dec. 2008, p. 1452)

17–21 **The 14th Asian Technology Conference in Mathematics (ATCM 2009)**, Beijing Normal University, Beijing, China. (Apr. 2009, p. 525)

19–21 **International Conference on Current Trends in Mathematics**, Allahabad, Uttar Pradesh, India. (May 2009, p. 659)

January 2010

2–4 **International Convention on Mathematical Sciences**, Allahabad, India. (May 2009, p. 659)

17–19 **ACM-SIAM Symposium on Discrete Algorithms (SODA10)**, Hyatt Regency Austin, Austin, Texas. (Apr. 2009, p. 525)

24–26 **International Conference on Analysis and Applications (ICAA10)**, Sultan Qaboos University, Muscat, Oman. (May 2009, p. 659)

* 25–29 **Metamaterials: Applications, Analysis and Modeling**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California.
Overview: This workshop brings together three groups of people: physicists and engineers working on metamaterials and their applications; mathematicians who are studying homogenization in high contrast materials and are providing a greater understanding of the mathematics of metamaterials; and numerical analysts interested in the solving the microscopic and macroscopic equations governing the behavior of metamaterials.
Organizing Committee: Robert Kohn, Graeme Milton, Susanne Brenner, Maria-Carme Calderer, Tatsuo Itoh, Jichun Li, Chi-Wang Shu, Richard Ziolkowski.
Application/Registration: An application and registration form is available at: `http://www.ipam.ucla.edu/programs/meta2010`. Applications received by November 30, 2009, 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.

February 2010

8–11 **The International Symposium on Stochastic Models in Reliability Engineering, Life Sciences, and Operations Management**, Sami Shamoon College of Engineering, Bialik/Basel Sts., Beer Sheva, 84100, Israel. (May 2009, p. 659)

* 8–12 **Mathematical Problems, Models and Methods in Biomedical Imaging**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California.
Overview: The workshop's topics will include some of the current major technologies and emerging mathematical problems in biomedical imaging. The emphasis will be on the interface between Mathematics and Biomedical Imaging to promote new ideas and research at the frontiers of interdisciplinary studies.
Organizing Committee: Hongkai Zhao, Yair Censor, Steve Jiang, Belinda Seto, Lei Xing.
Application/Registration: An application and registration form is available at: `http://www.ipam.ucla.edu/programs/bmed2010`. Applications received by Dec. 14, 2009, 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.

* 18–19 **February Fourier Talks 2010**, Norbert Wiener Center, University of Maryland, College Park, Maryland.
Description: Each year the two-day February Fourier Talks, organized by the Norbert Wiener Center in the Department of Mathematics at the University of Maryland, College Park, feature a diverse array of invited talks in the field of Harmonic Analysis and Applications. A single track of presentations from top academic, industry, and government researchers is scheduled, allowing ample time for interaction with other participants. The conference will feature a talk in our Distinguished Lecturer Series by Elias Stein of Princeton University, and the Norbert Wiener Lecture, delivered by Charles Fefferman of Princeton University.
Information: `http://www.norbertwiener.umd.edu/FFT/FFT10/index.html`.

22–26 **IMA Workshop: Analysis and Computation of Incompressible Fluid Flow**, Institute for Mathematics and its Applications (IMA), University of Minnesota, Minneapolis, Minnesota. (Apr. 2009, p. 525)

* 22–26 **Statistical and Learning-Theoretic Challenges in Data Privacy**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California.
Overview: The workshop's goal is to establish a coherent theoretical foundation for research on data privacy. This implies work on how the conflicting goals of privacy and utility can or should be formulated mathematically, and how the constraints of privacy affect the accuracy of statistical inference and machine learning.
Organizing Committee: Adam Smith, Cynthia Dwork, Stephen Fienberg, Aleksandra Slavkovic.
Application/Registration: An application and registration form is available at `http://www.ipam.ucla.edu/programs/data2010`. Applications received by December 21, 2009, 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.

24–26 **SIAM Conference on Parallel Processing and Scientific Computing (PP10)**, Hyatt Regency Seattle, Seattle, Washington. (Apr. 2009, p. 525)

March 2010

* 8–12 **AIM Workshop: Mock Modular Forms in Combinatorics and Arithmetic Geometry**, American Institute of Mathematics, Palo Alto, California.
Description: This workshop, sponsored by AIM and the NSF, will focus on mock modular forms as they occur in combinatorics and arithmetic geometry and explore some other potential applications.
Information: `http:// www.aimath.org/ARCC/workshops/mockmodular.html`.

8–June 11 **Long Program: Model and Data Hierarchies for Simulating and Understanding Climate**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California. (Apr. 2009, p. 526)

15–19 **Localization techniques in equivariant cohomology**, American Institute of Mathematics, Palo Alto, California. (May 2009, p. 659)

* 18–21 **First International Conference on Mathematics and Statistics, AUS-ICMS '10**, American University of Sharjah (AUS), Sharjah, United Arab Emirates.
Description: The main objective of the conference is to bring together researchers and scientists working in all areas of mathematics and statistics from academia and industry to exchange research ideas, discuss the most recent advancements in all fields of mathematics and sciences, and to promote interaction between our faculty and researchers from the region and worldwide.
Topics: To be covered include, but are not limited to: Algebra, analysis, applied mathematics, applied statistics, differential equations, discrete mathematics, financial mathematics, mathematics education, number theory, numerical analysis, probability theory, statistics, stochastic differential equations, and topology and geometry.
Information: `http://www.aus.edu/conferences/icms10/`.

* 29–April 2 **AIM Workshop: Computational optimization for tensor decompositions**, American Institute of Mathematics, Palo Alto, California.
Description: This workshop, sponsored by AIM and the NSF, will be devoted to facilitating the development of new decomposition methods and to provide fundamentally new insights into both tensor decompositions and numerical optimization.
Information: `http://aimath.org/ARCC/workshops/comptensor.html`.

April 2010

12–16 **IMA Workshop: Transport and Mixing in Complex and Turbulent Flows**, Institute for Mathematics and its Applications (IMA), University of Minnesota, Minneapolis, Minnesota. (Apr. 2009, p. 526)

May 2010

* 17–20 **25th Annual Shanks Lecture and Conference: Optimal Configurations on the Sphere and Other Manifolds**, Vanderbilt University, Nashville, Tennessee.
Description: The aim of this conference is to bring together mathematicians and scientists for the purpose of gaining a better understanding of the structure of particle systems under a variety of physical constraints. These include, for example, classical ground states for interacting particle systems, best-packing, random packings, jammed states, granular and colloidal systems, as well as minimal discrete and continuous energy problems for general kernels.
Information: `http://www.math.vanderbilt.edu/~shanks2010`.

* 25–28 **8th AIMS Conference on Dynamical Systems, Differential Equations and Applications**, Dresden, Germany.
Plenary Speakers: Luis Caffarelli, Emmanuel Candes, Kuo-Chang Chen, Barbara Gentz, Louis Nirenberg, Masaharu Taniguchi, Gunther Uhlmann, Lai-Sang Young
Organizers: The American Institute of Mathematical Sciences Dresden University of Technology.

Information: Stefan Siegmund, stefan.siegmund@tu-dresden.de; Shouchuan Hu, shu@missouristate.edu; Xin Lu, lux@uncw.edu; http://aimsciences.org/AIMS-Conference/2010/.

* 25–29 **BALWOIS 2010: Fourth International Scientific Conference**, Ohrid, Republic of Macedonia.
Description: Conference on Water Observation and Information System for Decision Support. Scientific presentations, Forum exchange, Workshops, Exhibition, Social program, etc.
Main topics: Climate and hydrology, environment and human activities, water related risks, integrated water resouces management, ecohydrology, computing and technologie.
Deadlines: Submission of Abstract: November 15, 2009. Author Notification of Abstract Acceptance: December 15, 2009. Submission of Full Paper: February 15, 2010. Author Notification of Full Paper Acceptance: March 15, 2010.
Supporters: Ministry of Environment of Republic of Macedonia, French Ministry of Ecology, French Embassy in Macedonia, and International Association of Hydrological Sciences
Information: email: secretariat@balwois.com; http://www.balwois.com/2010. Project website: http://www.balwois.com.

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.

June 2010

* 2–5 **Number Theory and Representation Theory—A conference in honor of Dick Gross' 60th birthday**, Science Center, Harvard University, Cambridge, Massachusetts.
Description: A conference focusing on the many exciting interactions between number theory and representation theory.
Speakers: Manjul Bhargava, Henri Darmon, Samit Dasgupta, Noam Elkies, Wee-Teck Gan, Joe Harris, Mike Hopkins, Nick Katz, Curt McMullen, Steve Kudla, Dipendra Prasad, Mark Reeder, Gordan Savin, Doug Ulmer, Marie-France Vigneras, Jiu-Kang Yu, Don Zagier, and Shou-Wu Zhang. On the evening of June 4th, 2010, there will be a dinner in honor of Dick Gross' 60th birthday.
Information: http://www.math.harvard.edu/conferences/gross_10/index.html.

* 17–19 **Coimbra Meeting on 0-1 Matrix Theory and Related Topics**, Department of Mathematics, University of Coimbra, Portugal.
Description: Matrices with entries consisting only of zeros and ones, whose entry sums of rows and columns are constrained, play an active role in modern mathematics and its applications, extending far beyond their natural context of Matrix Theory, Combinatorics, or Graph Theory. The purpose of this meeting is to bring together mathematicians from different areas with a view to exploring a number of new properties on the set A(R,S), whose insertion tableau has a previously-fixed shape, and identifying fruitful avenues for further research. In spite of their extremely demanding nature, recent developments and procedures have evidenced a remarkable elegance and beauty, strengthening the interdisciplinary approach of the issue. It is the purpose of this meeting to attract more mathematicians to this exciting and important area, and to foster collaborations with other scientific users. This meeting is endorsed by the International Linear Algebra Society–ILAS.
Information: http://www.mat.uc.pt/~cmf/01MatrixTheory.

* 21–26 **"Alexandru Myller" Mathematical Seminar Centennial Conference**, "Al. I. Cuza" University of Iaşi, Romania.
Description: The Conference is a centennial celebration of the "Alexandru Myller" Mathematical Seminar of the "Al. I. Cuza" University of Iaşi. This celebration is also part of the anniversary of 150 years from the founding of the University of Iaşi. The Mathematical Seminar was founded in 1910 by the late Professor A. Myller, who obtained his Ph.D. degree at Göttingen in 1907. Besides a general session dedicated to the history of the Mathematical Seminar, there will be several sessions on the basic branches of mathematics listing both invited and contributed presentations.
Organizing Committee: Professors Viorel Barbu (chairman), Radu Miron, Constantin Corduneanu, Ovidiu Cârjă, Răzvan Lițcanu, Marius Durea. All current and former members of the "A. Myller" Mathematical Seminar are invited to participate. The invitation is also extended to all interested persons from the international mathematical community.
Information: http://www.math.uaic.ro/~Myller2010.

* 26–30 **2010 International Conference on Topology and its Applications**, Nafpaktos, Greece.
Description: The Department of Mathematics of the University of Patras and the Department of Telecommunication Systems and Networks of the T.E.I. of Messologhi with the hospitality of the city of Nafpaktos organize the 2010 International Conference on Topology and its Applications. All areas of Topology and its Applications are included (General topology, set-theoretic topology, geometric topology, algebraic topology, applied topology. In particular, topological groups, dimension theory, dynamical systems and continua theory, computational topology, history of topology). The conference is the continuation of the 2006 International Conference on Topology and its Applications (see http://www.math.upatras.gr/~aegion).
Organizing Committee: S. D.Iliadis (Chairman), D. N. Georgiou, I. E. Kougias, Th. Papathanasis.
Information: http://www.math.upatras.gr/~nafpaktos/; email: nafpaktos@math.upatras.gr.

August 2010

* 12–15 **International Conference on Recent Trends in Graph Theory and Combinatorics, ICRTGC-2010**, Cochin, India.
Information and Location: This conference is a Satellite Conference of the International Congress of Mathematicians to be held at Hyderabad, India, from August 19–27, 2010, http://www.icm2010.in.
Programme: The academic programme will consist of plenary and invited talks by eminent researchers in the field of Graph theory, Combinatorics and related topics, contributed presentations and mini symposia/special sessions on specific themes such as Algebraic Graph Theory, Metric Graph Theory and Graph Products, Graph Labeling and Graph Operators.
Contact: Ambat Vijayakumar, Convener ICRTGC-2010, Department of Mathematics, Cochin University of Science and Technology, Cochin-682 022 India. Email: icrtgc 2010 at gmail dot com; icrtgc2010 at cusat dot ac dot in. http://icrtgc2010.cusat.ac.in/.

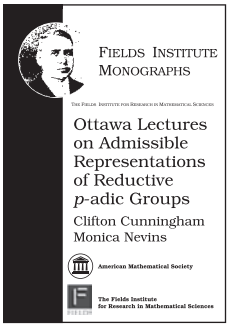
* 23–27 **International Workshop on Geodesics**, Chern Institute of Mathematics, Nankai University, Tianjin, China.
Description: This joint workshop of the American Institute of Mathematics (AIM) and the Chern Institute of Mathematics (CIM), sponsored by AIM, CIM, and the NSF, will be devoted to the study of the behavior of geodesics in the large. Although this is an old subject, with important contributions first made by J. Hadamard and H. Poincare, many of the fundamental problems are still open.
Information: http://aimath.org/ARCC/workshops/geodesics.html.

* 31–September 4 **Permanents and modeling probability distributions**, American Institute of Mathematics, Palo Alto, California.
Description: This workshop, sponsored by AIM and the NSF, will study the problem of estimating a probability distribution from a small data sample it generates. The workshop will investigate consolidating a theoretical and algorithmic framework for this topic.
Information: http://aimath.org/ARCC/workshops/permanents.html.

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



Ottawa Lectures on Admissible Representations of Reductive p-adic Groups

Clifton Cunningham, *University of Calgary, AB, Canada*, and **Monica Nevins**, *University of Ottawa, ON, Canada*, Editors

Ottawa Lectures offers researchers and graduate students a rare introduction to some of the major modern themes in the representation theory of p-adic groups: the classification and construction of their (complex) admissible representations, the calculation of their characters, and the realization of the celebrated local Langlands correspondence. Recent years have seen significant and rapid progress made toward each of these goals; the purpose of this book is to help bridge the gap from the classical literature to the forefront of research.

The first part of this volume is devoted to the tools and techniques used to classify and construct smooth representations of p-adic groups: the Bernstein decomposition, Bruhat–Tits theory and filtrations of subgroups, and an overview of J.-K. Yu's construction of supercuspidal representations, together with J.-L. Kim's proof that it is exhaustive. The second part begins with a historical overview of character computations and continues with an introduction to motivic integration. The volume concludes, in the third part, with an introduction to the local Langlands programme and a proof of the local Langlands correspondence for algebraic tori.

The chapters, written by leaders in this field, arose from lecture notes of mini-courses delivered at workshops held at the University of Ottawa in 2004 and 2007.

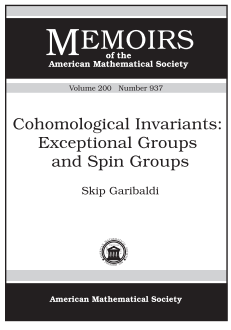
This item will also be of interest to those working in number theory.

Titles in this series are co-published with The Fields Institute for Research in Mathematical Sciences (Toronto, Ontario, Canada).

Contents: *Smooth representations:* **A. Roche**, The Bernstein decomposition and the Bernstein centre; **J.-K. Yu**, Bruhat–Tits theory and buildings; **J.-L. Kim**, Supercuspidal representations: Construction and exhaustion; *Character theory:* **P. J. Sally, Jr.** and **L. Spice**, Character theory of reductive p-adic groups; **J. Gordon** and **Y. Yaffe**, An overview of arithmetic motivic integration; *Local Langlands correspondence:* **P. Mezo**, Notes on the local Langlands program; **J.-K. Yu**, On the local Langlands correspondence for tori; Bibliography; Index.

Fields Institute Monographs, Volume 26

June 2009, 199 pages, Hardcover, ISBN: 978-0-8218-4493-9, LC 2009006750, 2000 *Mathematics Subject Classification:* 22E50; 14L15, 11S37, **AMS members US$55**, List US$69, Order code FIM/26



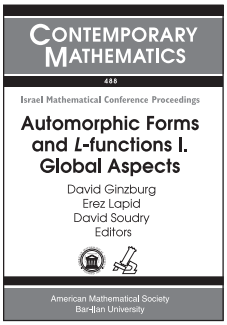
Cohomological Invariants: Exceptional Groups and Spin Groups

Skip Garibaldi, *Emory University, Atlanta, GA*
with an appendix by Detlev Hoffmann

Contents: Part I. Invariants, especially modulo an odd prime; Part II. Surjectivities and invariants of E_6, E_7, and E_8; Part III. Spin groups; Appendices; Bibliography; Index.

Memoirs of the American Mathematical Society, Volume 200, Number 937

June 2009, 81 pages, Softcover, ISBN: 978-0-8218-4404-5, LC 2009008059, 2000 *Mathematics Subject Classification:* 11E72; 12G05, 20G15, 17B25, **Individual member US$39**, List US$65, Institutional member US$52, Order code MEMO/200/937



Automorphic Forms and L-functions I

Global Aspects

David Ginzburg, *Tel-Aviv University, Israel*, **Erez Lapid**, *The Hebrew University of Jerusalem, Israel*, and **David Soudry**, *Tel-Aviv University, Israel*, Editors

This book is the first of two volumes, which represent leading themes of current research in automorphic forms and representation theory of reductive groups over local fields. Articles in this volume mainly represent global aspects of automorphic forms. Among the topics are the trace formula; functoriality; representations of reductive groups over local fields; the relative trace formula and periods of automorphic forms; Rankin–Selberg convolutions and L-functions; and p-adic L-functions. The articles are written by leading researchers in the field, and bring the reader, advanced graduate students and researchers alike, to the frontline of the vigorous research in these deep, vital topics. The companion volume (Contemporary Mathematics, Volume 489) is devoted to local aspects of automorphic forms.

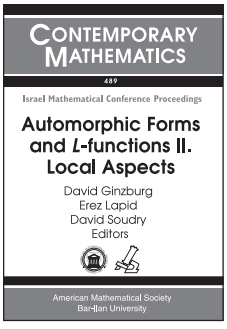
This item will also be of interest to those working in number theory.

This book is co-published with Bar-Ilan University (Ramat-Gan, Israel).

Contents: J. Arthur, Report on the trace formula; **A. Ben-Artzi** and **D. Soudry**, L-functions for $U_m \times R_{E/F}GL_n \left(n \leq \left[\frac{m}{2}\right]\right)$; **B. Brubaker**, **D. Bump**, and **S. Friedberg**, Gauss sum combinatorics and metaplectic Eisenstein series; **J. W. Cogdell** and **I. I. Piatetski-Shapiro**, On partial Poincaré series; **W. T. Gan**, **N. Gurevich**, and **G. Savin**, Restrictions of Saito-Kurokawa representations; **D. Ginzburg**, **D. Jiang**, and **S. Rallis**, Models for certain residual representations of unitary groups; **B. Krötz**, Crown theory for the upper half plane; **O. Offen**, Unitary periods and Jacquet's relative trace formula; **D. Ramakrishnan**, Remarks on the symmetric powers of cusp forms on $\mathbf{GL}(2)$; **J. Schwermer**, The cohomological approach to cuspidal automorphic representations.

Contemporary Mathematics, Volume 488

July 2009, 285 pages, Softcover, ISBN: 978-0-8218-4706-0, LC 2009000412, 2000 *Mathematics Subject Classification:* 11F70, 11F67; 11F72, 11F27, 11F33, 11F75, 11F80, **AMS members US$71**, List US$89, Order code CONM/488



Automorphic Forms and L-functions II

Local Aspects

David Ginzburg, *Tel-Aviv University, Israel*, **Erez Lapid**, *The Hebrew University of Jerusalem, Israel*, and **David Soudry**, *Tel-Aviv University, Israel*, Editors

This book is the second of two volumes, which represent leading themes of current research in automorphic forms and representation theory of reductive groups over local fields. Articles in this volume mainly represent global aspects of automorphic forms. Among the topics are the trace formula; functoriality; representations of reductive groups over local fields; the relative trace formula and periods of automorphic forms; Rankin–Selberg convolutions and L-functions; and p-adic L-functions. The articles are written by leading researchers in the field, and bring the reader, advanced graduate students and researchers alike, to the frontline of the vigorous research in these deep, vital topics. The companion volume (Contemporary Mathematics, Volume 488) is devoted to global aspects of automorphic forms.

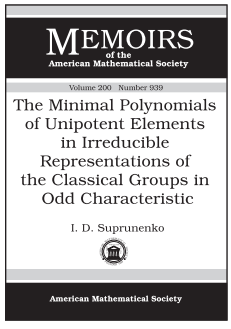
This item will also be of interest to those working in number theory.

This book is co-published with Bar-Ilan University (Ramat-Gan, Israel).

Contents: S. Böcherer and **A. A. Panchishkin**, p-adic interpolation for triple L-functions: Analytic aspects; **G. Henniart**, Sur les représentations modulo p de groupes réductifs p-adiques; **H. Jacquet**, Archimedean Rankin-Selberg integrals; **E. Lapid** and **J. Rogawski**, On a result of Venkatesh on Clozel's conjecture; **C. Mœglin**, Paquets d'Arthur discrets pour un groupe classique p-adique; **F. Shahidi** and **W. Kuo**, Complexity of group actions and stability of root numbers; **M. Tadić**, $GL(\mathbf{n}, \mathbb{C})\hat{}$ and $GL(\mathbf{n}, \mathbb{R})\hat{}$.

Contemporary Mathematics, Volume 489

August 2009, 313 pages, Softcover, ISBN: 978-0-8218-4708-4, LC 2009000412, 2000 *Mathematics Subject Classification:* 11F70; 11F85, 22E50, **AMS members US$79**, List US$99, Order code CONM/489



The Minimal Polynomials of Unipotent Elements in Irreducible Representations of the Classical Groups in Odd Characteristic

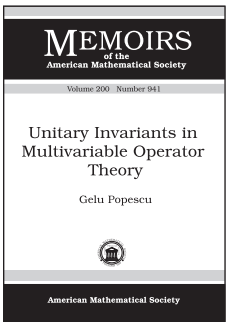
I. D. Suprunenko, *National Academy of Sciences of Belarus, Minsk, Belarus*

Contents: Introduction; Notation and preliminary facts; The general scheme of the proof of the main results; p-large representations; Regular unipotent elements for $n = p^s + b$, $0 < b < p$; A special case for $G = B_r(K)$; The exceptional cases in Theorem 1.7; Theorem 1.9 for regular unipotent elements and groups of types A, B, and C; The general case for regular elements; Theorem 1.3 for groups of types A_r and B_r and regular elements; Proofs of the main theorems; Some examples; Appendix. Tables; Appendix. Bibliography; Appendix. Index.

Memoirs of the American Mathematical Society, Volume 200, Number 939

June 2009, 154 pages, Softcover, ISBN: 978-0-8218-4369-7, LC 2009008895, 2000 *Mathematics Subject Classification:* 20G05, **Individual member US$43**, List US$72, Institutional member US$58, Order code MEMO/200/939

Analysis



Unitary Invariants in Multivariable Operator Theory

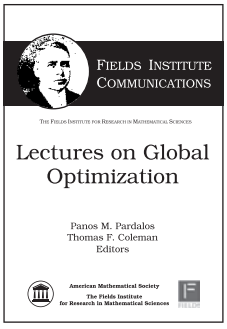
Gelu Popescu, *University of Texas at San Antonio, TX*

Contents: Introduction; Unitary invariants for n-tuples of operators; Joint operator radii, inequalities, and applications; Bibliography.

Memoirs of the American Mathematical Society, Volume 200, Number 941

June 2009, 91 pages, Softcover, ISBN: 978-0-8218-4396-3, LC 2009008282, 2000 *Mathematics Subject Classification:* 47A13, 47A20, 47A12; 47A56, 47A63, **Individual member US$39**, List US$65, Institutional member US$52, Order code MEMO/200/941

Applications



Lectures on Global Optimization

Panos M. Pardalos, *University of Florida, Gainesville, FL*, and **Thomas F. Coleman**, *University of Waterloo, ON, Canada*, Editors

A large number of mathematical models in many diverse areas of science and engineering have lead to the formulation of optimization problems where the best solution (globally optimal) is needed. Due to the interdisciplinary nature of global optimization, there has been astonishing progress in this field during the last few decades. Many powerful computational algorithms and new theoretical developments have been introduced to solve a spectrum of hard problems in several disciplines.

This book covers a small subset of recent important topics in global optimization with emphasis on recent theoretical developments and scientific applications. The chapters are based on the talks presented at the workshop on "Global Optimization: Methods and Applications" that was held at the Fields Institute from May 11–12, 2007. The target audience includes graduate students in mathematics, engineering, and sciences, academic researchers, as well as practitioners, who use global optimization for their specific needs and applications.

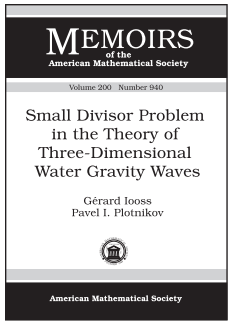
Titles in this series are co-published with the Fields Institute for Research in Mathematical Sciences (Toronto, Ontario, Canada).

Contents: **C. Audet**, **P. Hansen**, and **F. Messine**, Extremal problems for convex polygons—an update; **X. Bao** and **N. V. Sahinidis**, Finite algorithms for global minimization of separable concave programs; **J. Carlsson**, **D. Ge**, **A. Subramaniam**, and **Y. Ye**, Solving min-max multi-depot vehicle routing problem; **H.-D. Chiang**, **J.-H. Chen**, and **C. Reddy**, Trust-tech-based global optimization methodology for nonlinear programming; **V. Dua**, **K. Kouramas**, and **S. Pistikopoulos**, Global optimization issues in parametric programming and control; **C. A. Floudas** and **C. E. Gounaris**, An overview of advances in global optimization during 2003–2008; **O. E. Kundakcioglu** and **P. M. Pardalos**, Optimization in biomedical research; **J. D. Pintér**, Software development for global optimization; **L. Li**, **X. Zhu**, **D.-Z. Du**, **P. M. Pardalos**, and **W. Wu**, Connected dominating set in hypergraph; **A. Tsoukalas**, **W. Wiesemann**, and **B. Rustem**, Global optimisation of pessimistic bi-level problems.

Fields Institute Communications, Volume 55

July 2009, 243 pages, Hardcover, ISBN: 978-0-8218-4485-4, LC 2009004065, 2000 *Mathematics Subject Classification:* 90C26, 90C27, 90C29, 90C30, **AMS members US$79**, List US$99, Order code FIC/55

Differential Equations



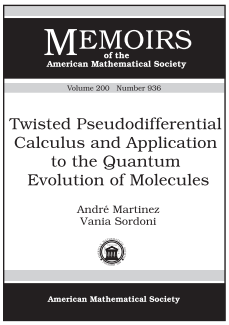
Small Divisor Problem in the Theory of Three-Dimensional Water Gravity Waves

Gérard Iooss, *Université de Nice, France*, and **Pavel I. Plotnikov**, *Lavrentyev Institute of Hydrodynamics RAS, Novosibirsk, Russia*

Contents: Introduction; Formal solutions; Linearized operator; Small divisors. Estimate of $\mathcal{L}-$ resolvent; Descent method-inversion of the linearized operator; Nonlinear Problem. Proof of Theorem 1.3; Appendix A. Analytical study of $\mathcal{G}_\eta$; Appendix B. Formal computation of 3-dimensional waves; Appendix C. Proof of Lemma 3.6; Appendix D. Proofs of Lemmas 3.7 and 3.8; Appendix E. Distribution of numbers $\{\omega_0 n^2\}$; Appendix F. Pseudodifferential operators; Appendix G. Dirichlet–Neumann operator; Appendix H. Proof of Lemma 5.8; Appendix I. Fluid particles dynamics; Bibliography.

Memoirs of the American Mathematical Society, Volume 200, Number 940

June 2009, 128 pages, Softcover, ISBN: 978-0-8218-4382-6, LC 2009008894, 2000 *Mathematics Subject Classification:* 76B15, 47J15, 35S15, 76B07, **Individual member US$40**, List US$67, Institutional member US$54, Order code MEMO/200/940



Twisted Pseudodifferential Calculus and Application to the Quantum Evolution of Molecules

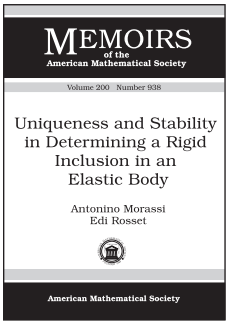
André Martinez and **Vania Sordoni**, *Università di Bologna, Italy*

This item will also be of interest to those working in applications.

Contents: Introduction; Assumptions and main results; A modified operator; Twisted h-admissible operators; Twisted partial differential operators; Construction of a quasi-invariant subspace; Decomposition of the evolution for the modified operator; Proof of Theorem 2.1; Proof of Corollary 2.6; Computing the effective Hamiltonian; Propagation of wave-packets; Application to polyatomic molecules; Appendix A. Smooth pseudodifferential calculus with operator-valued symbol; Appendix B. Propagation of the support; Appendix C. Two technical lemmas; Appendix. Bibliography.

Memoirs of the American Mathematical Society, Volume 200, Number 936

June 2009, 82 pages, Softcover, ISBN: 978-0-8218-4296-6, LC 2009008050, 2000 *Mathematics Subject Classification:* 35Q40, 81Q20; 35S99, 81Q05, 81Q10, 81S30, 81V55, **Individual member US$37**, List US$62, Institutional member US$50, Order code MEMO/200/936



Uniqueness and Stability in Determining a Rigid Inclusion in an Elastic Body

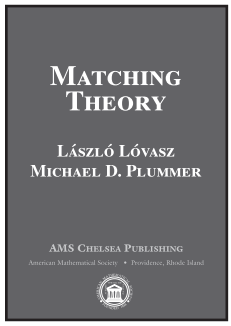
Antonino Morassi, *Università degli Studi di Udine, Italy*, and **Edi Rosset**, *Università degli Studi di Trieste, Italy*

Contents: Introduction; Main results; Proof of the uniqueness result; Proof of the stability result; Proof of Proposition 4.1; Stability estimates of continuation from Cauchy data; Proof of Proposition 4.2 in the 3-D case; A related inverse problem in electrostatics; Bibliography.

Memoirs of the American Mathematical Society, Volume 200, Number 938

June 2009, 58 pages, Softcover, ISBN: 978-0-8218-4325-3, LC 2009008260, 2000 *Mathematics Subject Classification:* 35R30; 35R25, 35J55, 74B05, **Individual member US$34**, List US$57, Institutional member US$46, Order code MEMO/200/938

Discrete Mathematics and Combinatorics



Matching Theory

László Lóvasz, *Eötvös Loránd University, Budapest, Hungary*, and **Michael D. Plummer**, *Vanderbilt University, Nashville, TN*

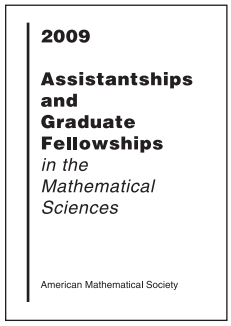
This book surveys matching theory, with an emphasis on connections with other areas of mathematics and on the role matching theory has played, and continues to play, in the development of some of these areas. Besides basic results on the existence of matchings and on the matching structure of graphs, the impact of matching theory is discussed by providing crucial special cases and nontrivial examples on matroid theory, algorithms, and polyhedral combinatorics. The new Appendix outlines how the theory and applications of matching theory have continued to develop since the book was first published in 1986, by launching (among other things) the Markov Chain Monte Carlo method.

Contents: Matchings in bipartite graphs; Flow theory; Size and structure of maximum matchings; Bipartite graphs with perfect matchings; General graphs with perfect matchings; Some graph-theoretical problems related to matchings; Matching and linear programming; Determinants and matchings; Matching algorithms; The f-factor problem; Matroid matching; Vertex packing and covering; Appendix: Developments in matching theory since this book was first published; References; Index of terms; Index of symbols; Errata.

AMS Chelsea Publishing, Volume 367

August 2009, 547 pages, Hardcover, ISBN: 978-0-8218-4759-6, LC 2009007644, 2000 *Mathematics Subject Classification:* 05C70, 05C07, 05C85, 05B35, 90C27, 90C57, **AMS members US$71**, List US$79, Order code CHEL/367.H

General and Interdisciplinary



Assistantships and Graduate Fellowships in the Mathematical Sciences 2009

From a review of a previous edition:

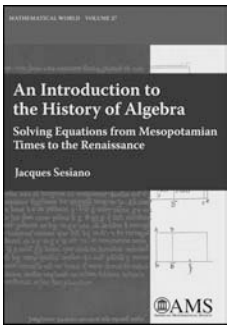
This directory is a tool for undergraduate mathematics majors seeking information about graduate programs in mathematics. Although most of the information can be gleaned from the Internet, the usefulness of this directory for the prospective graduate student is the consistent format for comparing different mathematics graduate programs without the hype. Published annually, the information is up-to-date, which is

more than can be said of some websites. Support for graduate students in mathematics is a high priority of the American Mathematical Society, which also provides information for fellowships and grants they offer as well as support from other societies and foundations. The book is highly recommended for academic and public libraries.

—***American Reference Books Annual***

This valuable reference source brings together a wealth of information about resources available for graduate study in mathematical sciences departments in the U.S. and Canada.

November 2009, approximately 100 pages, Softcover, ISBN: 978-0-8218-4868-5, **Individual member US$18**, List US$23, Order code ASST/2009



An Introduction to the History of Algebra

Solving Equations from Mesopotamian Times to the Renaissance

Jacques Sesiano, *Swiss Federal Institute of Technology, Lausanne, Switzerland*
Translated by Anna Pierrehumbert

This text should not be viewed as a comprehensive history of algebra before 1600, but as a basic introduction to the types of problems that illustrate the earliest forms of algebra. It would be particularly useful for an instructor who is looking for examples to help enliven a course on elementary algebra with problems drawn from actual historical texts.

—***Warren Van Egmond about the French edition for MathSciNet***

This book does not aim to give an exhaustive survey of the history of algebra up to early modern times but merely to present some significant steps in solving equations and, wherever applicable, to link these developments to the extension of the number system. Various examples of problems, with their typical solution methods, are analyzed, and sometimes translated completely. Indeed, it is another aim of this book to ease the reader's access to modern editions of old mathematical texts, or even to the original texts; to this end, some of the problems discussed in the text have been reproduced in the appendices in their original language (Greek, Latin, Arabic, Hebrew, French, German, Provençal, and Italian) with explicative notes.

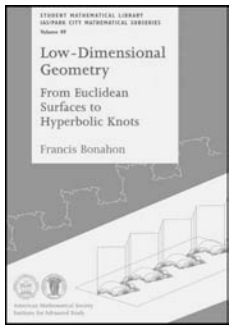
This item will also be of interest to those working in algebra and algebraic geometry, analysis, and differential equations.

Contents: Algebra in Mesopotamia; Algebra in ancient Greece; Algebra in the Islamic world; Algebra in medieval Europe; Algebra in the Renaissance; Appendix A. Mesopotamian texts in translation; Appendix B. Greek and Latin texts; Appendix C. Arabic texts; Appendix D. Hebrew text; Appendix E. French, German, Italian, and Provençal texts; Index.

Mathematical World, Volume 27

July 2009, 176 pages, Softcover, ISBN: 978-0-8218-4473-1, LC 2009008068, 2000 *Mathematics Subject Classification:* 01A05, 17-XX, 20-XX, 30-XX, 35-XX, 40-XX, **AMS members US$28**, List US$35, Order code MAWRLD/27

Geometry and Topology



Low-Dimensional Geometry

From Euclidean Surfaces to Hyperbolic Knots

Francis Bonahon, *University of Southern California, Los Angeles, CA*

The study of 3-dimensional spaces brings together elements from several areas of mathematics. The most notable are topology and geometry, but elements of number theory and analysis also make appearances. In the past 30 years, there have been striking developments in the mathematics of 3-dimensional manifolds. This book aims to introduce undergraduate students to some of these important developments.

Low-Dimensional Geometry starts at a relatively elementary level, and its early chapters can be used as a brief introduction to hyperbolic geometry. However, the ultimate goal is to describe the very recently completed geometrization program for 3-dimensional manifolds. The journey to reach this goal emphasizes examples and concrete constructions as an introduction to more general statements. This includes the tessellations associated to the process of gluing together the sides of a polygon. Bending some of these tessellations provides a natural introduction to 3-dimensional hyperbolic geometry and to the theory of kleinian groups, and it eventually leads to a discussion of the geometrization theorems for knot complements and 3-dimensional manifolds.

This book is illustrated with many pictures, as the author intended to share his own enthusiasm for the beauty of some of the mathematical objects involved. However, it also emphasizes mathematical rigor and, with the exception of the most recent research breakthroughs, its constructions and statements are carefully justified.

This volume was co-published with the Institute for Advanced Study/Park City Mathematics Institute.

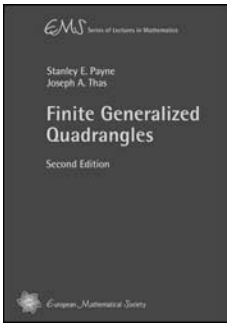
Contents: The euclidean plane; The hyperbolic plane; The 2-dimensional sphere; Gluing constructions; Gluing examples; Tessellations; Group actions and fundamental domains; The Farey tessellation and circle packing; The 3-dimensional hyperbolic space; Kleinian groups; The figure-eight knot complement; Geometrization theorems in dimension 3; Tool kit; Bibliography and references; Index.

Student Mathematical Library, Volume 49

August 2009, approximately 391 pages, Softcover, ISBN: 978-0-8218-4816-6, LC 2009005856, 2000 *Mathematics Subject Classification:* 51M05, 51M10, 30F40, 57M25, **AMS members US$43**, List US$54, Order code STML/49

New AMS-Distributed Publications

Discrete Mathematics and Combinatorics



Finite Generalized Quadrangles

Second Edition

Stanley E. Payne, *University of Colorado, Denver, CO*, and **Joseph A. Thas**, *Ghent University, Belgium*

Generalized quadrangles (GQ) were formally introduced by J. Tits in 1959 to describe geometric properties of simple groups of Lie type of rank 2. The first edition of *Finite Generalized Quadrangles* (FGQ) quickly became the standard reference for finite GQ.

The second edition is essentially a reprint of the first edition. It is a careful rendering into LaTeX of the original, along with an appendix that brings to the attention of the reader those major new results pertaining to GQ, especially in those areas where the authors of this work have made a contribution.

The first edition has been out of print for many years. The new edition makes available again this classical reference in the rapidly increasing field of finite geometries.

This item will also be of interest to those working in geometry and topology.

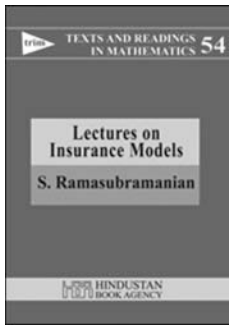
A publication of the European Mathematical Society (EMS). Distributed within the Americas by the American Mathematical Society.

Contents: Combinatorics of finite generalized quadrangles; Subquadrangles; The known generalized quadrangles and their properties; Generalized quadrangles in finite projective spaces; Combinatorial characterizations of the known generalized quadrangles; Generalized quadrangles with small parameters; Generalized quadrangles in finite affine spaces; Elation generalized quadrangles and translation generalized quadrangles; Moufang conditions; Generalized quadrangles as group coset geometries; Coordinatization of generalized quadrangles with $s = t$; Generalized quadrangles as amalgamations of desarguesian planes; Generalizations and related topics; Appendix. Development of the theory of GQ since 1983; Bibliography; Index.

EMS Series of Lectures in Mathematics, Volume 9

April 2009, 298 pages, Softcover, ISBN: 978-3-03719-066-1, 2000 *Mathematics Subject Classification:* 05-02, 51-02, 05B05, 05B25, 51B10, 51B15, 51B20, 51E05, 51E12, 51E14, 51E20, 51E21, 51E30, **AMS members US$35**, List US$44, Order code EMSSERLEC/9

Probability



Lectures on Insurance Models

S. Ramasubramanian, *Indian Statistical Institute, Bangalore, India*

Insurance has become a necessary aspect of modern society. The mathematical basis of insurance modelling is best expressed in terms of continuous time stochastic processes.

This introductory text on actuarial risk theory deals with the Cramer–Lundberg model and the renewal risk model. Their basic structure and properties, including the renewal theorems as well as the corresponding ruin problems, are studied. There is a detailed discussion of heavy tailed distributions, which have become increasingly relevant. The Lundberg risk process with investment in risky asset is also considered.

This book will be useful to practitioners in the field and to graduate students interested in this important branch of applied probability.

A publication of Hindustan Book Agency. Distributed on an exclusive basis by the AMS in North America. Online bookstore rights worldwide.

Contents: Introduction; Poisson model; Renewal model; Claim size distributions; Ruin problems; Lundberg risk process with investment; Appendix 1. Basic notions; Appendix 2. On the central limit problem; Appendix 3. Martingales; Appendix 4. Brownian motion and Itô integrals; Bibliography; Index.

Hindustan Book Agency

April 2009, 206 pages, Hardcover, ISBN: 978-81-85931-93-7, 2000 *Mathematics Subject Classification:* 91B30; 60K05, 62P05, 60Exx, 60Gxx, 60Jxx, 60H20, 91B28, **AMS members US$35**, List US$44, Order code HIN/41

Classified Advertisements

Positions available, items for sale, services available, and more

DELAWARE

DELAWARE STATE UNIVERSITY
Department of Mathematical Sciences
Chairperson/Associate or Full Professor

Delaware State University invites applications for the position Chairperson of Department of Mathematical Sciences. The department offers baccalaureate and master's degrees in mathematics and mathematical education, and has an interdisciplinary Ph.D. program in applied mathematics. The department also supports the mathematics component of the universities general education program. The successful candidate must have a Ph.D. in mathematics, mathematics education or a closely related field. The candidate must have experience in research, teaching, and service and have a successful record in grant writing and publication. The candidate should also have outstanding leadership, interpersonal, and communication skills. Application requires 1) application letter, 2) curriculum vitae, 3) research statement, 4) teaching philosophy, 5) administrative philosophy, 6) transcripts (official transcripts will be required prior to employment) 7) evidence of authorization to work in the United States, and 8) two letters of reference sent to: Dr. Richard Barczewski, Chair Search Committee, College of Mathematics, Natural Sciences, and Technology, Delaware State University, 1200 N. DuPont Highway, Dover, DE 19901. Applications will be considered until the position is filled. For first consideration, send completed application by May 30, 2009.

000027

SOUTH CAROLINA

UNIVERSITY OF SOUTH CAROLINA
Call for Nominations for Vasil Popov Prize

The Vasil Popov Prize is awarded every three years for outstanding research contributions in fields related to the work of Vasil A. Popov, who is best known for his contributions to Approximation Theory. Candidates must have received their Ph.D. within the previous six years. Nominations should include a brief description of the relevant work and a vita of the candidate. The deadline for nominations is November 1, 2009. Nominations should be sent to Pencho Petrushev, Chair, Popov Prize Selection Committee, Department of Mathematics, University of South Carolina, Columbia, SC 29208; email: popov@math.sc.edu. For further information, visit the website: http://www.math.sc.edu/~popov/.

000031

TEXAS

THE UNIVERSITY OF TEXAS AT SAN ANTONIO
Associate/Full Professor
Mathematics

The Department of Mathematics in the College of Sciences at The University of Texas at San Antonio (UTSA) invites applications for one tenured position at the associate or full professor level. With a student body of over 28,000 students, UTSA is now the second largest component of The University of Texas system and is an emerging institution expanding to become a tier one university and developing a national reputation for excellence.

Responsibilities include conducting an active research program; teaching both graduate and undergraduate courses that are offered at both the UTSA 1604 and downtown campuses; seeking grant funding; serving on thesis committees; and providing service to the department, college, university, and community constituencies. The successful candidate will be expected to assist the department in strengthening and finalizing its evolving proposal for a Ph.D. degree in mathematics.

Associate/Full Professor Required Qualifications: (1) Ph.D. degree in mathematics; (2) strong research record in mathematics as appropriate for the level of the position; and (3) university teaching experience commensurate with the position.

Associate/Full Professor Preferred Qualifications: (1) Outstanding research

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 2007 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: August 2009 issue–May 28, 2009; September 2009 issue–June 29, 2009; October 2009 issue–July 29, 2009; November 2009 issue–August 28, 2009; December 2009 issue–September 28, 2009; January 2010 issue–October 28, 2009.

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.

achievements in the areas of analysis or algebra (or other fields of interest of our current faculty: http://math.utsa.edu/) receive special attention, but candidates who present a record of exceptional accomplishments in any research area in mathematics are also considered and (2) experience and success in seeking and obtaining external funding.

Initial Screening: Qualified candidates must submit an application letter that addresses the required and preferred qualifications; current curriculum vitae; 1 to 2 page description of research agenda; copies of 2 to 3 published, peer-reviewed research articles; and the names, addresses, email addresses, and telephone numbers of three references. The review of applications will begin immediately and will continue until the position is filled.

All applicants should send application materials to: Math Faculty Position, c/o Wanda Crotty, Department of Mathematics, The University of Texas at San Antonio, One UTSA Circle, San Antonio, TX 78249, mathfacultyad@utsa.edu.

UTSA is an Affirmative Action/Equal Employment Opportunity Employer. Women, minorities, veterans, and individuals with disabilities are encouraged to apply. Applicants who are selected for interviews must be able to show proof that they will be eligible and qualified to work in the United States. This position is pending budget approval.

000032

ENGLAND

ALL SOULS COLLEGE
OXFORD
Senior Research Fellowships

All Souls College proposes to elect up to four Senior Research Fellows with effect from 1st October 2010 (or an agreed later date): in Classical Studies, in Law, and in Mathematics (all subjects broadly conceived).

A Senior Research Fellowship is of comparable academic standing to a professorship in the University of Oxford. Applicants are expected to have a correspondingly distinguished record of achievement in research.

Further particulars, including details of salary and other terms of appointment, may be obtained from the Warden's Secretary, All Souls College, Oxford OX1 4AL; mary.yoe@all-souls.ox.ac.uk. See also the college's website: http://www.all-souls.ox.ac.uk. The deadline for applications will be Friday, 25th September 2009.

Potential mathematical candidates may contact graeme.segal@all-souls.ox.ac.uk or dan.segal@all-souls.ox.ac.uk for more information about the position.

All Souls College is an Equal Opportunities Employer.

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SAUDI ARABIA

KING SAUD UNIVERSITY
Riyadh, Kingdom of Saudi Arabia

King Saud University invites distinguished Ph.D. holders in the field of mathematics to join the university staff.

Requirements:

· Ph.D. holders from well-respected universities in Europe and/or USA

· with experience both in teaching and research.

Please send your application and CVs to: ndaghri@ksu.edu.sa. For more information please visit: http://www.ksu.edu.sa; http://faculty.ksu.edu.sa/5781/default.aspx.

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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: June 30, 2009
For abstracts: August 25, 2009

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, *Title to be announced.*

Alexander A. Kiselev, University of Wisconsin, *Title to be announced.*

Michael C. Reed, Duke University, *Title to be announced.*

Igor Rodnianski, Princeton University, *Title to be announced.*

Special Sessions

Applicable Algebraic Geometry (Code: SS 12A), **Luis David Garcia-Puente**, Sam Houston State University, and **Frank Sotille**, Texas A&M University.

Commutative Algebra: Module and Ideal Theory (Code: SS 4A), **Lars W. Christensen**, Texas Tech University, **Louiza Fouli**, University of Texas at Austin, and **David Jorgensen**, University of Texas at Arlington.

Contemporary Complex and Special Function Theory (Code: SS 14A), **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 (Code: SS 1A), **John M. Davis**, **Ian A. Gravagne**, and **Robert J. Marks**, Baylor University.

Formations of Singularities in Geometric Flows (Code: SS 15A), **Maria-Cristina Caputo**, University of Texas at Austin, and **Natasa Sesum**, Columbia University.

Fusion Categories and Applications (Code: SS 7A), **Deepak Naidu** and **Eric Rowell**, Texas A&M University.

Global Analysis on Homogeneous Spaces (Code: SS 13A), **Ruth Gornett**, University of Texas at Arlington, and **Ken Richardson**, Texas Christian University.

Harmonic Analysis and Partial Differential Equations (Code: SS 8A), **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 (Code: SS 11A), **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 (Code: SS 6A), **Markus Hunziker**, **Mark Sepanski**, and **Ronald Stanke**, Baylor University.

Mathematical Models of Neuronal and Metabolic Mechanisms (Code: SS 3A), **Janet Best**, Ohio State University, and **Michael Reed**, Duke University.

Mathematical Aspects of Spectral Problems Related to Physics (Code: SS 10A), **Klaus Kirsten**, Baylor University, **Gregory Berkolaiko** and **Stephen Fulling**, Texas A&M University, **Jon Harrison**, Baylor University, and **Peter Kuchment**, Texas A&M University.

Numerical Solutions of Singular or Perturbed Partial Differential Equation Problems with Applications (Code: SS 2A), **Peter Moore**, Southern Methodist University, and **Qin Sheng**, Baylor University.

Recent Developments on Turbulence (Code: SS 9A), **Eleftherios Gkioulekas**, University of Texas-Pan American, and **Michael Jolly**, Indiana University.

The Topology of Continua (Code: SS 16A), **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 (Code: SS 5A), **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: July 7, 2009
For abstracts: September 1, 2009

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Michael K. H. Kiessling, Rutgers University, *Title to be announced.*

Kevin R. Payne, Universita degli di Milano, *Title to be announced.*

Laurent Saloff-Coste, Cornell University, *Title to be announced.*

Robert C. Vaughan, Pennsylvania State University, *Title to be announced.*

Special Sessions

Algebraic Combinatorics (Code: SS 6A), **Peter McNamara**, Bucknell University, and **Mark Skandera**, Lehigh University.

Analytic Number Theory (Code: SS 16A), **Angel V. Kumchev**, Towson University, **Michael P. Knapp**, Loyola College, and **Robert C. Vaughan**, Pennsylvania State University.

Arithmetic and Profinite Groups (Code: SS 19A), **Alireza Salehi-Golsefidy**, Princeton University, **Martin D. Kassabov**, Cornell University, and **Mikhail V. Ershov**, University of Virginia.

Automorphisms of Riemann Surfaces and Related Topics (Code: SS 15A), **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 (Code: SS 3A), **Amanda I. Beecher**, United States Military Academy, and **Alexandre B. Tchernev**, University at Albany.

Commutative Algebra and Applications to Algebraic Geometry (Code: SS 11A), **Janet Striuli**, Fairfield University, and **Jooyoun Hong**, Southern Connecticut State University.

Difference Equations and Applications (Code: SS 2A), **Michael A. Radin**, Rochester Institute of Technology.

Function Fields and Their Applications (Code: SS 20A), **Mihran Papikian** and **Kirsten Eisentrager**, Pennsylvania State University.

Geometry of Integrable and Non-Integrable Dynamics (Code: SS 5A), **Boris Khesin**, University of Toronto, and **Mark Levi** and **Sergei Tabachnikov**, Pennsylvania State University.

Heat Kernel Analysis (Code: SS 8A), **Maria Gordina**, University of Connecticut, and **Laurent Saloff-Coste**, Cornell University.

Homotopy Theory (Code: SS 1A), **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 (Code: SS 4A), **Sam Evans** and **Michael Gekhtman**, University of Notre Dame, and **Luen-Chau Li**, Pennsylvania State University.

Microlocal Analysis and Spectral Theory on Singular Spaces (Code: SS 14A), **Juan B. Gil** and **Thomas Krainer**, Pennsylvania State University, Altoona.

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: July 14, 2009
For abstracts: September 8, 2009

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Spyros Alexakis, Massachusetts Institute of Technology, *Title to be announced.*

Kai-Uwe Bux, University of Virginia, *Title to be announced.*

Dino J. Lorenzini, University of Georgia, *Title to be announced.*

Eduardo D. Sontag, Rutgers University, *Title to be announced.*

Special Sessions

Applied Partial Differential Equations (Code: SS 10A), **Shar Sajjadi** and **Timothy A. Smith**, Embry Riddle Aeronautical University.

Arithmetic Geometry (Code: SS 16A), **Pete L. Clark** and **Dino Lorenzini**, University of Georgia.

Commutative Ring Theory (Code: SS 3A), **Alan Loper**, Ohio State University, and **Lee C. Klingler**, Florida Atlantic University.

Concentration, Functional Inequalities, and Isoperimetry (Code: SS 2A), **Mario Milman**, Florida Atlantic University, **Christian Houdre**, Georgia Institute of Technology, and **Emanuel Milman**, Institute for Advanced Study.

Constructive Mathematics (Code: SS 1A), **Robert Lubarsky**, **Fred Richman**, and **Martin Solomon**, Florida Atlantic University.

Dynamical Systems (Code: SS 6A), **William D. Kalies** and **Vincent Naudot**, Florida Atlantic University.

Enumerative Combinatorics (Code: SS 4A), **Christian Krattenthaler**, University of Vienna, and **Aaron D. Meyerowitz**, **Heinrich Niederhausen**, and **Wandi Wei**, Florida Atlantic University.

General Relativity and Related Partial Differential Equations (Code: SS 18A), **Spyridon Alexakis**, Massachusetts Institute of Technology, and **Gilbert Weinstein**, University of Alabama Birmingham.

Geometry and Topology (Code: SS 20A), **Alexander N. Dranishnikov** and **Yuli B. Rudyak**, University of Florida.

Graded Resolutions (Code: SS 13A), **Christopher Francisco**, Oklahoma State University, and **Irena Peeva**, Cornell University.

Graph Theory (Code: SS 11A), **Zixia Song** and **Yue Zhao**, University of Central Florida.

Harmonic Analysis (Code: SS 5A), **Galia D. Dafni**, Concordia University, and **J. Michael Wilson**, University of Vermont, Burlington.

Homological Aspects of Module Theory (Code: SS 7A), **Andrew R. Kustin**, University of South Carolina, **Sean M. Sather-Wagstaff**, North Dakota State University, and **Janet Vassilev**, University of New Mexico.

Hypercomplex Analysis (Code: SS 12A), **Craig A. Nolder**, Florida State University, and **John Ryan**, University of Arkansas at Fayetteville.

Invariants of Knots and Links (Code: SS 9A), **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 (Code: SS 14A), **M. Zuhair Nashed** and **Qiyu Sun**, University of Central Florida.

Lattices, Coxeter Groups, and Buildings (Code: SS 19A), **Kai-Uwe Bux**, University of Virginia, **Jon McCammond**, University of California Santa Barbara, and **Kevin Wortman**, University of Utah.

Mathematical Models in Biology (Code: SS 17A), **Patrick de Leenheer**, University of Florida, and **Yuan Wang**, Florida Atlantic University.

Modular Forms and Automorphic Forms (Code: SS 21A), **Jonathan P. Hanke**, University of Georgia.

Partial Differential Equations from Fluid Mechanics (Code: SS 15A), **Chongsheng Cao**, Florida International University, **Jiahong Wu**, Oklahoma State University, and **Baoquan Yuan**, Henan Polytechnic University.

Recent Advances in Probability and Statistics (Code: SS 8A), **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: July 21, 2009
For abstracts: September 15, 2009

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, *Title to be announced.*

Birge Huisgen-Zimmerman, University of California Santa Barbara, *Title to be announced*.

Jun Li, Stanford University, *Title to be announced*.

Joseph Teran, University of California Los Angeles, *Title to be announced*.

Special Sessions

Algebraic Geometry (Code: SS 1A), **Christopher Hacon**, University of Utah, and **Ziv Ran**, University of California Riverside.

Algebraic Structures in Knot Theory (Code: SS 17A), **Alissa S. Crans**, Loyola Marymount University, and **Sam Nelson**, Claremont McKenna College.

Arithmetic Combinatorics (Code: SS 16A), **Mei-Chu Chang**, University of California Riverside, and **Alex Gamburd**, University of California Santa Cruz and Northwestern University.

Calabi-Yau Manifolds (Code: SS 15A), **Owen Dearricott**, University of California Riverside, **Jun Li**, Stanford University, and **Bun Wong** and **Yat-Sun Poon**, University of California Riverside.

Dynamical Systems (Code: SS 18A), **Nicolai Haydn**, University of Southern California, and **Huyi Hu**, Michigan State University.

Fluid Mechanics (Code: SS 5A), **James Kelliher** and **Qi Zhang**, University of California Riverside.

Fractal Geometry, Dynamical Systems, Number Theory and Analysis on Rough Spaces (Code: SS 6A), **Michel L. Lapidus**, University of California Riverside, **Hung Lu**, Hawaii Pacific University, and **Erin P. J. Pearse**, University of Iowa.

Global Riemannian Geometry (Code: SS 14A), **Fred Wilhelm**, University of California Riverside, and **Peter Petersen**, University of California Los Angeles.

History and Philosophy of Mathematics (Code: SS 4A), **Shawnee L. McMurran**, California State University San Bernardino, and **James J. Tattersall**, Providence College.

Homotopy Theory and Higher Algebraic Structures (Code: SS 8A), **John Baez** and **Julie Bergner**, University of California Riverside.

Interactions Between Algebraic Geometry and Noncommutative Algebra (Code: SS 9A), **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 (Code: SS 11A), **Martin Scharlemann**, University of California Santa Barbara, and **Mohammed Ait Nouh**, University of California Riverside.

Noncommutative Geometry (Code: SS 2A), **Vasiliy Dolgushev** and **Wee Liang Gan**, University of California Riverside.

Operator Algebras (Code: SS 13A), **Marta Asaeda** and **Aviv Censor**, University of California Riverside, and **Adrian Ioana**, Clay Institute and Caltech.

Representation Theory (Code: SS 3A), **Vyjayanthi Chari**, **Wee Liang Gan**, and **Jacob Greenstein**, University of California Riverside.

Representations of Finite Dimensional Algebras (Code: SS 7A), **Frauke Bleher**, University of Iowa, **Birge Huisgen-Zimmermann**, University of California at Santa Barbara, and **Markus Schmidmeier**, Florida Atlantic University.

Research Conducted by Students (Code: SS 10A), **Robert G. Niemeyer** and **Jack R. Bennett**, University of California Riverside.

Stochastic Analysis and Applications (Code: SS 12A), **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: 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: October 31, 2009

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/internmtgs.html`.

AMS 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*.

AMS Special Sessions

(Code: SS 3A), **Jaeyoung Byeon**, Pohang University of Science & Technology, and **Zhi-Qiang Wang**, Utah State University.

(Code: SS 4A), **Youn-Seo Choi**, Korea Institute for Advanced Study, **YoungJu Choie**, Pohang University of

Science & Technology, and **Wen-ching Winnie Li**, Pennsylvania State University.

Algebraic Geometry (Code: SS 2A), **Yongnam Lee**, Sogang University, **Ian Morrison**, Fordham University, and **James McKernan**, University of California Santa Barbara.

Arithmetic of Quadratic Forms (Code: SS 13A), **Myung-Hwan Kim**, Seoul National University, and **Wai Kiu Chan**, Wesleyan University.

Combinatorial Matrix Theory (Code: SS 8A), **Suk-Geun Hwang** and **Bryan Shader**.

Combinatorics (Code: SS 17A), **Dongsu Kim**, Korea Advanced Institute of Science & Technology, **Soojin Cho**, and **Bruce Sagan**, Michigan State University.

Computational Science and Engineering (Code: SS 25A), **Jeehyun Lee**, Yonsei University, and **Max Gunzburger**, Florida State University.

Creativity, Giftedness, and Talent Development in Mathematics (Code: SS 23A), **Kyeong-Hwa Lee** and **Bharath Sriramanii**.

Cryptography (Code: SS 22A), **Hyang-Sook Lee**, and **Alice Silverberg**, University of California Irvine.

Differential and Integral Geometry (Code: SS 28A), **Young Jin Suh**, Kyungpook National University, **Byung Hak Kim**, Yonsei University, **Yongdo Lim**, Kyungpook National University, and **Ga Yong Zhang** and **Jiazu Zhou**.

Ergodic Theory and Dynamical Systems (Code: SS 18A), **Keonhee Lee**, **Jeong-Yup Lee**, Korea Institute for Advanced Study, and **Jane Hawkins**, University of North Carolina.

Financial Mathematics (Code: SS 10A), **Hyejin Ku** and **Hyunggeon Koo**, and **Kiseop Lee**, University of Louisville.

Geometric Structures and Geometric Group Theory (Code: SS 1A), **In Kang Kim**, Korea Advanced Institute of Science & Technology, and **Seonhee Lim**, Cornell University.

Geometry of Syzygies and Computations (Code: SS 6A), **Sijong Kwak**, Korea Advanced Institute of Science & Technology, **Hyungju Park**, Korea Institute for Advanced Study, and **Jerzy Weyman**, Northeastern University.

Harmonic Analysis and Its Applications (Code: SS 12A), **Sunggeum Hong**, Chosun University, and **Andreas Seeger**, University of Wisconsin.

Inverse Problems and Imaging (Code: SS 19A), **Hyeonbae Kang**, Inha University, and **Gunther Uhlmann**, University of Washington.

Knot Theory and Related Topics (Code: SS 24A), **Jae Choon Cha**, Pohang University of Science and Technology.

Lie Symmetries and Solitons (Code: SS 11A), **Woo-Pyo Hong**, **Anjan Biswas**, Delaware State University, and **Chaudry M. Khalique**, North-West University.

Mathematical Analysis in Fluid, Gas Dynamics, and Related Equations (Code: SS 21A), **Minkyu Kwak**, **Hyeong-Ohk Bae**, Ajou University, **Seung-Yeal Ha**, Seoul National University, and **Simon Seok Hwang**, LaGrange College.

Mathematical Biology (Code: SS 26A), **Eunok Jung**, Konkuk University, and **Jae-Hun Jung**, SUNY at Buffalo.

Mathematical Logic and Foundation (Code: SS 27A), **Byunghan Kim**, Yonsei University, and **Ivo Herzog**, Ohio State University.

Noncommutative Ring Theory (Code: SS 7A), **Yang Lee**.

Nonlinear Partial Differential Equations and Viscosity (Code: SS 15A), **Ki-ahm Lee**, Seoul National University, and **Inwon Kim**, University of California Los Angeles.

Operator Theory and Operator Algebras (Code: SS 9A), **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 (Code: SS 20A), **Hyung Woon Koo**, Korea University, **Boo Rim Choe**, and **Kehe Zhu**, SUNY at Albany.

Representation Theory (Code: SS 5A), **Jae-Hoon Kwan**, University of Seoul, and **Kyu-Hwan Lee**, University of Connecticut.

Spectral Geometry and Global Analysis (Code: SS 16A), **Jinsung Park**, Korea Institute for Advanced Study, and **Maxim Braverman**, Northeastern University.

Symplectic Geometry and Mirror Symmetry (Code: SS 14A), **Jae-Suk Park**, **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: July 28, 2009
For abstracts: September 22, 2009

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/national.html`.

AMS Invited Addresses

James G. Glimm, Stony Brook University, *Title to be announced* (AMS Retiring Presidential Address).

Olga Holtz, University of California Berkeley, *Title to be announced.*

Richard W. Kenyon, Brown University, *Title to be announced.*

Igor Y. Rodnianski, Princeton University, *Title to be announced.*

Peter W. Shor, Massachusetts Institute of Technology, *Title to be announced* (AMS Josiah Willard Gibbs Lecture).

Richard P. Stanley, MIT, *Title to be announced* (AMS Colloquium Lectures.

Amie Wilkinson, Northwestern University, *Title to be announced.*

Lexington, Kentucky

University of Kentucky

March 27–28, 2010

Saturday – Sunday

Meeting #1057

Southeastern Section
Associate secretary: Matthew Miller
Announcement issue of *Notices*: January
Program first available on AMS website: February 11, 2010
Program issue of electronic *Notices*: March
Issue of *Abstracts*: Volume 31, Issue 2

Deadlines

For organizers: August 28, 2009
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, University of Virginia, *Title to be announced.*

Bruce Reznick, University of Illinois at Urbana Champaign, *Title to be announced.*

Bernd Ulrich, Purdue University, *Title to be announced.*

Doron Zeilberger, Rutgers University, *Title to be announced* (Erdős Memorial Lecture).

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: September 10, 2009
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.*

Vladimir Touraev, University of Indiana, *Title to be announced.*

Peter Webb, University of Minnesota, *Title to be announced.*

Special Sessions

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.

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: September 17, 2009

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.*

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 2010
Program first available on AMS website: April 8, 2010
Program issue of electronic *Notices*: May
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.

Berkeley, California

University of California Berkeley

June 2–5, 2010

Wednesday – Saturday

Meeting #1061

Eighth Joint International Meeting of the AMS and the Sociedad Matemáica 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.*

Syracuse, New York

Syracuse University

October 2–3, 2010

Saturday – Sunday

Meeting #1062

Eastern Section
Associate secretary: Steven H. Weintraub
Announcement issue of *Notices*: June/July 2010
Program first available on AMS website: August 19, 2010
Program issue of electronic *Notices*: October 2010
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

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.*

David Fisher, Indiana University, *Title to be announced.*

Jared Wunsch, Northwestern University, *Title to be announced.*

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

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

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

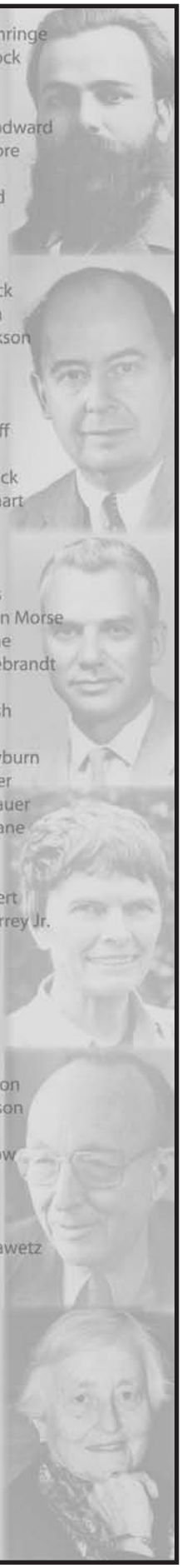
For organizers: April 1, 2014
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

AMS PRESIDENTS

A TIMELINE

AMS presidents play a key role in leading the Society and representing the profession. Browse through the timeline to see each AMS president's page, which includes the institution and date of his/her doctoral degree, a brief note about his/her academic career and honors, and links to more extensive biographical information.

John Howard Van Amringe
John Emory McClintock
George William Hill
Simon Newcomb
Robert Simpson Woodward
Eliakim Hastings Moore
Thomas Scott Fiske
William Fogg Osgood
Henry Seely White
Maxime Bôcher
Henry Burchard Fine
Edward Burr Van Vleck
Ernest William Brown
Leonard Eugene Dickson
Frank Morley
Gilbert Ames Bliss
Oswald Veblen
George David Birkhoff
Virgil Snyder
Earle Raymond Hedrick
Luther Pfahler Eisenhart
Arthur Byron Coble
Solomon Lefschetz
Robert Lee Moore
Griffith Conrad Evans
Harold Calvin Marston Morse
Marshall Harvey Stone
Theophil Henry Hildebrandt
Einar Hille
Joseph Leonard Walsh
John von Neumann
Gordon Thomas Whyburn
Raymond Louis Wilder
Richard Dagobert Brauer
Edward James McShane
Deane Montgomery
Joseph Leo Doob
Abraham Adrian Albert
Charles Bradfield Morrey Jr.
Oscar Zariski
Nathan Jacobson
Saunders Mac Lane
Lipman Bers
R H Bing
Peter David Lax
Andrew Mattel Gleason
Julia Bowman Robinson
Irving Kaplansky
George Daniel Mostow
William Browder
Michael Artin
Ronald L. Graham
Cathleen Synge Morawetz
Arthur M. Jaffe
Felix E. Browder
Hyman Bass
David Eisenbud
James G. Arthur



www.ams.org/ams/amspresidents.html

AMERICAN MATHEMATICAL SOCIETY

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

Conferences: (see http://www.ams.org/meetings/ for the most up-to-date information on these conferences.)
Co-sponsored conferences:
June 13–July 3, 2009: Mathematics Research Communities, Snowbird, UT (see www.ams.org/amsmtgs/mrc.html for more information).
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).

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