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Notices

of the American Mathematical Society

September 2012 **Volume 59, Number 8**

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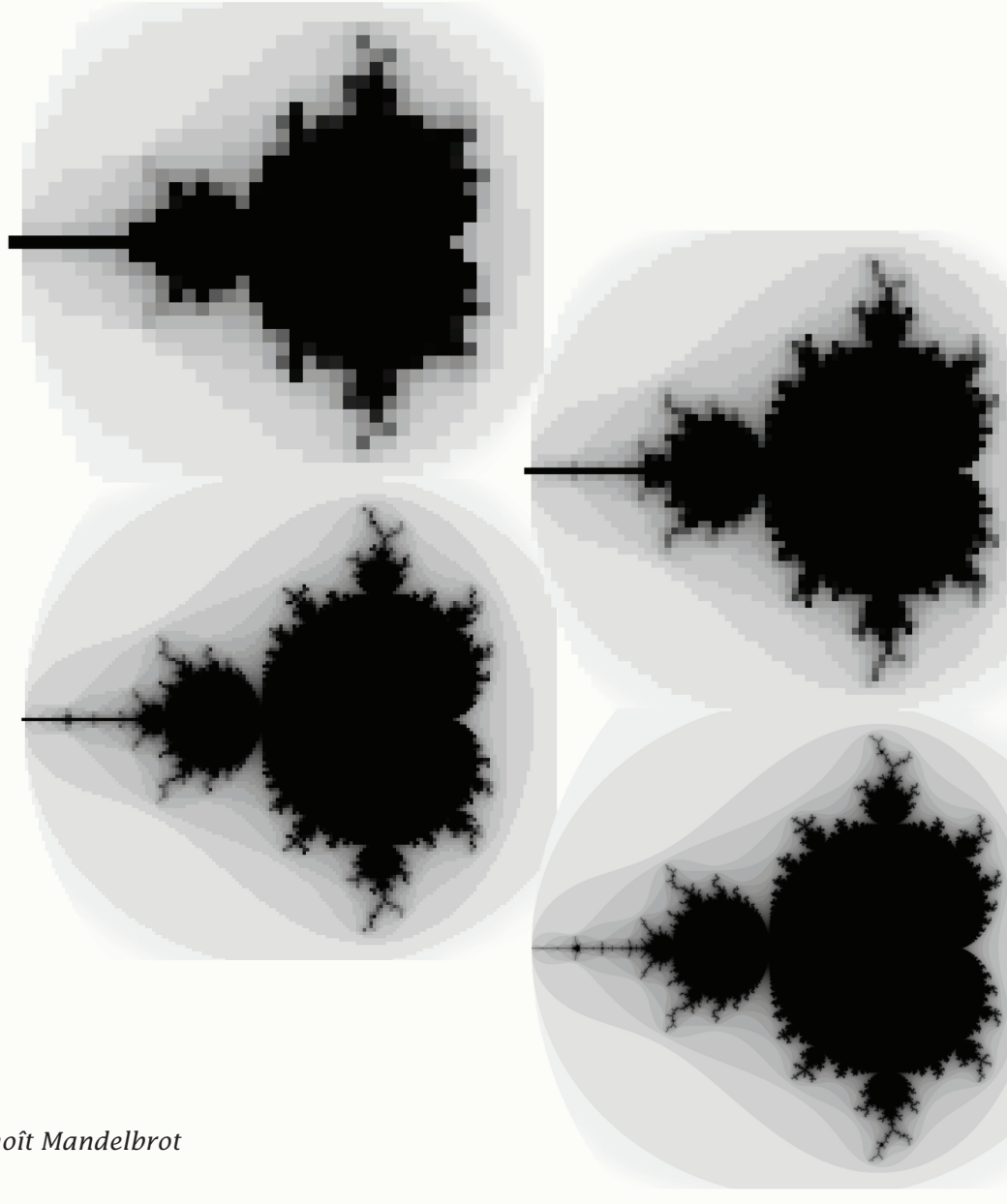

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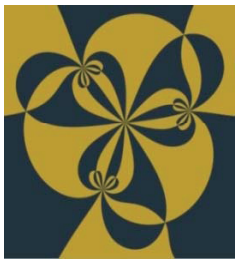

INTERACTIONS BETWEEN ANALYSIS AND GEOMETRY

March 11 – June 14, 2013

ORGANIZING COMMITTEE: **Mario Bonk** (UCLA), **John Garnett** (UCLA), **Ursula Hamenstädt** (University of Bonn), **Pekka Koskela** (University of Jyväskylä), **Eero Saksman** (University of Helsinki)

Scientific Overview

The purpose of this program is to promote the interaction between two core areas of mathematics--analysis and geometry.

Sophisticated methods have been developed in complex analysis, harmonic analysis, partial differential equations, and other parts of analysis; many of these analytic techniques have found applications in geometry. However, research in analysis is often driven by intrinsic motives rather than by potential applications to other parts of mathematics. Geometers can give analysts new perspectives and focus for their research.

On the other hand, analysts often use ideas and tricks that are well-known to themselves, but mysteries to researchers in other areas; so geometers can benefit from an exchange of ideas with analysts by becoming more familiar with the powerful tools of their field. Such fruitful interactions should not be left to serendipity. This program is intended to enhance communications between analysts and geometers by focusing on recent developments on the borderline of these subjects.

Workshop Schedule

- Interactions Between Analysis and Geometry Tutorials, March 12 – 15, 2013
- Workshop 1: Analysis on Metric Spaces, March 18 – 22, 2013
- Workshop 2: Dynamics of Groups and Rational Maps, April 8 – 12, 2013
- Workshop 3: Non-Smooth Geometry, April 29 – May 3, 2013
- Workshop 4: Quasiconformal Geometry and Elliptic PDEs, May 20 – 24, 2013
- Culminating Workshop at Lake Arrowhead (by invitation only), June 9 – 14, 2013

Participation

This long program will involve a community of senior and junior researchers. The intent is for participants to have an opportunity to learn about new developments in and possible interactions between geometry and analysis, and to meet a diverse group of people and have an opportunity to form new collaborations.

Full and partial support for long-term participants is available. We are especially interested in applicants who intend to participate in the entire program, but will consider applications for shorter periods. Funding is available for participants at all academic levels, though recent PhDs, graduate students, and researchers in the early stages of their careers are especially encouraged to apply. Encouraging the careers of women and minority mathematicians and scientists is an important component of IPAM's mission and we welcome their applications. More information and an application is available online.

www.ipam.ucla.edu/programs/iag2013

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$$r = \frac{7e^t + C}{\ln t}$$

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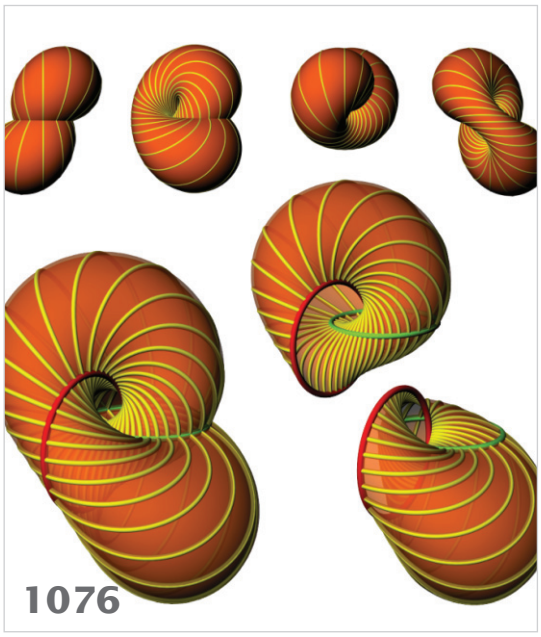

The September issue features an article examining the role of Francesco Severi in the Italian mathematics of the Mussolini era. The photographs that accompany that article are noteworthy. There is also a remembrance of the remarkable mathematician Benoît Mandelbrot. We have an article exhibiting new (and old) ways of viewing the Klein bottle. And an article examining elliptic functions in an unusual light. As usual, the issue is rounded out by the Doceamus and Scripta Manent columns.

—Steven G. Krantz, Editor

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of the American Mathematical Society

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Sonia Kovalevsky Days and Encouraging Young Women in Mathematics

For the past twenty years, the Association for Women in Mathematics (AWM) has been providing funds on a competitive basis for hosting "Sonia Kovalevsky Days". These SK Days are daylong events for encouraging young (middle school and high school age) women to pursue their mathematical interests. In the fall of 2011 the mathematics department at Dartmouth College hosted such a day, and it was a resounding as well as (to be honest) a somewhat surprising success, considering our small rural community. We thought it worthwhile to communicate our basic template for the day in the hope that other institutions might be inspired to host their own SK Days. We hope that the relatively low cost of the event coupled with its potential benefits might make it an attractive proposition for other math departments (possibly with a little help from a provost or dean!). We now intend to institute it as one of our yearly outreach events.

The SK Day was organized by Dartmouth faculty Rosa Orellana and Zajj Daugherty and mathematics graduate student Patricia Cahn. We originally had planned for a total of fifty participants, but had to close registration two weeks before the event when the number of registrants reached eighty-one. Ultimately, there were seventy-four participants (sixty-four students, seven teachers, and three parents). We had many more people contact us and ended up with a long waiting list. We already have good connections with many of the "local" (which in Hanover, NH, can mean over twenty miles away) schools through yearly math summer camps that we run, mainly in the service of our graduate teaching seminar training, and we used those contacts to generate invitations.

After registration and a continental breakfast we opened with a few welcoming remarks by the chair of the Mathematics Department, followed by a short introduction from Rosa Orellana, who talked about Sonia Kovalevsky and her struggles as a female mathematician of the nineteenth century. After this, Dartmouth faculty member Carolyn Gordon gave a gentle introduction to the subject of spectral geometry with a plenary lecture "Can you hear the shape of a drum?" We followed this with two hour-long hands-on group activities in fractal geometry and the game SET ("SET Magic Tricks") led by our graduate students and undergraduates from our local AWM chapter. These activities bookended a catered buffet lunch during which the participants played an icebreaker game: at registration each student was given a SET card, and students were asked to form "sets" with other participants. Once they found two other students with whom they formed a set, they were asked to write down something interesting about those other participants. At the end of the day, we awarded prizes to the three students who had found the most sets.

During the afternoon, students again split into two groups and participated in one of the group activities. This was followed by a "featured activity": an active panel discussion, led by Dartmouth women undergraduate and graduate students, on the subject of "Why study math?" The panel was designed to provide a closer connection for the participants to the Dartmouth women who have been successful in studying mathematics. This was very exciting for all involved.

The members of the panel addressed the following questions: (1) Which experiences led you to realize that you wanted to study math? (2) What do you think you will be doing with your math major? For graduate students, what other careers did you consider before you decided to go to graduate school? (3) What difficulties have you faced and how did you overcome them? (4) Can you share personal stories of earlier failures (or disappointing outcomes), as they relate to math, e.g., not liking a particular course, etc.? How do you feel about those experiences now? Panelists were also asked to share their interests outside of mathematics. The goals of the panel were to encourage young girls to study math and provide role models with whom the girls can identify, as well as to give reasons to pursue math and remove reasons not to.

Following the panel the students wrote a short positive essay about their strengths, capabilities, and hopes for the future. Several studies have shown that this type of activity can have a significant effect on future success. The prompt for our essay was:

Name something (extracurricular activity, sport, subject in school, or a job you have) that you are good at (don't be shy) and explain how you became an expert at it. If you wrote math, explain how what you learned today can help you continue to succeed. If it is not math, explain how you could succeed in math using the same strategies you used to become good at the activity you wrote about.

The day ended with a short evaluation of the day's activities and prize presentations for the SET game winners.

The results of the evaluations were extremely positive overall, but particularly overwhelmingly so amongst teachers and students in grades 6–8. In the future, we may concentrate on grade 6–10 students so as to accommodate more of them and reach the group with whom we seemed the most successful. Here are some samples of some of the particularly enthusiastic comments:

"I am excited about learning that math is in everything"
"I LOVED learning about fractals"
"It was nice to laugh with the teachers"
"It was awesome! I had sooo much fun!"
"I thought is was very fun and I want to do this every two weeks"

We also received lots of emails from parents thanking us for the wonderful day their girls had experienced. For example:

"My daughter has done summer math camp with you twice, now this wonderful Math Day, and is finally beginning to see that math is bigger than beginning algebra. These kinds of programs you provide are hugely eye opening for kids like her. This could not happen without the inspiration of very cool young Dartmouth math women."

We hope that this description of our SK Day might make the idea of hosting such an event seem less daunting. The return on your efforts would be well worth it.

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Letters to the Editor

Remembering Larry Payne

I commend Howard Levine, Phil Schaefer, and Si Levin for taking the initiative to write a homage for Larry Payne "Tribute to Lawrence E. Payne", *Notices* 59, May 2012, pp. 653–654. I would like to add here a few of my own words in Larry's honor.

Larry took me on as his student (Ph.D. 1965, University of Maryland) at a critical juncture in my professional life. I was emerging from top-secret electronic espionage work within a four-year military obligation at the Naval Research Laboratory in Washington D.C. At that time I could have continued on with the government work. Or, being a rare young computing expert, I could have written my own ticket in the burgeoning computer industry. But Larry offered me a National Science Foundation research assistantship to work with him in partial differential equations. Immediately I sensed a warm, caring Ph.D. advisor with whom I would really like to work.

Readers of the *Notices* will find more on Larry Payne in my just-published autobiography *The Crossing of Heaven: Memoirs of a Mathematician*, Springer (2012).

—Karl Gustafson
University of Colorado at Boulder
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(Received May 2, 2012)

The Provenance of Zero

I am writing this letter in reference to the review of Keith Devlin's book *The Man of Numbers: Fibonacci's Arithmetic Revolution* in the *Notices*, vol. 59, no. 5 [May 2012]. The Indian decimal system is referred to more than once, but mention is made of only the numbers 1 through 9, never of zero—called zephirum in Arabic. As we see from the quotation below, Fibonacci did mention "the sign 0". (Like a lot of others, he seemed to have trouble thinking of it as a number).

On page 361 of his book *The Universal History of Numbers: From Prehistory to the Invention of the Computer* (John Wiley & Sons, 1998), Georges Ifrah gives the following quotation from Fibonacci's *Liber Abaci* (which he wrote in 1202), along with a somewhat free translation:

Cum genitor meus a patria publicus scriba in duana bugee pro pisanis mercatoribus ad eam confluentibus preesset, me in pueritia mea ad se uenire faciens, inspecta utilitate et commoditate futura, ibi me studio abaci per aliquot dies stare uoluit et doceri. Vbi ex mirabili magisterio in arte per nouem figuras Indorum introductus… Novem figurae Indorum hae sunt:

9 8 7 6 5 4 3 2 1

Cum his itaque novem figuris, et cum hoc signo 0. Quod arabice zephirum appellatur, scribitur qu libet numerus.

(*My father was a public scribe of Bejaia, where he worked for his country in Customs, defending the interests of Pisan merchants who made their fortunes there. He made me learn how to use the abacus when I was still a child because he saw how I could benefit from this in later life. In this way I learned the art of counting using the nine Indian figures:*

The nine Indian figures are as follows:

9 8 7 6 5 4 3 2 1

[figures given in contemporary European cursive form].

That is why, with these nine numerals, and with this sign 0, called zephirum in Arab, one writes all the numbers one wishes. [Boncompagni (1857). Vol. 1.])

—Padmini T. Joshi
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(Received May 18, 2012)

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.

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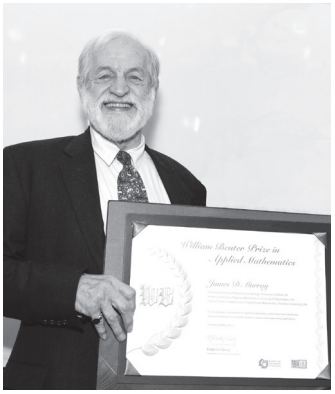
James Murray receives the William Benter Prize in Applied Mathematics



James Murray

City University of Hong Kong (CityU) has awarded the second William Benter Prize in Applied Mathematics to James Murray, one of the hugely influential scientists in the field of mathematical biology.

James Murray, Senior Scholar, Princeton University; Professor Emeritus of Mathematical Biology, University of Oxford; and Professor Emeritus of Applied Mathematics, University of Washington, was chosen as the winner for his unprecedented contributions to using mathematical models to address a wide spectrum of biomedical problems by understanding the underlying biomechanics of the human body for more accurate predictions of the outcome of various human interactions.

The William Benter Prize in Applied Mathematics was set up by the Liu Bie Ju Centre for Mathematical Sciences at CityU in honour of Mr William Benter for his dedication and generous support for the enhancement of the University's strengths in mathematics research. The US$100,000 prize, given once every two years, is awarded to outstanding mathematicians whose contributions have had a direct and fundamental impact on scientific, business, finance and engineering applications.

The Prize was presented to James Murray at the opening ceremony of the International Conference on Applied Mathematics 2012: Modeling, Analysis & Computation organized by the Liu Bie Ju Centre for Mathematical Sciences at CityU on 28 May 2012.

Biographical Sketch

James Murray was born on 2 January 1931 at Moffat, Scotland. He received his bachelor's degree in mathematics and doctorate in applied mathematics from the University of St Andrews, Scotland in 1953 and 1956, respectively. He was awarded a master of arts degree in 1961 and a doctor of science degree in mathematics in 1968 from the University of Oxford, UK. He became Professor of Mathematical Biology at the University of Oxford in 1986, before which he had held positions in Harvard University, University of London, University of Michigan and New York University. He left Oxford for the University of Washington in the late 1980s. James Murray became Emeritus Professor of Mathematical Biology at Oxford in 1992 and became Emeritus Professor of Applied Mathematics at the University of Washington in 2000.

He was the founder and director of the Centre for Mathematical Biology at Oxford from 1983-1992 during which time it became the world centre in theoretical biology. He was also the founding President of the European Society for Mathematical and Theoretical Biology, the largest scientific society in the field from 1991-1994.

James Murray holds many prestigious honors and awards. He is Guggenheim Fellow, Fellow of the Royal Society of Edinburgh, Fellow of the Royal Society of London, Fellow of the Institute of Biology, UK, and Foreign Member of the French Academy of Sciences. He won the London Mathematical Society Naylor Prize for Applied Mathematics in 1988, the Akiro Okubo Prize in 2005 and the European Academy of Science Leonardo da Vinci medal in 2011.

Citation

James Murray began working on the application of mathematics to biology in the late 1960s, at which time there was no recognized field of mathematical biology, and he has played an influential role in the development of the field over the last fifty years. His book, *Mathematical Biology* published in 1989, has become a classic in the field which is still widely used in teaching and research. His contributions and achievements have earned him the title of "the father of modern mathematical biology".

James Murray adopts an interdisciplinary approach to research with an aim to increase scientists' understanding of the real world and to help improve the well-being of all living things. His research is characterized by diversity, originality and depth. Over the past decades, he has developed original and practical mathematical models to study various areas in biology, ecology, medicine and psychology. His many contributions include the study of animal coat pattern formation, the spread and control of rabies, brain tumour growth and control, marital interaction and divorce prediction, bovine tuberculosis, the mechanochemical theory of biological pattern formation, wound healing and scar formation. In recent years, he has worked on how individuals can affect group decisions in social animals, the benefit of cannibalism, and climate changes and species extinction.

James Murray is at the forefront in establishing a bridge between mathematics and biology, and his contributions have led to significant advances not only in biological knowledge but also in applied mathematics.

— News release from City University of Hong Kong

Glimpses of Benoît B. Mandelbrot (1924–2010)

Edited by Michael F. Barnsley and Michael Frame

Two roads diverged in a wood, and I
— I took the one less travelled by,
And that has made all the difference.
(Robert Frost, "The Road Not Taken")

Michael F. Barnsley

Introduction

Benoît B. Mandelbrot died in Cambridge, Massachusetts, on Thursday, 14 October 2010. He was eighty-five years old and Sterling Professor Emeritus of Mathematical Sciences at Yale University. He was also IBM Fellow Emeritus (physics) at the IBM T. J. Watson Research Center. He was a great and rare mathematician and scientist. He changed the way that many of us see, describe and model, mathematically and geometrically, the world around us. He moved between disciplines and university departments, from geology to physics, to computer science, to economics and engineering, talking excitedly, sometimes obscurely, strangely vain, about all manner of things, theorizing, speculating, and often in recent years, to the annoyance of others, pointing out how he had earlier done work of a related nature to whatever it was that someone was explaining, bobbing up and down to interrupt, to explain this or that. He was an unforgettable, extraordinary person of great warmth who was also vulnerable and defensive.

Figure 1. Benoît Mandelbrot next to John Robinson's sculpture *Intuition* outside the Isaac Newton Institute, Cambridge, during the Mathematics and Applications of Fractals Program in 1999. (Photo: Findlay Kember/Isaac Newton Institute.)

Looking back, Benoît saw his life as a rough path. In [7] he recounted how his father escaped from Poland and the Nazis with a group of others and, at a certain point, went a different route through the woods, which saved his life. Benoît saw his own life in similar terms: he too took the path less travelled by, and that made him very different from most mathematicians. What he did that was different was to work in many areas, following where his geometrical intuitions led, regardless of academic boundaries. This path repeatedly risked failure and embarrassment because each discipline has

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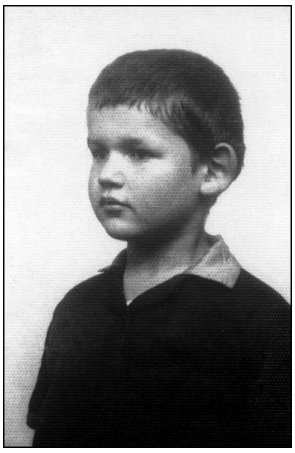

Photo courtesy of Aliette Mandelbrot.

Figure 2. Benoît, age four, in Poland.

its entrenched big guns, experts surrounded by well-constructed defenses, peer groups armed with stacks of citations.

Prior to writing both this article and [1], we emailed colleagues to ask for memories and comments on Benoît's contributions to mathematics, his influence, and personal recollections. We received replies from many—not only mathematicians, but artists, physicists, biologists, engineers, and so on. Our goal has been to put together a pair of memorial articles, something special, using the words of everyone who wrote, but, in general, editing and shortening to avoid repetitions of themes. The second article, [1], is centered on Benoît's influence and contributions to mathematics. The present article is more directed to the man himself in a personal manner. Both Michael Frame and I knew and loved Benoît: Michael Frame was his sidekick at Yale for many years, and I, Michael B., first met him in 1981 and a number of times during the following fifteen years, mainly during the early 1980s. In 1988 he came to my home in Atlanta for dinner during the Siggraph conference, together with Richard Voss, Heinz-Otto Peitgen, and others. His magical personality filled the dining room that hot summer evening, contrasted with his house in Scarsdale, where I first met him and Aliette on a February day in 1981, with snow and light gleaming off it into the windows of his book-and-Xerox-piled office.

There is a large body of written materials, available online, that are easily accessed and which recount aspects of Benoît's life, times, research, quotations, and opinions. But here we try to capture afresh the fact that he was one of us, a mathematician, and to give a glimpse and feeling, for the time that you read this, of the real and amazing man that he was.

Ian Stewart

He Began His Lecture by Shuffling His Slides

My first contact with Mandelbrot was when he phoned me to say that he'd been asked to write a popular article on fractals, didn't have time, and wondered whether I'd be interested. I accepted the invitation. From then on, he would occasionally call me when some unusually striking development in fractal geometry had happened. When *The Economist* asked me to write a feature article on applications of fractals, Benoît mailed me a stack of photocopies six inches thick, saving me weeks of work.

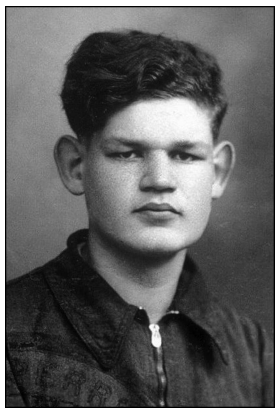

Photo courtesy of Aliette Mandelbrot.

Figure 3. Benoît, age thirteen or fourteen, in Paris.

I met him a few times. He visited the University of Warwick and began his lecture by shuffling his slides to make sure it was different from previous talks. My wife and I had breakfast with him at a conference on financial mathematics in Santa Fe. He was in great spirits because a conjecture of his had just been proved, but he knew that my wife was not a mathematician, so he took care to avoid talking shop.

David Mumford

He Opened a Door and Let in a Gale of Wind

I met Benoît when he came to Harvard as a visiting professor in 1979. At that time, the Harvard math department was an insulated place, a temple of pure math. His appearance opened a door and let in a gale of wind. He was a large man and his presence was large too. He gave lectures in a dozen departments, and every lecture dealt with a different phenomenon of nature. He seemed to have studied everything and picked up grist for his mill in every corner of the world.

I had some wonderful times socially with Benoît and his wife, Aliette. They were warm and fascinating hosts who seemed to know everyone too. I remember especially talking about Gadjusek, the discoverer of the link between cannibalism and prion diseases, who was a good friend of theirs. I last saw him at the birthday celebratory meeting in his honor at Bad Neuenahr. Surrounded by his hosts who had contributed so much to his theories, he gave a moving speech on the fact that this was his first visit to Germany since the Holocaust. Benoît was a completely unique person and scientist who cannot be pigeon-holed and his influence has been vast. I count myself very lucky to have known and worked with him.

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Kenneth Falconer

Benoît Told Me…Everyone Would Be Merry after Food and Wine

The first time that I met Benoît was at the Winter Workshop on Fractals at Les Houches in 1984. This was the first time that I had encountered the "fractal community". It was an eye-opening meeting, as I realized the wealth of ideas that was emerging from mathematicians and scientists interested in fractals. I have a vivid memory of the friendliness and encouragement shown to me by Benoît at that meeting. The highlight of the week's cuisine was the fondue, and I was scheduled to give the evening talk immediately afterwards. Benoît took me aside and told me that there was no need to be nervous, as everyone would be merry after the food and wine, so my talk was bound to be appreciated! In fact, I think that the talk did go well. This was the first occasion on which I presented my "digital sundial" theorem—that there exists a fractal such that its orthogonal projections can be essentially anything one wishes, for example, the thickened digits of the time. Along the same lines I also proposed the construction of a space station that was plainly visible to Western countries and effectively invisible to Eastern countries, to the amusement of many present. Benoît told me afterwards that he liked these examples because they gave a "visual" interpretation of an abstract mathematical theorem.

The year 1984 also saw the publication of *The Geometry of Fractal Sets* [4], which was one of the earliest books on fractals, apart from those of Benoît himself. Benoît provided very helpful comments on my manuscript, but in a review he did refer to "…the usual dry mathematics", though I don't think he meant it unkindly. In later years Benoît coauthored a number of papers employing similar formal mathematics, so I think that once his ideas had been accepted by the mathematical community, he became less concerned about the "dryness".

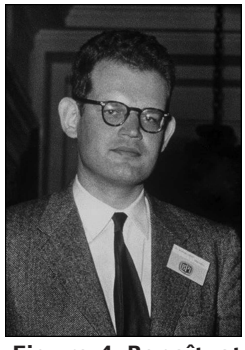

Photo courtesy of Aliette Mandelbrot.

Figure 4. Benoît, at age twenty-eight or twenty-nine, was living in France.

I saw a great deal of Benoît during the program Mathematics and Applications of Fractals at the Isaac Newton Institute in Cambridge in 1999; indeed he, along with Aliette, occupied an office adjacent to mine. The four-month program was organized by Robin Ball and me, and we were delighted that Benoît stayed in Cambridge for the entire time. A number of young researchers and research students took part, and Benoît made a point of taking time to encourage them by talking to them all and discussing ideas with them individually.

I was delighted when Benoît accepted an honorary degree from the University of St. Andrews in 1999. It was a pleasure to entertain him and Aliette in my hometown, and it was clear that receiving such an honor from a Scottish university meant a great deal to him. I recall that, as we crossed the Firth of Forth on the way from the airport, he commented that the Forth Railway Bridge, constructed in 1890, displayed fine fractal features in its hierarchical structure!

For many years I met Benoît regularly at conferences; he was rarely absent from any meeting on fractals. He once paid me the biggest compliment that my lecturing has ever received: "I really liked your talk, Ken; you have such a wonderful theatrical style!"

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Ron Eglash

"That Is Not Criticism; That Is a Tribute to Your Work"

I am best known for my book *African Fractals* [3]. Needless to say, that would have been impossible without Benoît! Much of the research in ethnomathematics had been things like "how to count to 10 in Yoruba" or "African houses are shaped like a cylinder." But when I first saw aerial photos of African villages, their fractal structure was immediately obvious. That gave me a basis for a Fulbright fellowship to Africa, and once I was there I found that that recursive scaling cropped up in all sorts of artifacts and knowledge systems, from sculpture and textiles to divination and cosmology. The NSF has allowed us to develop software for teaching math and computing using fractal algorithms [13]. This work has also caught the eye of architects; for example, there are now plans for an entire university in Angola to have a fractal layout. Benoît leaves behind a legacy on many continents.

Photo courtesy of Aliette Mandelbrot.

Figure 5. Benoît at age thirty-nine or forty when he was working at IBM.

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Figure 6. Benoît Mandelbrot, Kenneth Falconer, and Keith Ball outside the Isaac Newton Institute, Cambridge, in 1999. (Photo: Findlay Kember/Isaac Newton Institute.)

Figure 7. This photo, taken by Richard Bernt, shows, from left to right, Richard Voss, Benoît B. Mandelbrot, Dietmar Saupe, and Heinz-Otto Peitgen. Richard Bernt believes it was taken in May 1987. It was the week Dietmar and Voss went sailing on his catamaran. Mandelbrot and he had talked about the fractal dimension of ocean waves and how it was similar to music. The photo was taken at UC Santa Cruz by the Applied Science Building, which had picnic tables nearby. It was near the offices of Heinz-Otto, Dietmar, and Ralph Abraham, near room 366, where they, with Richard Bernt, generated fantastic fractal images on SGI machines.

The first time I spoke to Benoît was when he visited UCSC, where I was in graduate school in the late 1980s. After his lecture, I asked him why some fractals show Euclidean shapes—the Sierpinski gasket, for example—and others show only mush or globs that show no recognizable shapes. To my surprise he said, "I have been asking myself that question for over a decade and have yet to find a satisfactory answer." The second time was a phone call; he wanted to know if I had been given tenure—he had written a recommendation for my case. We got to chatting about *African Fractals*, and he asked me if I was getting any criticism for it. So I described some of the hate mail I was receiving from critics who insisted that black people had genetically inferior brains and could not have created fractals on their own. He said, "That is not criticism; that is a tribute to your work!"

Harlan Brothers

Ways in Which Music Could Manifest Fractal Structure

Benoît's most important contribution to education was the work he did in conjunction with Michael Frame and Nial Neger in conducting the Fractal Geometry Workshops at Yale. Related collaborations included the book *Fractals, Graphics, & Mathematics Education* [5], the DVD *Mandelbrot's World of Fractals* [8], and the vast Yale website on fractal geometry [12], which contains the collection of labs called *Kitchen Science Fractals*. Thanks to Benoît's vision, countless young minds around the globe have come to appreciate mathematics through their exposure to fractal geometry.

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It was Benoît who set me on the path of establishing some mathematical rigor for the term "fractal music". Prior to the summer of 2003, someone had given him and Michael Frame a CD of what purported to be fractal music. They passed it on to me. When I explained that the composer did not seem to have a solid grasp of the fundamentals, Benoît agreed, saying, "Yes, I think you are right. If you would like to look into this subject, that would be wonderful."

In collaboration with Michael Frame, the following summer we did a presentation and lab on fractal music. I have since continued to publish and present on the subject and last year appeared in the BBC documentary *Bach & Friends* [2] discussing fractal geometry and its relationship to the music of Bach. I regularly receive email from students around the world, high school through grad school, who are working on projects or have questions about fractal music.

I had been recommended to Benoît by a former student of his, Miguel Garcia, who was my professor at Gateway Community College. I will always remember our first meeting at Yale. Benoît was seated, his hands pointed in and resting on his legs. He began by saying, in his inimitable accent, "So, Miguel tells me you are not the average cookie-cutter student…" I shared some of my research,

Figure 8. Benoît Mandelbrot in an iconic pose, fingers together, appearing in the documentary *Clouds Are Not Spheres* [9]. The shot was taken in Paris in 1999. (Photo courtesy of Nigel Lesmoir-Gordon.)

and by the time I left, he had shared everything from the lesser-known work of John Venn to the sociopolitical history of Budapest dating back to the sixteenth century. Since then, over the years, through the Fractal Geometry Workshops and in numerous phone calls, Benoît continued to share his overwhelming expertise, his humor, and his wisdom in practical matters. His generosity of spirit and fundamental good nature have inspired me and helped to define who I am.

Nigel Lesmoir-Gordon

Benoît Was Superb, Inspiring and Lucid

I made the film *The Colors of Infinity* [6] in 1992. After we had finished filming Arthur C. Clarke in Sri Lanka, I interviewed Benoît at his home. He was, in essence, happy with the questions that I proposed to ask. I commented uneasily that he looked a bit formal in his suit and tie and suggested that he should dress more casually. He laughed and said that he had a blue jacket he could wear and that he would drop the tie. When he came back into the room, instead of the bright blue jacket I was expecting, he was wearing a coat of subtle grey. He took his seat, and I sat down by the camera, clutching my notes and my list of questions. He looked good. Lights, camera, action! Then everything popped. We had blown a fuse. Our electrician rerouted the lights, and we started again. After ten minutes the lights blew again. I started to get very agitated, but Benoît remained as cool as a cucumber.

We had another coffee break while the electrician did some serious rewiring. Everyone stayed calm except for me. It was essential that I made a good job of the interview for the sake of our investors, the crew, and most of all for Benoît. We managed to get started again and, save for a half-hour lunch break, worked on into the afternoon. Benoît was superb—inspiring and lucid.

It took many months to complete the postproduction; then we sent tapes off to the contributors. Benoît was generous with his praise and his expressions of gratitude. We found a distributor for the film. It went on to sell in over forty territories worldwide and has been subtitled in three foreign languages. It was shown on eighty-two PBS stations in the United States.

When Benoît was recalling his research work at IBM, he told me:

> For me the first step with any difficult mathematical problem was to program it and see what it looked like. We started programming Julia sets of all kinds. It was extraordinary great fun! And in particular, at one point, we became interested in the simplest possible transformation: $z \mapsto z^2 + c$. ... And after a few weeks we had this very strong, overwhelming impression that this was a kind of big bear we have encountered!
>
> This discovery was named after me. It is called the Mandelbrot set. I think the most important implication is that from very simple formulas you can get very complicated results.…

Benoît, Michael Frame, and I went on to make the educational DVD production [8], which was commissioned by the National Science Foundation through Yale University. This DVD concludes with Benoît addressing the camera:

> I've spent most of my life unpacking the ideas that became fractal geometry. This has been exciting and enjoyable, most times. But it also has been lonely. For years few shared my views. Yet the ghost of the idea of fractals continued to beguile me, so I kept looking through the long, dry years. So find the thing you love. It doesn't so much matter what it is. Find the thing you love and throw yourself into it. I found a new geometry; you'll find something else. Whatever you find will be yours.

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Javier Barrallo

Not Only Should the Toy Be Built, But We Should Know How to Play with It

As Johannes Kepler used his toy, the ellipse, to explain our solar system, so did Benoît Mandelbrot use his toy, the fractal, to interpret the geometry of nature. Once Benoît explained to me: "Not only should the toy be built, but it should also be known how to play with it."

My first contact with Benoît was the invitation I sent to him to chair the international fractal art contest that bears his name. When attending the first exhibition contest at Conde Duque in Madrid, he was surprised to see a long line of people. "I am an inveterate optimist, but I never expected to see a crowd standing in a long line to admire mathematics in any of its forms," he said that night. I remember having to wait for him for over forty minutes while he signed autographs and took pictures with fans. He was more like a rock star or a Hollywood actor.

I remember while walking one beautiful autumn morning in San Sebastian, Benoît noticed a sculpture in the rocks of La Concha Bay. It was *The Comb of the Wind* by Eduardo Chillida. He immediately recognized the artist, then proceeded to tell me that born just a few miles away was Ignatius of Loyola, founder of the Jesuits; next he informed me that in the nearby port of Guetaria, the explorer who completed the first circumnavigation of the world, Juan Sebastian Elcano, was born. For a nonnative, he had remarkable cultural knowledge. He could talk about Hokusai style and immediately illustrate the Japanese character by relaying an anecdote that took place while he was dining with the empress of Japan. He told me once that Eugène Delacroix used to instruct his students that to paint a tree it was necessary to draw inside another smaller tree, and inside another, and another.

Benoît chaired three of the International Fractal Art Contests. In each case, twenty-five images were selected for exhibition. The results of the third contest, by artists of seventeen different nationalities, were exhibited in Bilbao (Spain), Buenos Aires (Argentina), and Hyderabad (India). Benoît guided our efforts to discover new ways to express fractal art. Thus, the typical filaments and spirals were reduced to an aesthetic closer to contemporary art rather than the usual fractal structures. Looking at the last exhibition contest, he said, "Many will prefer the old images, but compared with these, they look like antiques."

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Figure 9. Picture by Kerry Mitchell, a panel member image for the 2007 Benoît Mandelbrot Art Contest. Javier Barrallo noted that Benoît really enjoyed this picture.

The Benoît Mandelbrot International Fractal Art Contest also gave him the opportunity to participate for the first time in the International Congress of Mathematicians (ICM). He entered through the back door as honorary director of the fractal art contest. But when his presence became known, he raised unexpected excitement—well above any other guest speaker. Thus, Benoît Mandelbrot was invited to give the closing lecture of ICM2006, with several thousand people attending in the main auditorium. In his speech he congratulated Wendelin Werner for being a recipient of the Fields Medal as well as for being able to demonstrate one of his conjectures. In fact, he said, "This is the third time a Fields Medal was awarded for proving one of my conjectures."

For some people this may portray a smug man, but this is not true. I remember the night he turned down an invitation to a prestigious dinner with some of the best mathematicians in the world to join my group of young colleagues who had planned a beer and tapas tasting in the bustling Plaza of Santa Ana. "Could we join you?" he asked. That night we drank and laughed but mostly listened to Benoît tell fantastic stories and anecdotes from his life, science, history, and art …it was an unforgettable moment that revealed a much more approachable and intimate person than one might think.

My last conversations with Benoît dealt with the Mandelbrot set in 3D, also called Mandelbulb. Although he truly admired the gorgeous animations of the Mandelbulb and other graphics experiments, he never entered the debate on them. His era was ending and a new one was beginning.

Figure 10. Close-up and zoom on the attractor of an iterated function system comprising four projective transformations. Mandelbrot's work built on classical geometry and leads to simple mathematical models for natural objects, such as forests and leaves.

Benoît was not a conventional mathematician, but he was certainly the most brilliant mind I've had the chance to meet.

Sir Michael Berry

It Is Winter and the Trees Are Bare of Leaves

When Benoît visited the UK, he and Aliette occasionally stayed with us. My abiding memory is of his nonnegligible bulk dominating our kitchen amid a whirl of culinary activity. Fortified by a continuous supply of orange juice, he entertained and entranced us with his monologues about mathematics, his wartime experiences, his opinions of publishers and colleagues.…As I write, it is winter and the trees are bare of leaves. Frost on the branches dramatically enhances their fractility, and I remember Benoît, who taught us to see it.

Michael Frame

Epilogue: November 12, 2010

Benoît and I worked together for twenty years. We wrote papers, edited a book on fractals and education, ran summer workshops for teachers, and spent hours upon hours discussing . . . everything. These conversations were exhilarating, among the very best moments of my life. Benoît collaborated with many scientists, all much brighter than I, but our relationship was different. Deep inside, I remain an eleven-year-old kid, inhabiting a simpler world filled with mysteries, where the job of every kid is to explore. Benoît was more complicated, but with me he followed his sense of innocent wonder at the wide world. During our first freely roaming conversation, I had an image that has stayed with me through the years, that gives me some small comfort at his loss. Benoît and I were two little kids running around in a big field under a bright sky, showing each other what we found. Friends sharing the unalloyed joys of discovery.

Benoît was fascinated by complex things. His life's work revolved around finding a feature common to examples from mathematics, physics, economics, art, and music: patterns that kept recurring as he looked ever closer. Others had noticed some aspect of this before, but Benoît saw so much more: that complicated shapes can be understood dynamically as processes, not objects. Continuing to astound each new generation of students, the power of this view is remarkable.

I'll end with two more points: some of our final conversations, and what I really learned from Benoît.

When Benoît called to share the news of his diagnosis, at first he asked me to tell no one. All he wanted to discuss was how to try to finish the work that remained undone: his memoirs and projects on negative dimensions and lacunarity were much on his mind. Working from Benoît's notes, Aliette

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Figure 11. "I, Javier Barrallo, took this picture in Donostia-San Sebastián, a city in the Basque Country in northern Spain. The date was November 15, 2007. Benoît and Aliette are in Ondarreta Beach in front of a famous sculpture by Eduardo Chillida named 'The Combs of the Wind'. I remember it was a very happy day for them." (Photo courtesy of Javier Barrallo.)

Mandelbrot and Merry Morse finished the memoirs [11]. Through their considerable efforts, Benoît's story will be told.

In addition to unfinished projects, we continued to discuss some general scientific questions. Despite ample reason to think only of himself, curiosity—one of our very finest traits, the only thing that might save the species, the only thing that could make us worth saving—burned in Benoît with the brilliance it did in his youth eight decades earlier. These feelings would persist until the end.

Benoît and Aliette were very kind to Jean and me, but I cannot understand why he brought me into his world. Hundreds and hundreds of conversations, just he and I. Why? This made no sense. Surely he had better things to do with his time. But these talks have given me a detailed picture of Benoît.

What do I know for sure about Benoît? In his mind, shapes were fluid, bending, twisting, and turning without effort. He read everything, remembered everything, but dynamically, looking for connections in combinations both expected and unlikely. Familiarity with so many topics allowed Benoît to converse with anyone. With my father, a machinist, Benoît had a long discussion about annealing. Benoît loved music, especially opera, knew Charles Wuorinen's work long before Charles contacted Benoît to talk about fractal aspects of music. During the Yale memorial for Benoît, Ralph Gomory characterized Benoît as courageous, refining and extending his ideas about scaling across many disciplines, following the paths and practices of no field, ignored for years. Early in his life, Benoît wanted his own Keplerian revolution. This he achieved, but at a cost. Many years later Benoît lamented not having a large group of assistants; so much more would have been finished if the path he'd taken had not been so lonely. Still, that path got him to where he was, gave fractals to us all.

Years ago, when asked if he was a mathematician, a physicist, or an economist, Benoît replied that he was a storyteller. After Benoît died, I saw another interpretation of his answer. By emphasizing how an object grows, a fractal description of the object is a story. Twists and turns of a snowflake in a cloud, rough waves sculpting a jagged coastline, my lungs growing before I was born, the spread of galaxies throughout the deep dark of space. These share something? Benoît told us they have similar stories. Benoît told us science should tell more stories.

Did Benoît's stories change how we understand the world? Yes, indeed.

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A Fresh Look at Francesco Severi

Judith Goodstein and Donald Babbitt

A student of Corrado Segre, Eugenio Bertini, and Federigo Enriques, Francesco Severi is remembered today as one of the key architects of the Italian school of algebraic geometry in the first half of the twentieth century. (For a brief discussion of some of his most important contributions to algebraic geometry, see the appendix.) His eagerness to serve the Fascist regime after Mussolini became dictator in 1925 has cast a long shadow over his name. Even though Severi survived multiple investigations in Italy, rediscovered his Catholic faith, and emphatically denied repeated accusations that he was anti-Semitic, the stigma has persisted.

Among the first, if not the first, to come to Severi's defense in the post-World War II era was Beniamino Segre, who had lost his own academic chair in Bologna in 1938 in the wake of the government's anti-Jewish legislation. Relieved, at Severi's behest, of his duties as an editor of Italy's oldest scientific journal in the wake of the regime's racial laws, Segre nevertheless insisted that rumors of Severi's "supposed anti-Semitism" were "flimsy" and based on "some misunderstanding" [Segre 55*].[1] Although his tenure as Severi's assistant in Rome from 1927 to 1931 gave him a ringside seat as Severi's politics veered sharply from left to right, Segre took pains to remind Italy's mathematical and scientific communities that his mentor had once championed Italy's parliamentary democracy, protested the brutal 1924 murder of Giacomo Matteotti (a Socialist deputy in Parliament), and signed the philosopher Benedetto Croce's anti-Fascist manifesto—actions that forced his resignation in 1925 as rector of the University of Rome. These events, Segre once said, had led Severi to have "a profound disagreement with the fascist government, which lasted—if even in a form increasingly attenuated—for several years, even after having been called to take part in the Academy of Italy" [Segre 63*]. And, on that sober note, Segre took leave of Severi's political career under Mussolini.

Our story offers a fuller look at Severi's political dossier during the inter-war years and beyond. Primary sources range from the personal correspondence of Beniamino Segre and Oscar Zariski to Italian government records of the Fascist period in the Archivio Centrale dello Stato (ACS) to documents in the historical archives of the University of Rome and the Lincei. The whereabouts of Severi's personal papers is a mystery, and it is possible that he destroyed them. Some mathematicians may find a recounting of his activities under Fascism uncalled for, preferring to recall only his considerable mathematical legacy. (Again, see the appendix for a nontechnical discussion of some of the most important parts of this legacy.) Others

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[1] *References with an ∗ can be found at the website:* http://www.JudithGoodstein.com.

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Memorie scelte, 1950 (furnished by authors).

To celebrate fifty years of publishing activity, Severi offered Zanichelli, the publishing house with close ties to Federigo Enriques, the opportunity to publish his collected works, in multiple volumes. When Zanichelli said no, Severi enlisted Beniamino Segre's help in preparing a selection of his writings instead. Severi chose this picture of himself for the frontispiece, but asked Segre to remove the fascist insignia first.

are content to allow the proverbial skeletons in the closet to remain undisturbed.

In 1989 the Italian geometer Edoardo Vesentini raised the subject himself in a talk at the Accademia dei Lincei, which hosted a one-day meeting on the cultural consequences of the racial laws in Italy. Speaking about his own discipline, Vesentini said, "Even if we all know that closets exist and skeletons also, forgotten or hidden, and [even] if we all know that such recognition cannot be deferred indefinitely" [Ves 90], the thought of taking his own teachers and the more senior members of the Italian mathematical community to task fifty years after the Fascist regime issued its Manifesto of Italian Racism seemed unduly harsh. Some colleagues had only recently died, and remembering them, he told the group, brought back memories along with "a mixture of admiration and, sometimes, affection." Fortunately, the mathematicians of his own generation, those who came of age after 1945, had at least "been spared the shame of being among those mathematicians" who had been forced to tell Castelnuovo and Enriques (two Jewish mathematicians) they could not enter their institution's math library. Castelnuovo's lack of bitterness after the war ended, Vesentini noted, had played a crucial role in putting the country's mathematics back on track. "The generosity and far-sightedness of Castelnuovo," he added, "must not prevent, above all, the events of those years from being investigated and thoroughly examined …because those events belong to the history of science."

A Taste for Politics

Born in 1879 the youngest of nine children, Francesco Severi grew up in poverty in the Tuscan town of Arezzo, where as a boy he took a keen interest in politics, following in particular the socialist movement, then on the rise in Italy. After being appointed professor of mathematics at Padua in 1905, Severi allied himself with the left-wing *blocco popolare patavino*, which rewarded his allegiance by appointing him president of the municipal gas and water company. In 1910 he officially joined the Socialist Party and was quickly elected councilor for the commune of Padua and became the Socialist alderman for education. When World War I broke out, Severi sided with those who urged intervention on the side of Britain and France. He severed connections with the Socialist Party, which supported Italian neutrality, and quickly volunteered for military service once Italy entered on the Allied side in 1915.

Between 1918 and 1925 Severi flirted with running for political office and received backing from war veterans and Socialist-run unions. He served for a time as president of the newly formed National Association of University Professors and became rector of the University of Rome on the recommendation of Giovanni Gentile,[1] who at the time was enjoying a brief tenure as minister of public instruction. It is not entirely clear how Severi's association with Gentile, a philosopher and leading proponent of fascist ideology, may have affected his views. However, several years after Mussolini's

[1] *An ardent supporter of the fascist government and a major figure in Italian philosophical circles, Gentile implemented far-reaching and lasting educational reforms during his time as minister of education (1922–1924). Often referred to as "the philosopher of fascism", he wrote several key political tracts for Mussolini, including "The Manifesto of the Fascist Intellectuals", which many leading fascist writers and artists signed in 1925.*

Photo from a private collection.

Tullio Levi-Civita and his wife Libera Trevisani, one of his pupils at Padua, whom he married in 1914, celebrate their arrival in New York City, 1933.

1925 proclamation of a dictatorship—"We are not a ministry; we are not even a government. We are a regime" [Bo 05], *Il Duce* (Mussolini's title for himself as "chief" of the fascist movement) told the deputies in Parliament in the spring of that year—Severi began sending the Fascist leader a steady stream of articles, several embellished with a flowery personal note. Taking his lead from Mussolini's own political trajectory (*Il Duce* had started his political career as a socialist), Severi appears to have cast off his socialist political ties when they no longer suited his political ambitions. Although he later wrote that his act of defiance in speaking out against Matteotti's political assassination in 1924 had ended forever "his active participation in political life" [Sev 45*], the historical record suggests that he wanted to play a prominent role in the intellectual life of the new fascist state. Indeed, Severi used his considerable political connections to promote his advancement.

The Accademia d'Italia

Plans for a new state-sponsored cultural institution, the Reale Accademia d'Italia (The Royal Academy of Italy) began to take shape in 1926, and Severi took a keen interest in the slot reserved for a mathematician. It was an open secret that another algebraic geometer from Rome, Federigo Enriques, born into an Italian Jewish family, had been nominated. That Severi had been feuding with Enriques for several years over a satisfactory algebro-geometric proof of the "Completeness Theorem" (see [B-G 10]) and other matters only heightened the stakes for Severi.

The more he thought about his own political future, the more Severi seems to have become convinced that a Fascist loyalty oath was the answer. Speaking, he said, on behalf of "the great majority" of professors, in January 1929 Severi dispatched an unsolicited and impassioned memo to Mussolini himself, urging swift passage of an oath that would serve to indemnify those who, like himself, had engaged in "nonorthodox demonstrations," such as signing Croce's manifesto. Anything short of that, he added, would "deprive our Universities of most of the best mathematicians. On the faculty at Rome, almost none perhaps would remain."[2] Rest assured, Severi continued, "I have never done anything or criticized anyone that could even remotely be interpreted as contrary to the Regime" while abroad [G-N 05]. Although Severi had not yet become a party member (he joined the Fascist Party in 1932), he had begun to ingratiate himself with Benito Mussolini's regime.

In mid-February, Severi enlisted his university colleague and confidant Giovanni Gentile, no longer minister of public instruction, in his political aspirations. Less emotional, more practical in tone, Severi's letter to Gentile began by reiterating that Italy badly needed a loyalty oath to identify and isolate university professors hostile to the Fascist regime and to reward those, like himself, who had resolved their differences with Mussolini's government. "As I already told you in person," he reminded Gentile, "within the limits of my own poor powers, I have done as much as I could for this purpose, and I have reason to think that the Head of Government is very well disposed." He then went on to instruct Gentile at length about how to manage the other stakeholders in the matter, including the press, the fascist rank-and-file, and various ministries, and what they should and should not be told. Only in a

[2] *The loyalty oath required of all university professors was administered two years later in 1931. Twelve courageous academicians out of 1,250 refused to sign and lost their university posts, including Vito Volterra, the undisputed head of Italy's school of mathematics before the advent of Fascism. Relations between Severi and Volterra had always been rocky, helped along by the fact that Volterra, an avowed anti-Fascist, had once said to him during a session at the Lincei, "Algebraic geometry serves no purpose"* [Tri 67*].

brief postscript, in which Severi informed Gentile that he had marginally patched up a long-standing quarrel with Enriques over competing textbooks ("but with open [and] utter disgust"), did he mention that Enriques's Academy nomination might be in trouble [G-N 93*]. Gentile's response to this letter, if there was one, has not survived.

Whether by design or chance, Severi had landed in the right spot if things veered off track for Enriques, which they did. In mid-March, barely one month later, the government deleted Enriques's name from the list of candidates sent to the president-elect of the Academy of Italy. In its place appeared the name Severi. Recalling that period at Rome, Giorgio Levi della Vida, at the time director of the Oriental School, wrote, "The Rector then was Francesco Severi, a great mathematician and an energetic man of action …whose antifascism could not resist the seduction of the [Royal] Academy of Italy, and as the first error leads to a second one easily and a third, [the error] turned into enthusiastic support for the regime" [LeviV 66*].

One of the many congratulatory telegrams Severi received in 1929 following the government's public announcement of his nomination came from the differential geometer Tullio Levi-Civita, a colleague at the University of Rome and one of Italy's most distinguished mathematicians. In response, Severi sent Levi-Civita, his friend of more than twenty years, a letter marked "confidential" from Barcelona, where he was lecturing. He expressed "absolute surprise" at his own nomination and remorse over the omission of Levi-Civita's name. "I certainly would have loved to see you, the strongest among the columns of Italian mathematics, in the Academy also," he wrote. "Let us trust in the future" [Sev 29*], a veiled hint perhaps that Severi intended to nominate his friend. Later that year, in fact, when Severi raised the issue with his Jewish colleague, Levi-Civita reminded him in writing of the obstacles ("two distinct objections, stated or implied") standing in his way: politics and religion. As the historian Annalisa Capristo, who has written extensively about the exclusion of Jews from Italian academies before and after the racial laws, writes, "In fact, we have no knowledge of other possible 'objections.' On these delicate questions, however, the two correspondents maintained—at least in their exchange of letters—an understandable discretion" [Cap 03].

The Vatican acted first. In February 1929, Mussolini's government and the Vatican had signed the Lateran Accords, each recognizing the other's sovereignty as a state, and in April 1929, only a month after the Reale Accademia d'Italia announced its first thirty members, the Vatican's Accademia Pontificia delle Scienze elected Levi-Civita and the world-renowned mathematician Vito Volterra, both born into Jewish families, members of its group. Anti-fascist organizations had been quick to note the absence of any Italian Jews among the first members of Mussolini's Academy, and in fact the fascist academy was never to admit any Jews to its ranks [Good 84]. The Vatican simply leveled the playing field.

That October the thirty successful candidates for the Royal Academy of Italy, including the physicist Enrico Fermi, the composer Pietro Mascagni, and Francesco Severi, the sole mathematician, gathered in the Campidoglio, Rome's city hall, where Prince Francesco Boncompagni Ludovisi, the city's governor, proclaimed them the aristocracy of Italy's intelligentsia. Clad in a ceremonial suit embroidered in gold, a stipend of 3,000 lira a month lining his pocket, and promoted to the rank of "your Excellency", Severi had been appointed the regime's spokesman for Italian mathematics—and in the eyes of Italy's new rulers, he was. As one of Severi's assistants in Rome, Francesco Tricomi, the author of a classic text on integral equations, later recalled, Severi was as "exuberantly fascist as he had earlier been antifascist—who wanted to be and to a certain extent, was—the 'boss' of Italian mathematics in the fascist period" [Tri 67*].

Severi proceeded to play an active role in the affairs of the fascist academy. Besides diligently attending sessions, he nominated candidates for membership, including Levi-Civita in 1933 and again in 1934, although both he and Levi-Civita knew of the insurmountable obstacles other Jewish candidates had faced. In addition to serving on various commissions, including one charged with purifying the Italian language of foreign words (e.g. cocktail), he presented numerous papers, his own and others'; and, indeed, when called to account for his activities later, he proudly noted that he had personally introduced thirteen of the fourteen papers authored by Jewish scientists. However, in 1931, when Mussolini, with the complicity of Academy president Guglielmo Marconi, intervened decisively to prevent the Academy from awarding the first Mussolini Prize in science to the militantly anti-fascist and Jewish professor of human anatomy Giuseppe Levi, Severi did not speak up in defense of Levi, nor did he voice any objection to the government for not following its own rules [Fabre 08]. (The honor of receiving the first Mussolini Prize went to a well-known—and Christian—physiologist and explorer in good standing with the regime, Filippo de Filippi.)

Severi's Interactions with Colleagues

In his dealings with others, Severi often came across as arrogant, autocratic, and quick to take offense. There seemed to be no middle ground: he either dazzled those around him ("Severi is a man

with bewitching hands, when he does something, it is always splendid" [ScorD 62*], the Sicilian mathematician Gaetano Scorza once remarked) or demonstrated "a childlike incapacity either for self-criticism or for cool judgment," as Leonard Roth, the English algebraic geometer who spent the year 1930–1931 in Rome, famously observed. Worse still, Roth added, "he meddled in politics, whereas it would have been far better had he left them alone" [Roth 63].

Mathematical collaborations with Severi could also be challenging, recalled Scorza's son, Giuseppe Scorza Dragoni, who collaborated with Severi on the second and third volumes of *Lezioni di Analisi*, magisterial tomes, published in 1942 and 1951. As the younger Scorza recounted in a letter to Segre after Severi's death, some of the difficulties arose because the Tuscan mathematician always had a hundred different obligations to attend to. In fact, he had once spent his entire vacation in Rome without being able to meet with Severi once, except on the last day. Scorza also quickly learned that Severi would not admit to making any mistakes. "But this last obstacle, when I realized it," Scorza continued, "I got around easily: instead of saying where there was a mistake, and how it should be fixed, I pretended to not understand and I continued to not understand until Severi, furious by my artfully directed objections and questions, ended by finding the mistakes and [making] the corrections himself" [ScorD 62*].

Severi believed, according to Roth, "that the world at large failed to treat him with due consideration. For, incredible as it may seem, although during the whole period of his maturity honours were showered upon him and invitations poured in, yet he remained forever unsatiated …he seemed more or less permanently aggrieved" [Roth 63].

Severi's trip in 1930 to South America is a case in point. During his stay there he gave a series of technical lectures to a university crowd in Buenos Aires, telling his audience in so many words, according to one listener, that he had come to Argentina "to civilize and teach mathematics" to the country's inhabitants. He also ostentatiously announced in several lectures that he disagreed with Levi-Civita "from several points of view." Severi's pronouncements did not sit well with the mathematicians in the audience, who knew of Levi-Civita's pioneering work in differential geometry and admired it. Severi further enraged his hosts by asking point-blank, "If you have made [French mathematician Jacques] Hadamard and Enriques academicians [of Argentina's scientific society, the Sociedad Cientifica Argentina], why haven't you done the same for me?" With the society's members deeply divided over what to make of Severi's mathematical reputation, they postponed the decision on his election until they could learn more about him as a person. The task was entrusted to an old classmate of Levi-Civita's, Felix Carli, a member of both the Sociedad Cientifica Argentina and the Accademia di Scienze Fisiche e Matematiche di Buenos Aires. "I beg you to give me your opinion of the man" [Carli 30*], he wrote to Levi-Civita. While we lack Levi-Civita's reply, Severi's substantial list of honors and affiliations does not include membership in either of Argentina's scientific organizations, which may suggest a tepid response on Levi-Civita's part.

Serving as Severi's assistant for four years, Francesco Tricomi, like Roth, had ready answers for those wanting to know what he had experienced in Rome. As a professor and mentor, he reported, Severi knew how to push his students along; on the pedagogic side, he ranked as an extraordinary teacher, and Tricomi had found his classroom duties useful, unlike Severi's other assistants who considered them a "waste of time". However, Tricomi also thought that Severi behaved as if he was "the 'padrone' [the lord and master], a little overbearing…[although] I never had any real clash with him," which Tricomi attributed to treating his responsibilities as an extension of his recent military service. Later, when Tricomi moved up the academic ladder and became a professor of mathematics at Florence, he took less kindly to Severi's requests, reminding him, politely but firmly, that "I was no longer under his orders" [Tri 67*].

Beniamino Segre, who became Severi's assistant several years later and who remained closer to him than any of his other pupils, also remembered him as "ambitious and pugnacious" [Segre 62]. Straining after the events of World War II to paint an accurate and fair portrait of Severi as a man, Segre said, "We need to keep in mind that Severi had a complex, intense, tormented nature, and an exceptional personality," which Severi himself had described as a "restless energy, which takes away my breath and makes me unhappy" [Segre 63*]. All in all, Segre concluded, the appearance of fearless confidence that Severi projected probably concealed some "mysterious, unjustified fear of not being appreciated and loved." Recalling his own dealings with Severi in Rome in the early 1920s, the American mathematician Oscar Zariski told an interviewer that Severi once said to him, "I love you, Zariski, but you don't love me" [Parikh 91], although the correspondence between the two mathematicians after the war suggests a more complicated relationship.

Public Acts

Unlike Enrico Fermi, his colleague at Rome, who never talked politics, Severi actively cooperated with Mussolini's government. In an article aptly titled "Fascismo e Scienza", published in 1933 in *L'Illustrazione Italiana*, a popular weekly magazine, Severi dismissed those who remained mired in the past ("a wretched preoccupation with conventional analytical politics and trifling doctrines from other times") while extolling, in the name of patriotism, loyalty to the regime for its goal of restoring the grandeur of Rome and reclaiming Italy's place in the world of science, starting with mathematics [Sev 33*]. The Italian school of mathematics was a matter of deep national and personal pride for Severi, who told his readers: "Not everyone knows that…Italy, in fact, occupies one of the foremost places, if not the first, in mathematics in the world today. Foreign mathematicians everywhere," he continued, "recognize this and as Italians and as fascists we are legitimately bound to be proud of it." More importantly, he concluded, "we export many ideas, nay many more than those we import." Even after the war ended, Severi persisted in believing that Italian mathematics (and by extension, his own achievements) did not receive the recognition they deserved outside Italy.[3] "Thank you for the draft …of [Fabio] Conforto's review," Severi began one letter to Ralph Boas, executive editor of the *Mathematical Reviews*, in March of 1949,

> I note, however, that the last lines of the original review, which had expressed a sensible opinion of my work, have been deleted. I would not point this out if I had not been very hurt by the way my works are generally reviewed in MR. This is the first time, after a half-century of intense, nonstop work in science, that I find myself having to express such grievances to a publication. Publishing …Conforto's final comments would perhaps have served to reaffirm that the Directors of MR do not share the unfavorable attitude of certain reviewers, which is something you kindly mentioned to me and which I certainly believe.…In any case, in your position…you have connections with many mathematicians and frequent opportunities to bring people together. Therefore I have faith in your efforts to restore the reputation of Italian mathematics, which is alive and active.…As one [who] loves my country and my science…this would distress me greatly, and if I am induced to do something that costs me some sacrifice (no one likes to talk about himself), it is because I believe I have to do it not so much in my own interest as in defense of my School, which follows me faithfully and which, like the majority of Italians, is working to restore our country, after the great disaster, to a high international level in the intellectual and spiritual realm, which is the realm where Italy has always distinguished itself throughout the centuries. [Sev 49*]

Photo courtesy ©Archivio Storico Luce.

Inaugural session of the fascist Academy of Italy, Farnesina Palace, 1930. Guglielmo Marconi, in ceremonial uniform, is seated next to Mussolini. Other academicians gathered around the table include Francesco Severi, Cesare Bazzani (first and second from left), and Francesco Giordani (third from right).

Enacted in 1938, Italy's anti-Jewish legislation altered abruptly Segre's relationship with Severi. "You already know of the whirlwinds that have shocked us over the past several months, inflicting unspeakable moral pain on us," Segre wrote to Zariski from Bologna on October 16, the day after the racial laws had banished him from the classroom, expelled him from numerous scientific academies and organizations, and relieved him of his duties as a managing editor of *Annali di Matematica Pura ed Applicata* [Segre 38*]. "Still more distressing," he added, "is the apathetic—if not to say hostile—attitude of certain individuals of our common acquaintance," being careful not to mention anyone by name. That same day, Segre sent a letter to Levi-Civita, also a member of the journal's editorial board, in which he identified Severi as the chief instigator behind their dismissal. In it, he wrote: "The initiative was started by S[everi], who—some time ago—indicated to the President of the [organization unidentified] the situation in the editorial office of the *Annali*. Said

[3] *Nor, for that matter, does the recent authoritative reference treatise* The Princeton Companion to Mathematics [Gowers 08] *cite the contributions of the Italian school of algebraic geometers by name.*

President then wrote to Dr. [unidentified name], requesting advice and this person left the matter completely up to Severi's decision" [N 96*]. Of the journal's four editors, three were Jewish (Guido Fubini was also dismissed), leaving Severi, who had joined the editorial board in 1925, as the journal's sole editor. "In no other case up to now has anything similar happened," he told Levi-Civita. Recalling the event in an article dedicated to Giovanni Sansone and published many years later in the *Annali*, Severi noted the "deplorable decree" that left him remaining "alone on the scientific committee of the 'Annali', becoming automatically, without my desire, the only managing editor" [Sev 60]. His colleague Giovanni Sansone, added Severi, had been the very first to share with him the duties of running the journal.

When the publisher of Springer ordered its editor, Otto Neugebauer,[4] in 1938 to remove Levi-Civita's name from the masthead of the *Zentralblatt*, the renowned international review journal in mathematics founded by Neugebauer, on the grounds that according to Italy's racial laws he was no longer a university professor, Severi's name quickly appeared in his place. While planning for the second meeting of the Italian Mathematical Union in Bologna in 1940, the organizers debated whether Levi-Civita, a former member and an expert on general relativity theory, could be invited to speak on that topic as a guest. Severi is reported to have said, "Please! We just got rid of that race."[5] The historians of Italian mathematics Giorgio Israel and Pietro Nastasi, who have written extensively about science and race in fascist Italy, have also reported that Severi personally intervened to deny his Jewish colleagues access to the University of Rome's mathematics library after the racial laws went into effect.[6] Two years later, Severi wrote Levi-Civita a friendly, if short, note in which he apologized for not being able to personally deliver a recent issue of the *Annali*, "but since I see that it is late, I am sending it to you, reserving to myself to come and greet you as soon as it will be possible for me" [Sev 40*]. History does not reveal if Severi kept the appointment.

By the end of the decade, Severi had consolidated his leadership position within Italy's mathematical community. In spring 1938, Severi petitioned Mussolini to underwrite an Institute of Higher Mathematics in Rome [INDAM], which was inaugurated in 1940, with the *Duce*; the minister for national education, Giuseppe Bottai; and a host of other Fascist dignitaries in attendance. Not surprisingly, Severi also became the institute's first president. In the wake of the racial laws, he had succeeded Enriques as professor of higher geometry at the University of Rome; he had also replaced Enriques as director of Rome's school of post graduate studies in the history of science. One of the few items still missing from his lengthy list of honors and appointments was membership in the Pontifical Academy of Sciences, whose roster had recently expanded to include Robert Millikan, Max Planck, Erwin Schrödinger, and other notable scientists. In 1939 an opening occurred. As one of four scientists in the running for the one vacant seat, Severi's credentials were hard to top. As one academy member wrote to Caltech's Millikan, highlighting the advantages that Severi's election would confer on the Pontifical Academy, "[W]e all have a great interest in concentrating our designation on the name of H[is] E[xcellency], Professor Severi, not only because he is a prince among the mathematicians, and probably the most prominent in the world in the branch of algebraic geometry…but on account of his great authority and his political position in Italy, we are in need of his help as a friendly link between the Italian authorities and the Pontifical Academy" [Giorgi 39*]. One wonders if Severi, who won the election, appreciated the irony of listening to papers presented by its long-time members Levi-Civita and Vito Volterra, both of whom had paid dearly for being both Jews and anti-fascists in Mussolini's Italy.

Investigation and Rehabilitation

After the liberation of Rome in June 1944, Italy's newly installed provisional government established a High Commission for Sanctions against Fascism to investigate allegations of wartime collaboration against party members, either for taking an active part in Fascist political life or for remaining loyal to Mussolini after he was deposed in September 1943. That year, at the behest of the Ministry of Public Instruction, the commission took up the case against Severi, the only mathematician dealt with in this fashion. When it initially suspended him from university teaching,

[4] *Neugebauer subsequently resigned from all editorial duties at Springer journals, left Germany, and joined the Brown faculty in 1939, where he became the founding editor of the AMS's new abstracting journal, MR (Mathematical Reviews).*

[5] *"Per carità, ci siamo appena liberati di quella razza." The story has been passed down from the mathematician Ugo Amaldi, present at the meeting, to Edoardo Amaldi, his son, who played a central role in rebuilding Italian physics after World War II, to Edoardo Vesentini, a distinguished algebraic geometer in his own right and former president of the Lincei, private communication, Tullio G. Ceccherini-Silberstein to the author (JG), November 11, 2011.*

[6] *Enzio Martinelli, a pupil of Severi, is the principal source for this story, private communication, Giorgio Israel to the author (JG), Oct. 28, 2011.*

effective August 1, 1944, Severi appealed the ruling. To the charge that he had been an apologist for the regime during the war, Severi countered by saying that he'd given scientific talks in Spain and Portugal, not political speeches, and that he had made a 1943 trip to Germany for the sole purpose of collecting a medal in connection with a Copernican anniversary. In May 1945, Severi's suspension was annulled and replaced by a *sanzioni minori*, a simple censure that involved a letter placed in his university personnel file, but that did not prevent him from teaching a course on higher geometry at INDAM during the 1945–46 academic year [Rog 05].

When pressed on the issue of anti-Semitism, Severi pointed to his repeated efforts on behalf of Levi-Civita (who had died in 1941) for membership in the Academy of Italy [Cap 03] and his continued friendship with Segre, whom he described as having always been his favorite student. Neither the central commission nor a separate commission assigned in 1945 to examine the behavior of former members of the Academy of Italy found anything to condemn in Severi's personal or professional conduct. In its report on Severi's conduct, in fact, the commission noted: "The moral rectitude and good services of [P]rofessor Severi as a person and as a scientist are beyond discussion and on the other hand no one could doubt it" [ACS 45*]. Faced with a new investigation the following year involving former Fascist academicians, Severi told Segre, "Naturally, I'll come out from this painful trial as immaculate as I have always been" [Sev 46*].

Severi's prediction proved true but only up to a point. In 1945 a separate committee, appointed by the provisional government to reconstitute Italy's storied Academy of the Lincei, homed in on members who had belonged to the Academy of Italy. The chairman of that commission went out of his way to note that the range of Severi's activities demonstrated "a marked independence and courageous conduct to ensure that science prevailed over the dominant politics" [ACS 45*]. In so many words, as the central commission had previously concluded, Severi "had not received from Fascism anything more than was his due as a distinguished scientist." Nevertheless, that summer the committee members unanimously decided to purge from the Lincei any members who had taken part in a March 1944 meeting held in German-occupied Florence, regardless of the reason behind their attendance. Severi had been present at that meeting, and so he was out. As Guido Castelnuovo, a committee member and Jewish mathematician who had gone into hiding during the war, wrote to Severi that June, "It pains me that it is necessary to take a step of such a nature with respect to a scientist who has honored Italy such as you" [Cast 45*].

According to the commission, Severi's transgression had been to accept an invitation from his old friend Gentile, at the time the Academy of Italy president, to attend a celebration there in honor of the eighteenth-century political philosopher Gianbattista Vico. "I have no reason to correct any page from the book of my life," Severi replied, after reading Castelnuovo's letter [Sev 45*]. Far from admitting any wrongdoing, Severi defended his visit, but thought it important to add a postscript in which he pointed out that "among the important examples of his behavior with respect to the racial laws," he had seen to it that Castelnuovo's book on the origins of the calculus remained in circulation after 1938.

Gentile was unavailable to shed any further light on the matter, having been assassinated by communists in Florence in August 1944 while riding his bicycle. Four years later, Italy's minister of justice, Palmiro Togliatti, declared a sweeping amnesty, and in July 1948, Severi was reelected a member of the Lincei. Severi, who had lost his position as president of INDAM, also recovered that post following the amnesty and held it until his death.

Although Severi emphatically denied being anti-Semitic at the end of the war, he saw evidence of others "paint[ing] me, especially in the Anglo-Saxon world, as anti-Semitic…[and presuming] racial preconceptions that I have never had," he wrote in one letter to Segre [Sev 49*], adding, "And you and many other Israelites know this well." A case in point was Oscar Zariski,[7] born into a Russian-Jewish family and an algebraic geometer at Harvard, who seemed in no rush to resume contact with Severi after 1945. "I am very sorry that he didn't answer [my letter]," Severi told Segre,

> I had sent him [in 1948] many of my papers including books, together with a very warm letter…I did the same with [Solomon] Lefschetz, who has already answered…expressing his deep appreciation. No answer, instead from Zariski, to whom I won't send anything more from now on, unless things

[7] *Zariski attended high school in Chernigov (Ukraine) and the University of Kiev (1918–1920). Admitted to the University of Rome in 1921 as a third-year student, Zariski received his doctor's degree in 1924 under the supervision of Castelnuovo. Zariski later said that Castelnuovo chose a problem that would suit him (Galois theory, solving by radicals) because he could see that Zariski was not, at heart, a geometer in the sense of the Italian school of algebraic geometry. He did postgraduate work at Rome on a Rockefeller fellowship (1924–1926) before going to Johns Hopkins University in 1927.*

> change. I know that Zariski had a grudge [against me]; [Tomás Rodriquez] Bachiller, who was there [at Harvard] …wrote to me that he had…explained to Zariski the real facts and that he seemed to be persuaded.
>
> Does he still perhaps believe in my anti-Semitism, the most disgusting calumny that has been circulated underground, without ever having the bravery to pronounce it publicly, it being so far from the truth? Why would he keep considering the polemics I had with Enriques in the past as a display of anti-Semitism? Can't anyone have a bone to pick with a Muslim without being against Mohammed. [Sev48*]

Severi also felt that these accusations had done great damage to the reputation of his own field of mathematics. As he wrote to Segre in another letter, "The attack that has been conducted against me has ended by damaging Italian geometry abroad and especially in America [Sev 49*]. You have only to look, continued Severi, at the "very hostile attitude towards us" by Zariski's group of abstract algebraists, despite the fact that Zariski "formed his outlook (that I always guided) in Italy."

Severi also found that some French mathematicians continued to harbor hard feelings toward him in the postwar period. Mounting a spirited defense of his aging mentor, in 1955 Segre wrote a letter to the French mathematician René Garnier, in which he stated unequivocally that rumors of Severi's anti-Semitism did not square with what he knew. In the paragraphs that followed, Segre reiterated many of the arguments Severi had used in the past to defend himself, including Segre's own interactions with Severi. In his reply, Garnier said that he was personally satisfied by Segre's narrative, but others might not be, given that "in Paris, there is strong resistance" [Ga 55*].

There is little correspondence between Severi and Zariski in Zariski's papers, which are deposited in the Harvard University Archives. There is none from before World War II, and the few letters they exchanged after 1948, when the correspondence seems to have resumed, at times turned testy. In response to a letter written by Zariski in summer 1953, Severi demanded to know why Zariski had brought up Hitler and Mussolini: "Do I have perhaps some responsibility in front of those who had to flee from paradise from the first and did not find asylum in the second?…Your references demonstrate to me that in certain areas of the mathematical world this non benevolent attitude towards me, from which I have greatly suffered, has not ceased.…On your part I have often had an impression of coldness, which at times I was not expecting. But it could be that it is only a consequence of your temperament" [Sev 53*]. Severi then turned to mathematical matters. Judging from their later correspondence, the subject never came up again.

One year later, when Severi's name was pointedly omitted from the list of speakers for an international symposium on algebraic geometry in 1954, Zariski wrote to the chair of the organizing committee: "I am particularly worried about the omission of the name of Severi. I think that Severi deserves a place of honor in any gathering of algebraic geometers as long as he is able and willing to attend such a meeting. We must try to avoid hurting the feelings of a man who has done so much for algebraic geometry" [Zar 54*]. An invitation was duly issued to Severi.[8]

Severi died in Rome on December 8, 1961, at the age of eighty-two; he remained proud of the fact that, as he once wrote, "I have never recanted nor repudiated any of the acts of my life that were, and are, expressions of the strongest attachment to my country" [Sev 53*].

Appendix: Severi the Mathematician

Francesco Severi, who contributed in fundamental ways to several areas of mathematics in the first half of the twentieth century, is generally acknowledged as one of the three great Italian algebraic geometers of that era, together with Guido Castelnuovo and Federigo Enriques. A hugely prolific author, Severi's bibliography contains 415 items, including 34 books that range from elementary to advanced monographs. He was gifted with extraordinary geometric intuition; however, when this was combined with the Italian algebraic geometers' imprecise mathematical language and their notion of what they considered a proof, it led him many times to either state a true theorem for which it was impossible to convert his proof to an acceptable modern one (e.g., see the article of Joseph Harris [Ha 86]), or to state as a true theorem one that was "almost true" but which later mathematicians had to modify in order to obtain a true theorem (e.g., see the article by Robert Lazarsfeld [Laz 81]). Ironically, Severi's own ideas in another context have often been utilized to furnish the correct proofs. For an authoritative discussion of Italian algebraic geometry and algebraic geometers, including Severi, between the two world wars, see the book by Aldo Brigaglia and Ciro Ciliberto [B-C 95].

In 1949 Severi presented a paper at the Colloque de géométrie algébrique, held in Liège [Sev 49], entitled "La géométrie algébrique italienne: sa rigueur, ses méthodes, ses problèmes". In it he

[8] *It was at this symposium where the famous exchange with André Weil took place (see next page).*

defended the Italian approach to what constituted a satisfactory proof. Here are two samples of what Severi had to say. In his opening paragraph he writes: "For many years a legend has run through a certain part, fortunately limited, of the mathematical community that Italian algebraic geometry, while being ingenious and rich in important results, has not yet attained the necessary rigor". He then goes on to discuss "substantial rigor", i.e., the sense of rigor of the Italian school, and "formal rigor," i.e., the sense of rigor of the Franco-American school of André Weil and Oscar Zariski.

Later in his talk (p. 41), while discussing a recent letter from "an eminent foreign geometer" (not named, but almost certainly Zariski), he says: "Personally, I believe that our methods, when carefully analyzed, give the same sense of assurance as the purely algebraic methods." Here by "algebraic methods" he seems to be referring to the Franco-American school's methods of proof. For the response of the "formal proof" community, see the critical and very interesting review of this paper by Claude Chevalley in *Mathematical Reviews*, 1951 [MR 0038094; 12, 353f].

What might be correct to say is that Severi, perhaps more than any other major mathematician of his day, stated more true theorems whose proofs were "irreparable" by modern standards or "almost true" theorems that required modifications to make them true or that were just plain false "theorems". But sorting through his triumphs and missteps is a story for another day.

Some of Severi's Main Contributions to Algebraic Geometry

Theorem of the Base. Severi's most cited work is almost certainly his *Theorem of the Base*, which he proved early in his career and is now usually referred to as the Néron-Severi Theorem [Sev 06].

It was one of the major results of early twentieth century algebraic geometry over the complex numbers **C**, and the paper itself was explicitly solicited for the *Math. Annalen* by Max Noether. The theorem says that a certain important abelian group NS(F) naturally associated with an algebraic surface F over **C** is finitely generated. Specifically, NS(F) is the quotient of the free group generated by the irreducible curves (divisors) on F by the subgroup of divisors algebraically equivalent to the zero divisor. Néron [Ner 52] showed that the theorem also holds for surfaces over any field, which is the reason that his name is also attached to it. For more detail on the theorem and Severi's contribution, see [Zar 71, Ch. 5.6].

Contribution to the Proof of the Fundamental Theorem of Smooth Surfaces over **C**. Both Severi [Sev 05] and Castelnuovo made related and key contributions to the proof of the Fundamental Theorem of Smooth Surfaces over **C**, one of the most beautiful and deepest contributions of early twentieth century algebraic geometry. The theorem states the equality of two apparently different birational invariants associated with the surface F: the dimension of the space of closed holomorphic 1-forms on F (called Picard integrals of the first kind) and the irregularity $q \equiv p_g - p_a$ of F, where p_g is the *geometric genus* and p_a is the *arithmetic genus* of F. See, e.g., [Kl 05, pp. 243–244] for a more thorough discussion of this theorem, including the relative contributions of the two mathematicians.

Principle of the Conservation of Number and Enumerative Geometry. Severi in 1912 made an exhaustive analysis of the validity of the Principle of the Conservation of Number, a very important tool in enumerative geometry [Sev 12]. However, he did this utilizing the foundational language and tools available in 1912. Further progress required a more refined foundational language, which indeed evolved in the following decades and consequently led to significant additional progress in enumerative geometry and Schubert's calculus (Hilbert's 15th problem). See [Kl 76] for a definitive history, including Severi's contributions.

Rational Equivalence of Algebraic Cycles and Intersection Theory on Smooth Projective Varieties over **C**. Severi's contributions here consist both of deep insights and serious missteps. He first introduced the notions of rational equivalence of algebraic cycles and studied its relationship to the intersection of algebraic cycles [Sev 33]. Early on, he became aware of difficulties with his definition of rational equivalence and its relationship to the intersection theory of algebraic cycles, and as a result, he continued to modify his definitions as time went on. At the 1954 International Conference of Mathematicians (as related by B. L. van der Waerden), Severi presented a new exposition of his theory, which Andre Weil famously (and correctly) criticized in the discussion session. Subsequently, in 1970 van der Waerden [Waer 70][9] showed to his satisfaction that Severi's definitions and results could in fact be adjusted to meet the modern standards of rigor. Precise and satisfactory definitions of rational equivalence in the rigorous language of the "French" school were given independently. See, e.g., Claude Chevalley [Chev 58]. To summarize the significance of Severi's contributions to rational equivalence and intersection theory, we

[9] *There were many exchanges over the years between Severi and van der Waerden concerning various aspects of algebraic geometry, including rational equivalence. For a description of some of these interactions, see the fascinating article by Norbert Schappacher* [Sch 07].

Courtesy of Istituto Nazionale di Alta Matematica "Francesco Severi".

Benito Mussolini and Francesco Severi (on the right) in the University of Rome's mathematics library, 1939.

turn to William Fulton [Ful 98, pp. 25–26], who, in his authoritative work on the subject, wrote: "It would be unfortunate, however, if Severi's pioneering work in this area were forgotten; and if incompleteness and the presence of errors are grounds for ignoring Severi's work, few of the subsequent papers on rational equivalence would survive."

Some Severi Conjectures

In addition to the multitude of theorems Severi claimed to have proved, he also made many interesting conjectures, some true, some false, including the examples below. Both of these conjectures have been settled—one as true, the other false—in two well-known papers of Kodaira [Kod 52] and Mumford [Mum 69].

Conjecture 1. Let V be a smooth irreducible projective variety of dimension n. In [Sev 09], Severi conjectured that

$$p_a = g_n - g_{n-1} + g_{n-2} - \cdots (-1)^{n-1} g_1,$$

where p_a is the arithmetic genus of V and g_j is the dimension of the vector space of holomorphic j-forms on V. This was proved by Kodaira in 1954.

Mumford proved the following conjecture of Severi to be false.

Conjecture 2. Let F be a smooth surface over $\mathbf{C}$. Then the group of 0-cycles modulo rational equivalence is finite dimensional.

Ironically, paraphrasing Mumford, the method of disproof of this conjecture is based almost entirely on Severi's systems of equivalence.

For an excellent discussion of this conjecture and several other related topics that Severi explored, see the article by A. Brigaglia, C. Ciliberto, and Claudio Pedrini [B-C-P 04]. Interestingly, they describe some of Severi's work, starting with his theory of rational equivalence in 1932, that has proved to be relevant to the study of motives, an important topic of current interest in algebraic geometry.

Acknowledgments

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The Klein Bottle: Variations on a Theme

Gregorio Franzoni

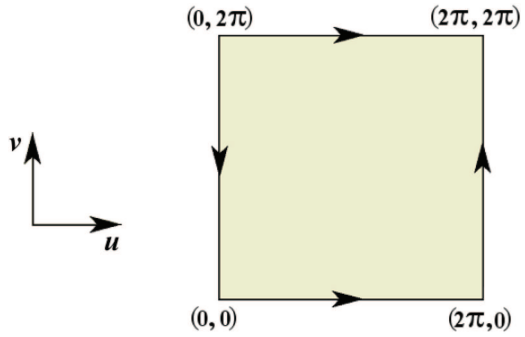

Figure 1. The Klein bottle as a square with the opposite sides identified in the sense of the arrows.

The Klein bottle ($\mathbb{K}$ in the following) is a topological object that can be defined as the closed square $[0, 2\pi] \times [0, 2\pi]$ with the opposite sides identified according to the equivalence relation

$$(u, 0) \sim (u, 2\pi),$$

$$(0, v) \sim (2\pi, 2\pi - v).$$

It is a well-known fact that $\mathbb{K}$ is a genus 2 nonorientable closed surface with Euler characteristic $\chi = 0$, which is topologically equivalent to a couple of Möbius bands glued together along the border, and that it is nonembeddable in $\mathbb{R}^3$. It is possible, however, to immerse it in $\mathbb{R}^3$, that is, to map it into $\mathbb{R}^3$ obtaining an image with no singular points. To give an immersion of $\mathbb{K}$ in $\mathbb{R}^3$, it suffices to define, on the fundamental square $[0, 2\pi] \times [0, 2\pi]$, an immersion that passes to the quotient with respect to the relation $\sim$. Felix Klein, in his original work in 1882 [18, §23], [15, pp. 308–310], described the object as follows: *tucking a rubber hose, making it penetrate itself, and then smoothly gluing the two ends together*, but he does not give any equation. Today we have some equations for this topological object which are fully satisfactory from a technical point of view and that can be called *canonical* for their simplicity and because of the clear and understandable shapes they lead to. They are due to T. Banchoff and B. Lawson and are described in detail later in this article. However, they do not resemble the object arising from the geometrical construction given by Klein, which will be called the *classical shape* in the following. It would also be desirable to have a good parametrization, with simple formulas and a nice shape, for the bottle in its classical version. Of course, the newer shapes are topologically equivalent to the classical one, but as immersions they belong to different regular homotopy classes (see the section about regular homotopy classes of immersed surfaces), so it makes sense to find a canonical expression for the classical bottle too, apart from historical and aesthetic reasons. To elaborate, we say that when a mathematical subject has a missing *tessera*, it is often perceived as a challenge to researchers, who put their best effort into it and sometimes go far beyond the original target, opening new research threads and/or revealing unknown links between different fields. The well-known story of the Costa surface and of the associated new family of minimal surfaces discovered by D. Hoffman and W. H. Meeks and the *sphere eversion* story, both summarized by R. S. Palais [20], on the one hand have challenged and inspired a number of geometers. On the other hand, they have played a key role in the development of mathematical visualization techniques and have contributed to bringing to the public's attention beautiful and spectacular aspects of mathematics. Finding good

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mathematical expression for surfaces is also useful if one wants to realize material models of them. Wire models of the Boy surface and of halfway steps of a sphere eversion made by F. Apéry and later by myself [2], [7] could be done because Apéry had expressed those surfaces as families of simple curves in space [1]. To say something more about material models of surfaces, we can claim that today the greatest potential in the field lies in *3D printing* systems, which help bringing 3D computer-generated models to the real world and that are today much more affordable than only a decade ago (less than US$10,000 for an entry-level system).

Tactile representation of mathematical objects is a natural extension of their visualization and, similarly, is a great source of inspiration for both young and senior mathematicians and an excellent way to highlight or communicate properties and concepts such as curvature, minimality, orientability, geodesic curves, singularity, and so on. Some very interesting work in this field has been done by pioneers like S. Dickson (see for example [7], [12]) and C. Séquin [22]. If the famous Brill-Schilling collection of plaster and wire models [13] had to be stopped in the 1920s because of high production costs and lack of interest by mathematicians, whose attention moved towards formalism and abstraction rather than visual and intuitive aspects, today we see a renewed interest in images and models. The trend portrayed by Palais [20] more than a decade ago is now stronger than ever, nourished also by a great interest in artistic expression inspired by mathematics. I believe that the time for the production of an extensive collection of models of surfaces, improved and updated if compared to Schilling's, might have arrived. In fact, in the specific case of the Klein bottle, I started looking for a nonsingular immersion in its classical shape and in a single piece because I needed a 3D model suitable to be used with a 3D printing system to be built as a real object. Later I learned that some conditions were not necessary, but the work was done by then!

A History of the Klein Bottle Representations

Until the 1970s, geometry and topology textbooks showed handmade drawings of the Klein bottle, which strictly followed the original geometric construction given by Klein, i.e., a tube that penetrates itself [15]. A second version of the Klein bottle, obtained by moving a *lemniscate* around a circle while it rotates, in its plane, half a turn around its center (see Figure 3), appeared in 1976 in a paper by T. Banchoff [3] dealing with minimal submanifolds of the bicylinder boundary. The author claims that he first discovered the model on the three-sphere, then projected it in three-space. The first computer graphics of this version of the Klein bottle appeared in 1982 in a work by S. Feiner, D. Salesin, and T. Banchoff as a case study for an animation language [4]. The paper provides wireframe and rendered images of the surface and also shows a sequence of steps of its geometrical construction which helps in the understanding of the topological structure. In this version, often called the *figure-eight* bottle or the Banchoff bottle, the self-intersection curve has a neighborhood made of two Möbius strips, while in the classical model the neighborhood of the double curve is a couple of annuli. Another interesting model of the bottle, very beautiful but maybe less immediately understood with respect to the previous one, can be obtained by projecting stereographically to $\mathbb{R}^3$ a minimal surface that lives on the three-sphere $\mathbb{S}^3$ and that belongs to one of the families of the minimal surfaces classified by H. B. Lawson in [19]. Lawson's work, dated 1970, does not contain any attempt at visualizing the surface. Its projection to $\mathbb{R}^3$ is a family of circles in space but also the zero set of a polynomial of degree six. In F. Apéry's book *Models of the Real Projective Plane* [1] one can find both parametric and algebraic formulas for the surface and—to my knowledge—the first computer graphics of it. In 1991, S. Dickson [11] provided equations for the bottle in its classical shape. He parameterized the surface in two distinct parts, whose union gives the desired object. This version was included among the examples in release 2.2 of the software *Mathematica* [25], a system for doing mathematics by computer that contains a powerful visualization tool for geometric objects. Again in 1991, D. Cox, G. Francis, and R. Idaszak made a striking video titled *The Etruscan Venus* [14], which shows a morphing (homotopy) between two new versions of the Klein bottle, one as the connected sum[1] of two copies of the Steiner Roman surface, the other as the connected sum of two copies of the Boy surface (Figure 2). The name is due to the fact that the double Roman surface recalls the shape of a woman's body. This morphing was obtained by modifying another remarkable one, called *Romboy*, which leads from the Roman surface to the Boy surface, worked out by F. Apéry and described and illustrated in [1]. A bottle composed of four pieces was worked out in 1993 by P. Chang, at that time a student at the Department of Mathematics at UCLA, and illustrated by S. Dickson [10]. The resulting model is suitable to be designed with CAD[2] software, even

[1] *The connected sum of two closed surfaces is obtained by removing a small disk from each one and by smoothly gluing together the borders of the holes; see also the section about regular homotopy classes of immersed surfaces.*

[2] Computer Aided Design.

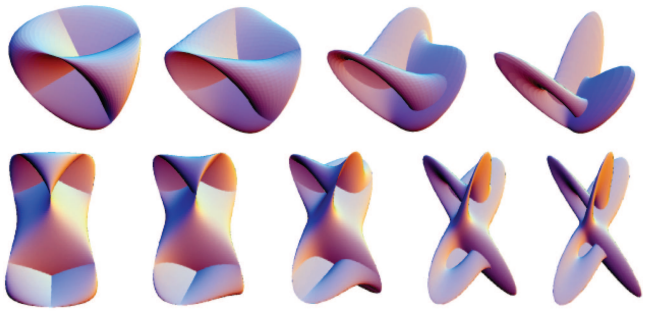

Figure 2. Top sequence: four steps of the Romboy morphing (F. Apéry); bottom sequence: five steps of the Etruscan Venus morphing (D. Cox, G. Francis, R. Idaszak).

by someone who knows very little mathematics, as it is the union of a set of sweepings of circular arcs along other circular arcs. In 1994, D. Cervone, in answer to a question posed by T. Banchoff [6], produced an effective representation of the Klein bottle in its classical shape. After that, J. Beall added transparency to the object and animated it. The resulting short movie was presented to D. Struik on his 100th birthday [16]. The surface is composed of two pieces, a tube around half of a lemniscate together with a piece of surface of revolution generated by the second half of the same lemniscate (more details follow later). A significant new step about representations of the Klein bottle was performed in 1999 by M. Trott [24], who provided both an algebraic and a parameterized expression of the surface in its classical shape, in a single piece, and used it as a test case to explain a survey of features of Mathematica software.

Regular Homotopy Classes of Immersed Surfaces

How much different from each other are the Klein bottles described in the previous section, apart from their appearance? The notion of regular homotopy of immersions gives us a rigorous criterion for telling whether any two immersions of a surface are *essentially* the same immersion or not. This is a quite technical subject, from which we will get only the key ideas that apply to our context. For a detailed discussion on the subject see for example [21]. A *homotopy* between two immersions is a continuous deformation which has as initial stage the first immersion and as final stage the second immersion; the homotopy is an equivalence relation; a *regular homotopy* is a smooth homotopy that is an immersion at each stage. An *immersed surface* can be considered as an equivalence class of immersions of a surface up to regular homotopy. It is possible to define a small set of immersed surfaces which generate, by means of the connected sum #, every compact immersed

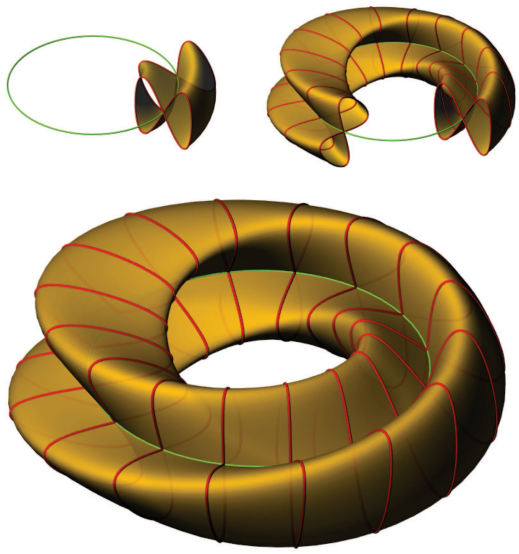

Figure 3. Three views of a Klein bottle generated by moving a *lemniscate*.

surface in $\mathbb{R}^3$. In particular, every immersion of the Klein bottle must be regularly homotopic to a connected sum of two copies of the Boy surface, which comes in two different classes, B and its mirror image $\overline{B}$ (see [1] for a detailed discussion about the Boy surface). Taking off a disk from B or $\overline{B}$ gives us respectively a right- or a left-handed Möbius band.

With this said, we can immediately recognize the regular homotopy classes of all the immersions of the Klein bottle described in the previous section: the classical one belongs to the $B\#\overline{B}$ class, for it can be seen as the union of two copies of the Möbius band which are the mirror images of each other, so they are twisted in opposite senses. Banchoff's bottle comes in two different classes, $B\#B$ and $\overline{B}\#\overline{B}$, because it is made of two Möbius bands twisted in the same sense. Lawson's bottle also contains two copies of the Möbius band twisted in the same sense; thus it comes in the same two classes as Banchoff's. The Etruscan Venus is nothing more than a canonical representative of the classes $B\#B$ and $\overline{B}\#\overline{B}$, depending on the "chirality" of the generators chosen. Are the three classes described so far all the possible ones? No. According to a result by James and Thomas [17] there must be *four* such classes, the number of classes given by $2^{2-\chi}$ where χ is the Euler characteristic of the surface, which is zero for the Klein bottle. This implies that a fourth kind of bottle, not equivalent to the three already mentioned, must exist. An interesting work concerning this aspect is being done at the moment by C. H. Séquin [23]. The author investigates how to construct a good representative for the fourth class and, along the way, shows several examples of immersions of

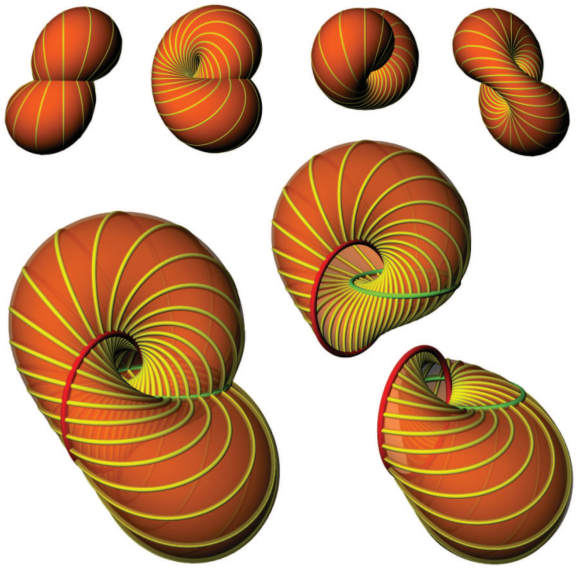

Figure 4. The Klein bottle as a one-parameter family of circles (H. B. Lawson): the top sequence shows four coordinate views; the larger images show that the surface is the union of two Möbius bands glued along their circular borders, colored in red, which pass through each other along the green circle. The red and green circles lie on the surface but do not belong to the family that generates the surface itself; both meet the generating family orthogonally.

the Klein bottle, some of which have never been depicted before.

Simple Equations for the Klein Bottle

This section recalls the parametrization and the resulting graphic images of two of the immersions of $\mathbb{K}$ in $\mathbb{R}^3$ which we called *canonical* at the beginning of the article, due respectively to T. Banchoff and to B. Lawson:

$$\text{BanchoffBottle}(u,v):\quad (1)\quad \begin{cases} x = (a+\cos(\frac{u}{2})\sin v - \sin(\frac{u}{2})\sin(2v)\cos u,\\ y = (a+\cos(\frac{u}{2})\sin v - \sin(\frac{u}{2})\sin(2v)\sin u,\\ z = \sin(\frac{u}{2})\sin v + \cos(\frac{u}{2})\sin(2v), \end{cases}$$

$$\text{LawsonBottle}(u,v):\quad (2)\quad \begin{cases} x = \cos 2u\ \sin v/\\ \quad (1-(\sin u\ \cos u+\sin 2u\ \sin v)/\sqrt{2}),\\ y = (\sin 2u\ \sin v-\sin u\ \cos v)/\\ \quad \sqrt{2}(1-(\sin u\ \cos u+\sin 2u\ \sin v)/\sqrt{2}),\\ z = \cos u\ \cos v/\\ \quad (1-(\sin u\ \cos u+\sin 2u\ \sin v)/\sqrt{2}). \end{cases}$$

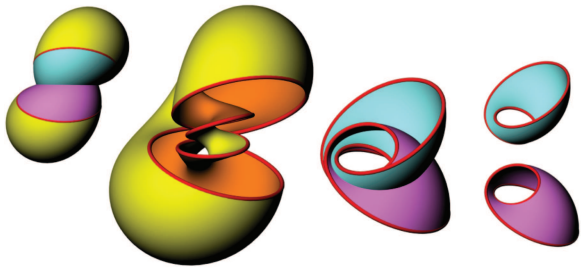

Figure 5. The same Klein bottle of previous image, cut in a different way. The part around the self-intersection circle is made of two Möbius bands. Cutting them away, the remaining portion of the surface is orientable, so it is possible to give its faces two different colors.

Some Classical-Looking Klein Bottles

In this section we recall some formulas and images of the Klein bottle in its classical shape, already mentioned in the chronological list. Some of them give the desired surface as the union of two or more pieces; some others have complicated expression, far from the shortness and the elegance of (1) and (2). The first one was created in 1994 by D. Cervone in answer to a scenario proposed by T. Banchoff: take a Bernoulli lemniscate and use half of it as the directrix for a tube and the other half as the generatrix for a revolution surface. Figure 6 shows how the construction is carried out. The union of the two pieces, which meet tangentwise, is a very effective and beautiful model of the bottle and fits perfectly with the description given by Klein. Its parametrization is also very simple. Now, before going on with the other two models of the classical bottle, due to S. Dickson and M. Trott, respectively, we will recall the basic technique of generating a *tube* around a curve. Let $\alpha(t) = (x(t), y(t))$, $t \in [a,b]$, be a curve lying on the xy-plane satisfying $\|\alpha'(t)\| \neq 0$. Let $\mathbf{k} = (0,0,1)$ be the z-axis unit vector and $\mathbf{T} = \frac{\alpha'}{\|\alpha'\|}$ be the unit tangent vector field of $\alpha(t)$. Let $\mathbf{N} = \mathbf{k} \wedge \mathbf{T}$. Then the couple of unit vectors $(\mathbf{N}, \mathbf{k})$ is a moving frame orthogonal to $\alpha'(t)$ and can be used to construct a tube around $\alpha(t)$ as follows:

$$\text{tube}(t,\theta) = \alpha(t) + r(t)(\cos\theta\,\mathbf{N} + \sin\theta\,\mathbf{k}),\quad (3)$$
$$(t,\theta) \in [a,b]\times[0,2\pi],$$

where the scalar continuous function $r(t)$ gives the radius of the tube. Note that, in this definition, $\mathbf{N}$ is not the standard unit normal to the curve $\alpha(t)$, which would point to the center of the osculating circle of $\alpha(t)$, because it would not be defined at the points where the curvature of $\alpha(t)$ vanishes.

The first model of the Klein bottle as a tube around a curve (in fact, the union of two distinct

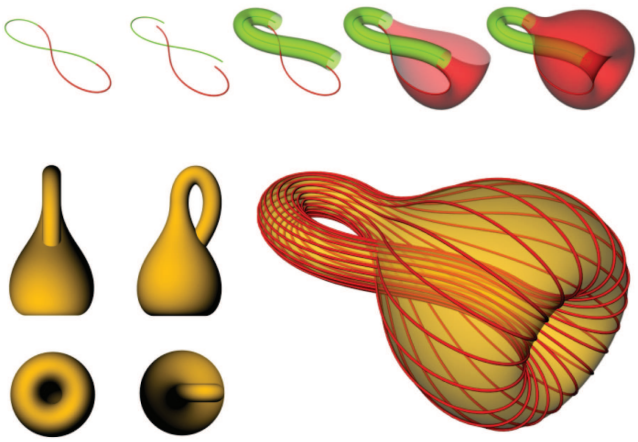

Figure 6. Construction of the Banchoff-Cervone bottle. Top sequence: a Bernoulli lemniscate is cut in two halves, one of which is moved aside by a distance *r*; a tube of constant radius *r* is generated about one of the halves and then a surface of revolution is generated by making the second half of the lemniscate turn around the axis passing by the two ends of the first half. Bottom: coordinate views and perspective of the resulting object.

tubes) is due to S. Dickson [11]. It is built up according to the scheme just described, except for the choice of the moving pair of vector fields, which is not orthogonal to the curve. Here is its parametrization:

(4)
$$\begin{aligned}&\text{DicksonBottle}(u,v)\\ &=\begin{cases} x=\begin{cases}6\cos u(1+\sin u)+4(1-\frac{1}{2}\cos u)\cos u\cos v & \text{for } 0\le u\le\pi,\\ 6\cos u(1+\sin u)+4(1-\frac{1}{2}\cos u)\cos(v+\pi) & \text{for } \pi<u\le 2\pi,\end{cases}\\ y=\begin{cases}16\sin u+4(1-\frac{1}{2}\cos u)\sin u\cos v & \text{for } 0\le u\le\pi,\\ 16\sin u & \text{for } \pi<u\le 2\pi,\end{cases}\\ z=4(1-\frac{1}{2}\cos u)\sin v.\end{cases}\end{aligned}$$

Parametrization (4) defines two distinct tubes, the first one built up on a frame which moves along the central curve remaining parallel to the xz-plane, the second one connecting the two ends of the first tube through a rotation of π of the moving frame. The union of these two parts turns out to be a good-looking object (Figure 7), which renders properly the idea outlined by Klein.

Note that the central curve used in this construction

(5)
$$\alpha(t):\begin{cases}x=6\cos t(1+\sin t),\\ y=16\sin t\end{cases}$$

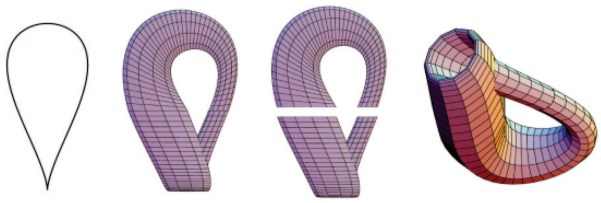

Figure 7. Klein bottle according to S. Dickson's definition; on the left, the central curve. Image on the right: courtesy of Wolfram Research, Inc.

is a *piriform*, a well-known curve (see for example [8] or [9]) whose general parametrization is

(6)
$$\text{Piriform}(t):\begin{cases}x=a(1+\sin t),\\ y=b\cos t(1+\sin t).\end{cases}$$

It can be easily proven, and also guessed by looking at Figure 7, that (4) defines a singular immersion, as the two tubes do not meet tangentwise along the common boundaries, and, of course, it would be better to get the surface as the image of a *single* parametrization, with no use of inequalities, as in (4). This has been achieved by M. Trott, who defines a parameterized bottle as a midstep in order to get an algebraic definition of it via *Mathematica*. We are interested in his parametric definition, which closely follows the scheme defined by (3). Trott puts some constraints on the directrix and on the radius, which can be summarized in the following:

(7)
$$\begin{aligned}&\text{i)} && \alpha(a)=\alpha(b),\\ &\text{ii)} && \alpha'(a)=-\alpha'(b),\\ &\text{iii)} && r(a)=r(b),\\ &\text{iv)} && r'(a)=r'(b)=\pm\infty.\end{aligned}$$

Conditions i), ii), and iii) mean that the two ends of the tube must be coincident, while iv) means that they must meet tangentwise. The curve and the radius he uses are

(8)
$$\beta(t)=\left(\frac{1}{t^4+1},\frac{t^2+t+1}{t^4+1}\right),\qquad t\in(-\infty,+\infty),$$

$$r(t)=\frac{84t^4+56t^3+21t^2+21t+24}{672(1+t^4)}$$

and the resulting image is shown in Figure 8. Equations (8) define an immersion, but the resulting shape is somehow edgy because of the choice of a directrix whose curvature has a nonsmooth behavior. Moreover, as t ranges on an open interval, when one tries to plot the surface, there is a missing strip corresponding to a neighborhood of the cusp (Trott uses $t\in[-20,+20]$ in his plots).

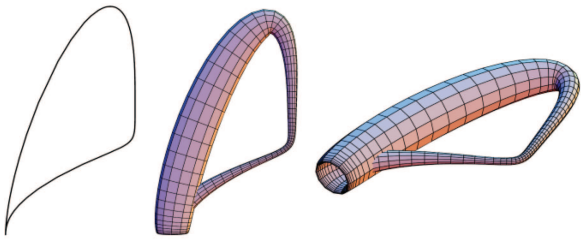

Figure 8. Klein bottle according to M. Trott's definition; on the left, the central curve.

A New Description

We propose here a new parametrization of the bottle in its classical shape. Starting from the two constructions described in the previous paragraph, it is natural to try to construct a new surface by taking the best features from both: the beautiful and symmetric directrix of Dickson's version and the rigorous geometric scheme of Trott's. In order to use the piriform as a directrix for our tube, we reparameterize it to make it start and end at the cusp:

$$\gamma(t) = \begin{cases} a(1-\cos t), \\ b\sin t(1-\cos t), \end{cases} \qquad t \in (0, 2\pi). \tag{9}$$

A suitable radius, which satisfies iii) and iv) of (7), is, for example,

$$r(t) = c - d(t-\pi)\sqrt{t(2\pi - t)}. \tag{10}$$

Parameters c and d affect, respectively, the radius of the whole tube and the difference between its minimum and maximum value. The resulting plot, with $(a, b, c, d) = (20, 8, \frac{11}{2}, \frac{2}{5})$ and $(t, \theta) \in (0, 2\pi) \times [0, 2\pi]$, is shown in Figure 9.

Some Remarks

Although, in our opinion, the described result is rather satisfactory, there are some facts to be pointed out. First, the parametrization of our surface, extensively written, has a long and complicated expressions. Secondly, similarly to what happens with Trott's parametrization, the image of the immersion fails to be closed because it misses a circle at the cusp of the directrix, as $\|\gamma'\|$ vanishes at $t = 0$ and $t = \pi$, while the scheme used needs $\|\gamma'\|$ to be nonzero everywhere. A way to eliminate this issue is to use one-half of the Dumbbell curve (see [9]) as a directrix. This is a famous sextic curve which also has the following parametrization:

$$\text{dumbbell}(t) : \begin{cases} x = \sin t, \\ y = \sin^2 t \cos t, \end{cases} \qquad t \in [0, 2\pi]. \tag{11}$$

If t ranges in $I = [0, \pi]$, one obtains a curve that satisfies the first three conditions of (7) and whose tangent vector is well defined for all $t \in I$,

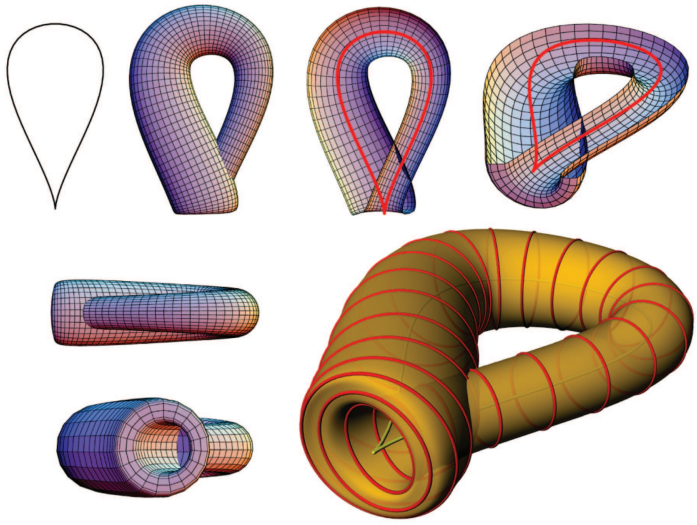

Figure 9. The piriform curve and a tube around it: an immersion of the Klein bottle in $\mathbb{R}^3$.

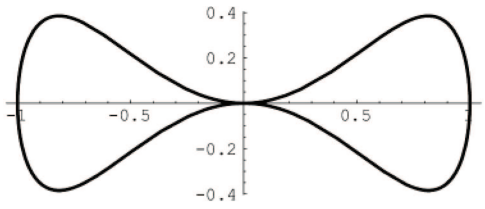

Figure 10. Dumbbell curve.

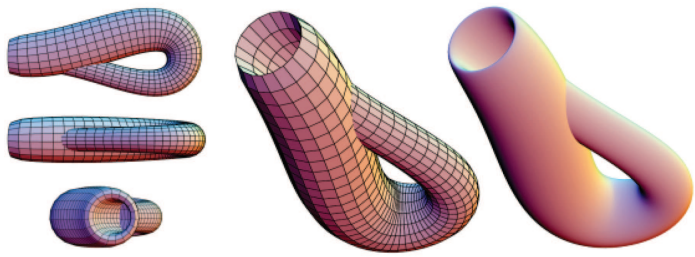

Figure 11. Some views of the Klein bottle as a tube around Dumbbell curve.

so it is possible to use a closed rectangle as a domain for the immersion, obtaining a closed image. By using a stretched Dumbbell curve $\alpha(t) = (5\sin t, 2\sin^2 t \cos t)$ as the directrix and $r(t) = \frac{1}{2} - \frac{1}{30}(2t-\pi)\sqrt{2t(2\pi - 2t)}$ as the radius function, with $t \in [0, \pi]$, we obtain another example of (closed) immersion of the Klein bottle (Figure 11).

Conclusion

After collecting some of the most interesting representations of the Klein bottle as a surface immersed in $\mathbb{R}^3$, recalling their equations and showing their graphics, we define two new

Figure 12. Photos of 3D printed models of three versions of the Klein bottle made by a Z-Printer Z310 Plus (material: plaster). Top left: Klein bottle according to parametrization (9)–(10); top right: Klein bottle according to parametrization (1); bottom left: Klein bottle cut in two parts, according to parametrization (2); bottom right: one half of the same surface, cut in such a way that each of the two halves is a Möbius band with circular border; some circular arcs lying on the surface itself are highlighted. (Models and pictures were created by the author.)

immersions of the bottle in the shape outlined by Klein in 1882, with a reasonably good appearance. They are suitable to make computer plots and, after generating a solid shell around them, to be used as an input dataset on 3D printing systems. The mathematical expression of both is still complicated and far from the elegance of versions like (1) and (2). They are intended to be a midstep towards an immersion of the Klein bottle in $\mathbb{R}^3$ which we would like to call canonical from both a mathematical and a historical point of view.

Acknowledgments

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The graphics in this article were produced with Mathematica by Wolfram Research, Inc.; some of the 3-D data was treated and rendered with McNeel Rhinoceros, v.4.

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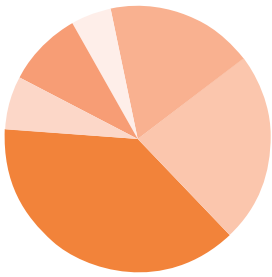


Report on the 2010-2011 New Doctoral Recipients

Richard Cleary, James W. Maxwell, and Colleen Rose

This report presents a statistical profile of recipients of doctoral degrees awarded by departments in the mathematical sciences at universities in the United States during the period July 1, 2010, through June 30, 2011. All information in the report was provided between July 2011 and April 2012 by the departments that awarded the degrees with information provided by the individual new doctoral recipients. The report includes an analysis of the fall 2011 employment plans of 2010–2011 doctoral recipients and a demographic profile summarizing characteristics of citizenship status, gender, and racial/ethnic group. This report provides a more extensive look at the 2010–2011 new doctorates and includes information about 2010-2011 doctoral recipients that were not included in the preliminary report in the April 2012 issue of *Notices*.

Detailed information, including tables which traditionally appeared in this report, is available on the AMS website at `www.ams.org/annual-survey/survey-reports`.

Doctoral Degrees Awarded

1,653 Ph.D.'s were awarded by 298 of the 302 doctoral-granting departments that we surveyed.

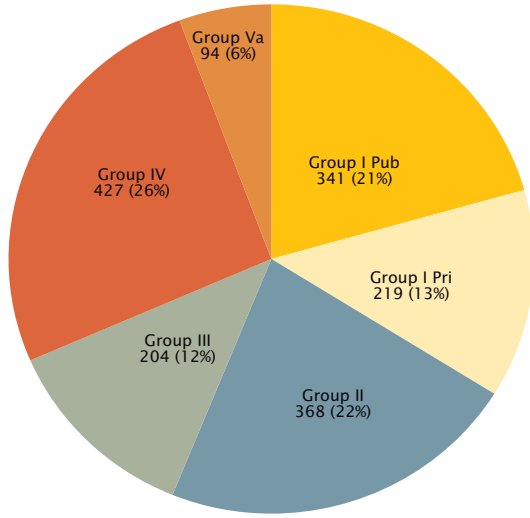
Group 1 Private reported the largest increase in the number of doctoral recipients, up 46 over the total of 173 reported for 2009-2010.

27% (448) of the new Ph.D.'s had a dissertation in statistics/biostatistics, followed by applied mathematics (251) with 15% and algebra/number theory (229) with 14%.

Comparing Ph.D.'s awarded this year to last year, the number of Ph.D.s awarded:

- Increased about 1% from 1,632 to 1,653.
- Groups I (Pu), III and Va awarded 7%, 6%, and 10% fewer degrees.
- Groups I (Pr), II and IV awarded 27%, 5%, and 1% more degrees.

Figure A.1: Number and Percentage of Degrees Awarded by Department Groupings*



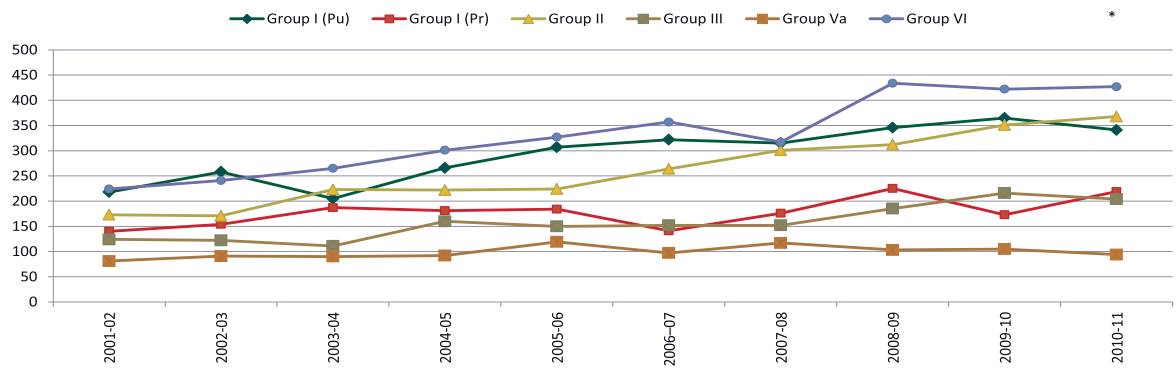
Total Degrees Awarded: 1,653

*See page 1093 for a description of the department groupings.

Richard Cleary is a professor in the Department of Mathematical Sciences at Bentley University. James W. Maxwell is AMS associate executive director for special projects. Colleen A. Rose is AMS survey analyst.

Doctoral Degrees Awarded

Figure A.2: New Ph.D.s Awarded by Group



*The increase shown in Group IV is due in part to the increase in response rate.

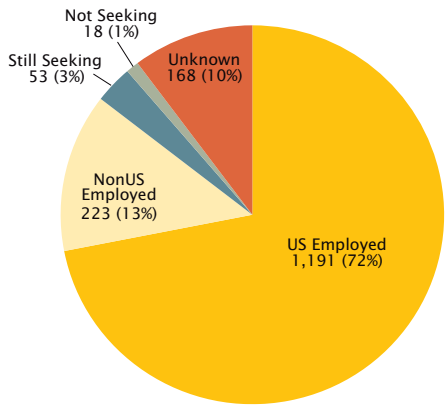
Looking at Ph.D.'s awarded this year with those awarded in 2001–2002:

- Ph.D.'s awarded have increased more than 72% over the last 10 years in all groups combined.
- Groups II continues to report record numbers each year, up 113% from 2001-2002.

Employment

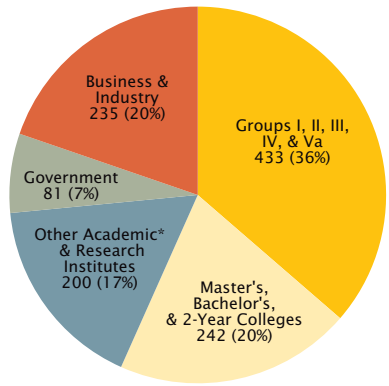
The overall unemployment rate is 4.3%, down from 6.9% last year. (Details on the calculations are on page 1093.) The employment plans are known for 1,485 of the 1,653 new doctoral recipients. The number of new doctoral recipients employed in the U.S. is 1,191, up slightly from last year's number of 1,163. Employment in the U.S. increased in all employer types except Groups IV, Va, B, and Other Academic. The number of new Ph.D.'s taking positions in government has increased to 81 this year compared to 75 last year. Academic hiring of new doctoral recipients increased slightly to 875.

Figure E.1: Employment Status



- 54% (642) of those employed in the U.S. are U.S. citizens, up from 53% last year.
- 74% (549) of non-U.S. citizens whose employment status is known are employed in the U.S., the remaining 194 non-U.S. citizens are either employed outside of the U.S. or are unemployed.
- 8% (110) of all new Ph.D.'s are working at the institution which granted their degree, the same percent as last year. These individuals constitute 13% of total U.S. Academic Employed.

Figure E.2: U.S. Employed by Type of Employer

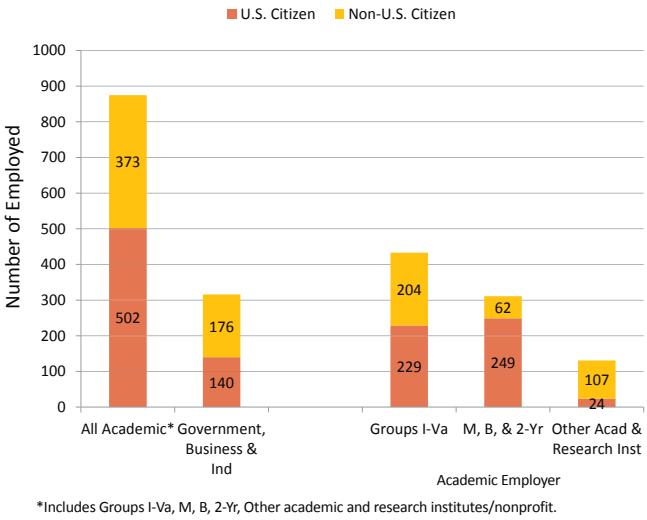


*Other Academic consists of departments outside the mathematical sciences including numerous medical related units.

- Total U.S. employed: 1,191
- U.S. Academic hiring increased slightly to 875 and all groups except IV, Va, B, and Other Academic reported increases.
- Business & Industry hiring increased 8% (from 217 to 235); all groups except Groups 1 (Pr) and II showed an increase in the number of Ph.D.'s taking positions in this sector.

Employment

Figure E.3: Employment in the U.S. by Type of Employer and Citizenship Total: 1,191

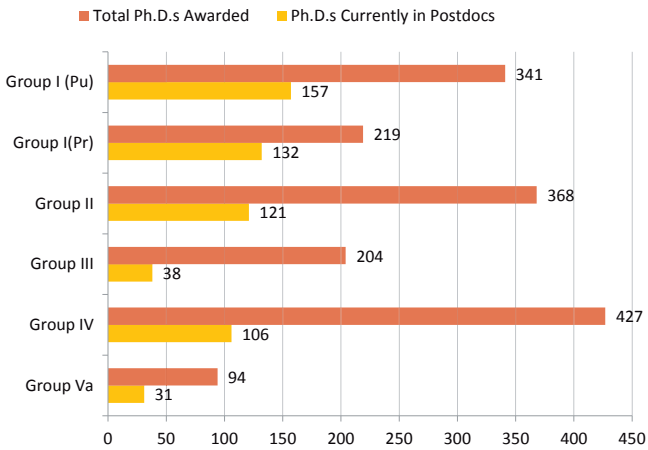


*Includes Groups I-Va, M, B, 2-Yr, Other academic and research institutes/nonprofit.

Looking at U.S. citizens whose employment status is known:

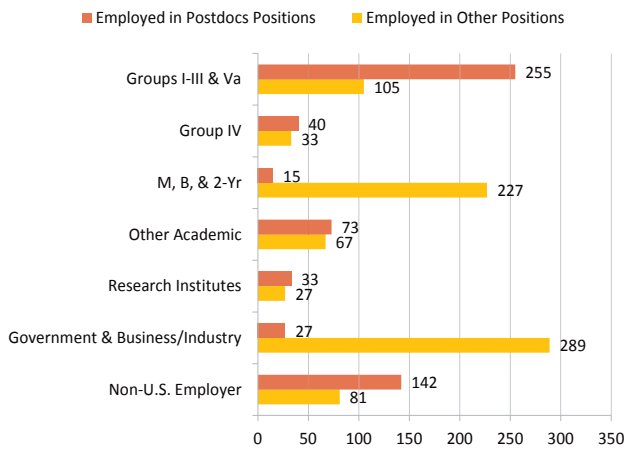
- 87% (642) are employed in the U.S., of these:
  - 36% are employed in Ph.D.-granting departments
  - 43% are employed in all other academic categories
  - 22% are employed in government, business and industry

Figure E.4: New Ph.D.'s Employed in Postdocs by Degree-Granting Group



- 41% (585) of the new Ph.D.'s are reported to be in postdoc positions, up from 40% last year.
- 24% of the new Ph.D.'s in postdoc positions are employed outside the U.S., last year this percentage was 20%.
- 48% of the new Ph.D.'s having U.S. academic employment are in postdocs; last year this percentage was 49%.
- 60% of the new Ph.D.'s awarded by Group I (Pr) are employed in postdocs, while only 19% of new Ph.D.'s awarded by Group III are in postdocs.

Figure E.5: Postdoc vs Non-Postdoc Employment by Type of Employer

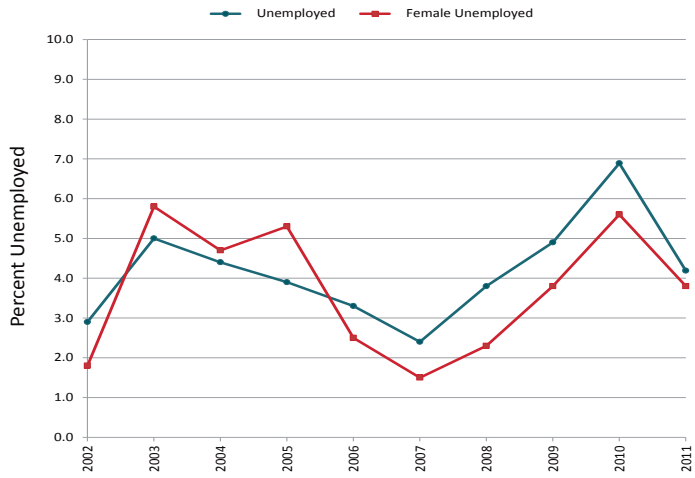


- Total known to be employed: 1,414
- 70% of the new Ph.D.'s employed in Groups I-Va are in postdoc positions, up from 68% last year. The analogous percent for Group I is 79%.

Employment

Figure E.6 displays the U.S. unemployment rate for new doctorates; details on the calculations are on page 1093.

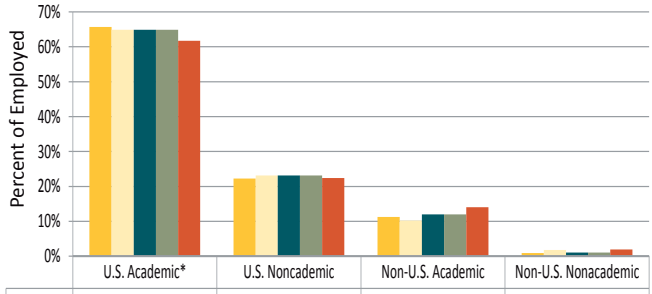
Figure E.6: Percentage of New Doctoral Recipents Unemployed 2002–2011*



*The difficult employment years of the 1990's are not show here but are located on the AMS website at www.ams.org/annual-survey/2010Survey-NewDoctorates.

- Unemployment among those whose employment status is known is 4.3%, down from 6.9% for fall 2010.
- Group I Pri reported highest unemployment at 5.2%.
- Group Va reported the lowest unemployment at 3.2%.
- 4.6% of U.S. citizens are unemployed, compared to 7% in fall 2010.
- 3.9% of non-U.S. citizens are unemployed; the rates by visa status are
  - 3.8% (3) for those holding a permanent visa, down significantly from last year's figure of 10.1% (7).
  - 4.0% for those holding a temporary visa.

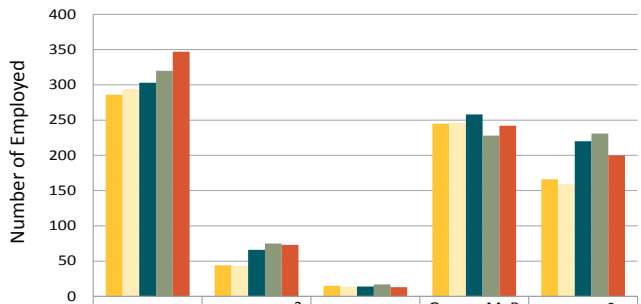
Figure E.7: Percentage of Employed New Ph.D.'s by Type of Employer



	U.S. Academic*	U.S. Noncademic	Non-U.S. Academic	Non-U.S. Nonacademic
Fall 2007	66%	22%	11%	1%
Fall 2008	65%	23%	10%	2%
Fall 2009	65%	23%	12%	1%
Fall 2010	65%	23%	12%	1%
Fall 2011	62%	22%	14%	2%

* Includes other academic departments and research institutes/other non-profits.

Figure E.8: New Ph.D.'s Employed in U.S. Academic Positions by Hiring Department Group[1]



	Groups I-III	Group IV [2]	Group Va	Groups M, B & 2-Yr	Other [3]
Fall 2007	286	44	15	245	166
Fall 2008	294	43	14	246	159
Fall 2009	303	66	14	258	220
Fall 2010	320	75	17	228	231
Fall 2011	347	73	13	242	200

1 For definitions of groups see page 954.
2 The increase shown in Group IV is due in part to the increases in response rate starting with fall 2009.
3 Includes other academic departments and research institutes/other nonprofits.

- Hiring of newP h.D.'s has increased in all groups except Groups M and B combined which hired 3% fewer new Ph.D.'s than last year.
- The percentage of Ph.D.'s hired into academic and nonacademic positions shows little variablility over the years.

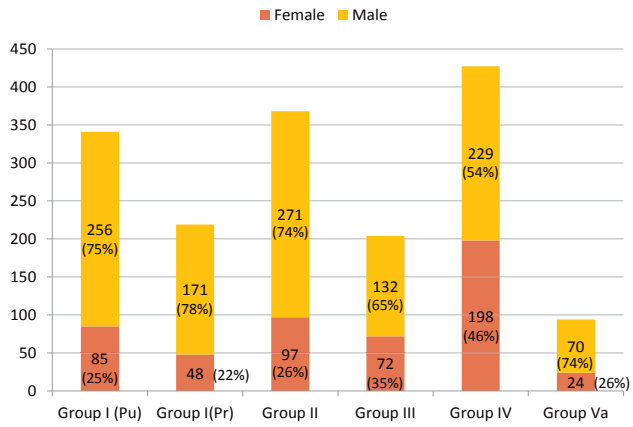
Comparing the last 5 years in Figure E.8 we see that:

- Groups I-III have showed an increasing trend in the hiring of new Ph.D.'s, hiring 21% more new Ph.D.'s than for Fall 2007.
- Groups IV, Va, M, B & 2-Yr and Other all show some variability over the years, but Groups IV and Other have hired 66% and 20% more new Ph.D.'s this year than they did in Fall 2007.
- Detailed information on new Ph.D.'s employed in the U.S. by degree-granting department group is available on the website at www.ams.org/annual-survey/2011Survey-NewDoctorates.

Demographics

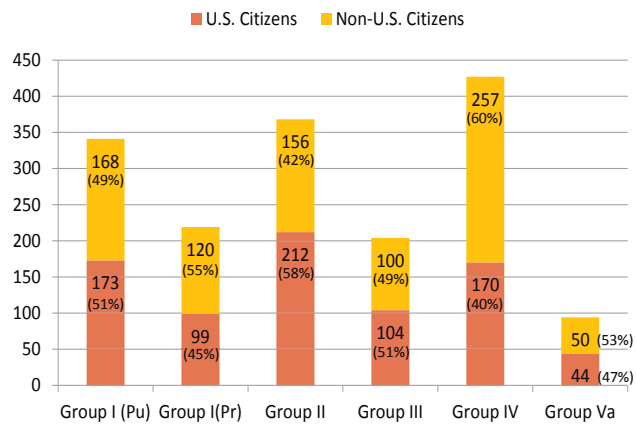
Gender and citizenship was known for all 1,653 new Ph.D.'s reported for 2010–2011. The number of U.S. citizens is 802 (49%) (up from 48% last year). The number of females accounted for 28% of the U.S. citizen total (down from 29% last year). The number of non-U.S. citizens receiving a Ph.D decreased to 51% from 52% last year; this is down 8 percentage points from the 10 year high of 59% reported in 2004–2005. 15% (83) of the non-U.S. citizens employed in the U.S. have permanent visa status (up from 13% last year).

Figure D.1: Gender of Doctoral Recipients by Degree-Granting Group



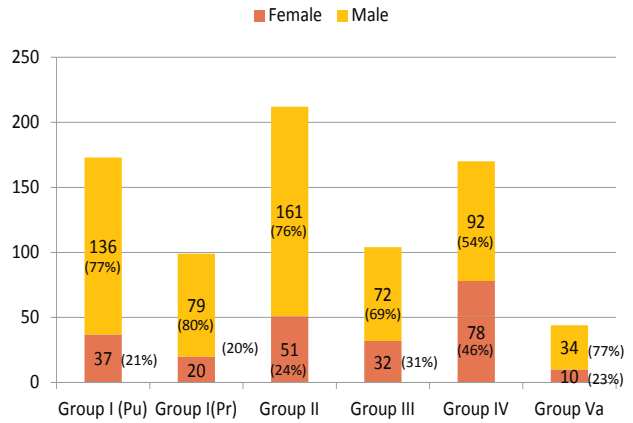
- Females account for 32% (524) of the 1,653 Ph.D.'s, up from last year's figure of 31%.

Figure D.2: Citizenship of Doctoral Recipients by Degree-Granting Group



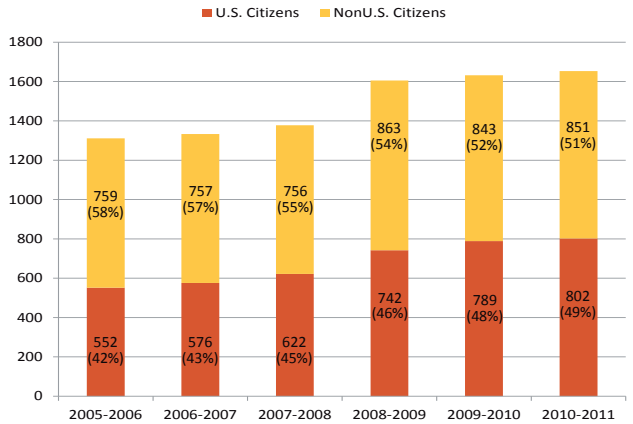
- Groups I (Pu), IV, and Va awarded more degrees to U.S. Citizens than Non-U.S. citizens, awarding 51%, 58% and 51% of their Ph.D.'s to U.S. citizens.

Figure D.3: Gender of U.S. Citizen Doctoral Recipients by Degree-Granting Group



- 51% of the males and 44% of the females are U.S. citizens.
- Females accounted for 28% of the U.S. citizens.
- Among the U.S. citizens: 4 are American Indian or Alaska Native, 40 are Asian, 21 are Black or African American, 20 are Hispanic or Latino, 3 are Native Hawaiian or Other Pacific Islander, 635 are White, and 79 are of unknown race/ethnicity.

Figure D.4: Citizenship of New Ph.D.* Recipients, 2004–2010



*The increase shown from 2007–2008 to 2008–2009 is due in part to the increase in the response rate for Group IV.

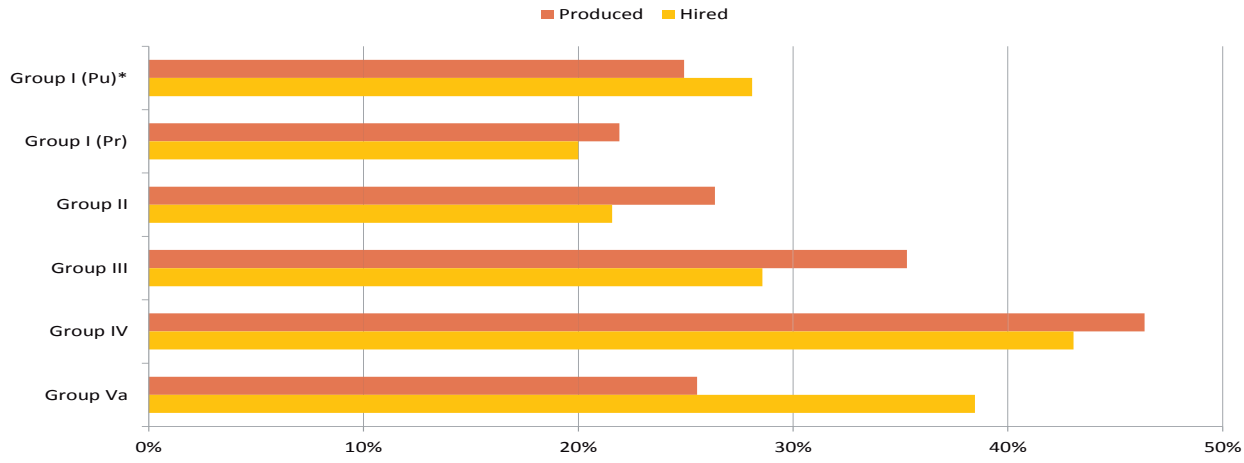
Looking at the last six years we see that:

- U.S. citizen counts have been increasing steadily, reaching a high of 802 this year. This is a 45% increase from Fall 2005–2006.
- Non-U.S. citizen counts which had been hovering around 750, are showing more variability increasing to 851 this year. While this is a 12% increase from Fall 2005–2006, it represents a 1% increase from last year.

Female New Doctoral Recipients

After trailing off slightly to 31% last year, the number of female new doctoral recipients is up slightly to 32% this year. Of the 875 new Ph.D.'s hired into academic positions 33% (289) were women, the same as last year. 28% of those hired into postdoc positions were women, with 41% of the women in postdocs being U.S. citizens, down from 57% last year. The U.S. unemployment rate for females is 3.8%, compared to 4.5% for males and 4.3% overall.

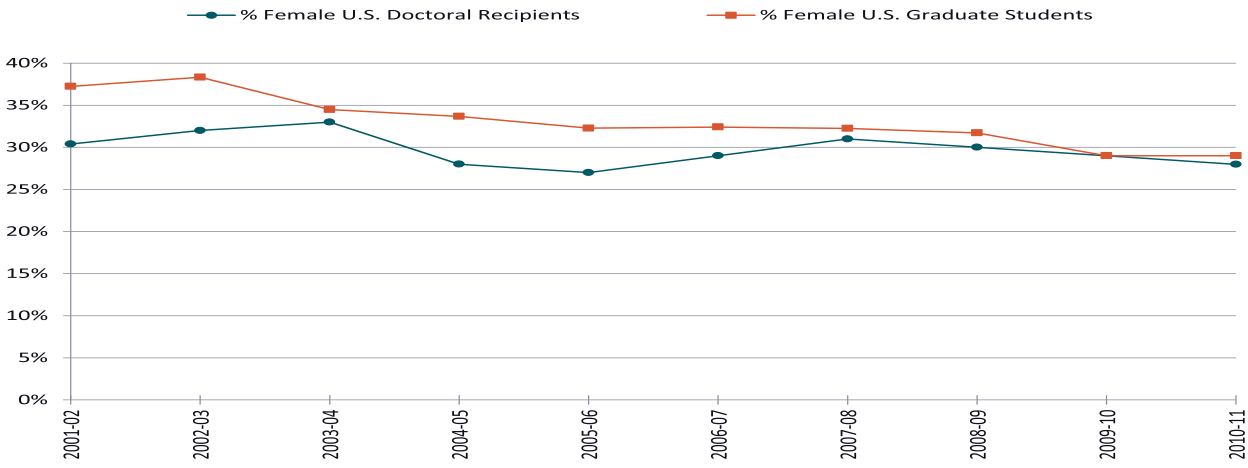
Figure F.1: Females as a Percentage of New Doctoral Recipients Produced by and Hired by Doctoral-Granting Group



* For definitions of groups see page 1093.

- 36% of those hired by Group B were women (down from 43% last year) and 33% of those hired by Group M were women (down from 39% last year).
- 62% of those hired into Research Institutes/Other non-profit positions were women (up rom 35% last year).
- 37% of those hired into Government positions were women (up from 36% last year).
- 62% of the women employed in Groups I-Va are in postdoc positions, compared to 70% of the men employed in postdocs in these groups.

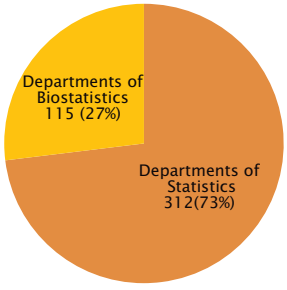
Figure F.2: Females as a Percentage of U.S. Citizen Doctoral Recipients



Ph.D.'s Awarded in Group IV (Statistics/Biostatistics)

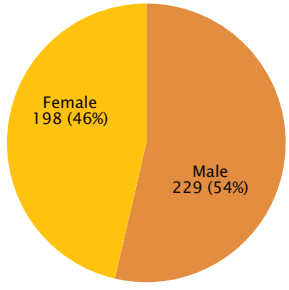
This section contains information about new doctoral recipients in Group IV (58 statistics and 35 biostatistics departments). Group IV produced 427 new doctorates, of which all but 52 had dissertations in statistics/biostatistics. This is a 1% increase in the number reported for fall 2010 of 422. In addition, Groups I–III and Va combined had 67 Ph.D. recipients with dissertations in statistics. In Group IV, 170 (40%) of the new doctoral recipients are U.S. citizens (while in the other groups combined 52% are U.S. citizens). The 90 departments responding last year and this year reported a total of 427 new doctoral recipients, an increase of 4% from last year. The unemployment among the Group IV new Ph.D.'s is 3.8% up from 2.3.

Figure S.1: Ph.D.'s Awarded in Group' IV



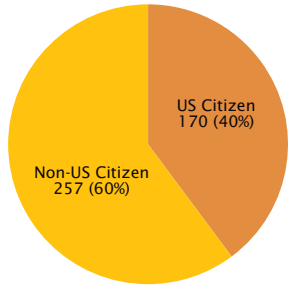
- 26% of all Ph.D.'s awarded were in Group IV.
- Females account for 41% of statistics and 60% of biostatistics Ph.D.'s awarded.

Figure S.2: Gender of Group IV Ph.D. Recipients



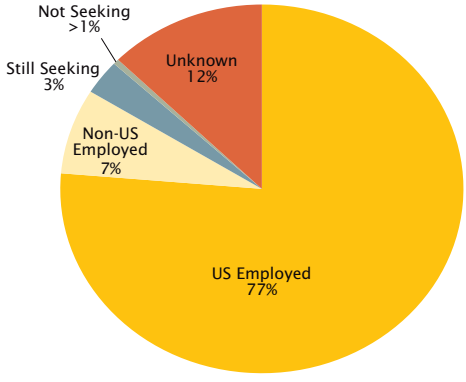
- Females accounted for 46% of the 427 Ph.D.'s in Group IV, compared to all other groups combined, where 27% are female.

Figure S.3: Citizenship of Group IV Ph.D. Recipients



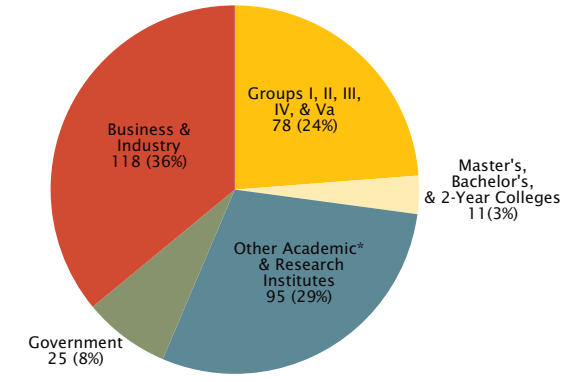
- 46% of Group IV U.S. citizen Ph.D. recipients are females, while in all other groups combined 24% of the U.S. citizens are females.

Figure S.4: Employment Status of Group IV Ph.D. Recipients



- 3.8% of Group IV Ph.D.'s are unemployed compared to 4.4% among all other groups. This is up from 2.3% last year.
- Unemployment among new Ph.D.'s with dissertations in statistics/probability is 3.6%, up from 3.4%. Among all other dissertation groupings 3.5% are unemployed.

Figure S.5: U.S. Employed Group IV Ph.D. Recipients by Type of Employer



*Other Academic consists of departments outside the mathematical sciences including numerous medical related units.

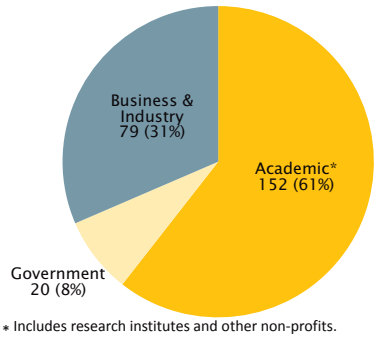
- Group IV total U.S. employed: 328
- 36% of Group IV Ph.D.'s are employed in Business/Industry, compared to 14% in all other groups.
- 42% of those hired by Group IV were females, compared to 24% in all other groups.

Information from the Employment Experiences of New Doctorates (EENDR) Survey

This section contains additional information on employment gathered from a subset of the 2010–2011 new Ph.D.'s on the EENDR Survey. It expands on the details of employment which are not available through the departments.

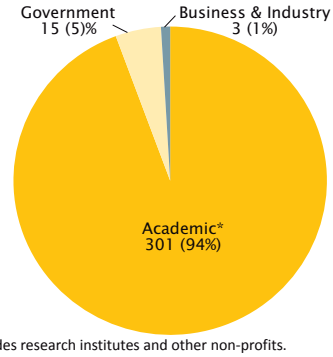
The 1,289 new Ph.D.'s reported in our Preliminary Report were sent this survey; of those individuals 699 (54%) responded. The employment status is known for 692 of these individuals, the U.S. unemployment among this group is 2.2%. The median age among this group of respondents is 30.

Figure EE.1: EENDR Respondents Reporting Permanent U.S. Employment by Sector



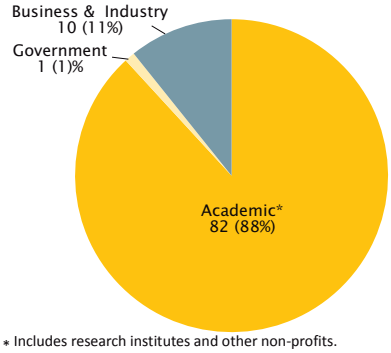
* Includes research institutes and other non-profits.

Figure EE.2: EENDR Respondents Reporting Temporary U.S. Employment by Sector



* Includes research institutes and other non-profits.

Figure EE.3. EENDR Respondents Employed Outside the U.S. by Sector



* Includes research institutes and other non-profits.

Of the 251 permanently employed:

- 34% are women.
- 74% of those reporting academic employment hold tenured/ tenure-track positions.

Of the 319 temporarily employed:

- 31% are women.
- 27% were unable to find a suitable permanent position (down from 51% last year).
- 71% are employed in postdocs and 39% of these reported they could not find a suitable permanent position.

Of the 93 employed outside the U.S.:

- 17% are women.
- 27% are U.S. Citizens.
- 79% of the U.S. Citizens are employed in postdocs and 50% of these reported they could not find a suitable permanent position.

Table EE.1: Number and Percentage of EENDR Respondents Employed in the U.S. by Job Status

					Temporary		Temporary Postdocs				
Year	Perm Total	%	Temp Total	%	Perm Not Avail	%	Total	%	Perm Not Avail	%	Unkown
Fall 2007	259	53%	227	47%	88	39%	172	76%	57	33%	0
Fall 2008	245	49%	222	45%	74	33%	172	77%	47	27%	0
Fall 2009	318	49%	326	51%	146	45%	234	72%	68	29%	0
Fall 2010	320	48%	341	52%	140	41%	246	72%	68	28%	0
Fall 2011	251	44%	319	56%	87	27%	225	71%	87	39%	0

Comparing the employment status of EENDR respondents employed in the U.S. over the last five years we see that:

- Permanent positions have dropped to 38% this year, a five-year low and down 22% from Fall 2010.
- Temporary positions have decreased to 48% this year, while this is up from Fall 2007 it is down from last year.
- 27% of those holding temporary positions were unable to find suitable permanent positions, a five-year low and down 38% from Fall 2010.
- 39% of those holding postdoc positions were unable to find suitable permanent positions, a five-year high.

Information from the Employment Experiences of New Doctorates (EENDR) Survey

Table EE.2: Percentage of EENDR Respondents Employed in the U.S. by Employment Sector within Job Status

Year	Permanent			Temporary		
	Acad	Govn	B/I	Acad	Govn	B/I
Fall 2007	68%	3%	29%	93%	4%	3%
Fall 2008	63%	6%	31%	95%	4%	1%
Fall 2009	64%	6%	29%	91%	5%	4%
Fall 2010	64%	8%	28%	93%	5%	2%
Fall 2011	61%	8%	31%	94%	5%	1%

Looking at at Table EE.2 we see that

- Permanent academic employment has dropped to 61%, reaching a five-year low and down 7 percentage points from 2007. While temporary employment in this sector has increased to 94%.
- Permanent government employment has leveled of at 8%.
- Business/Industry shows some variability in permanent employment, while temporary positions are showing a downward trend.

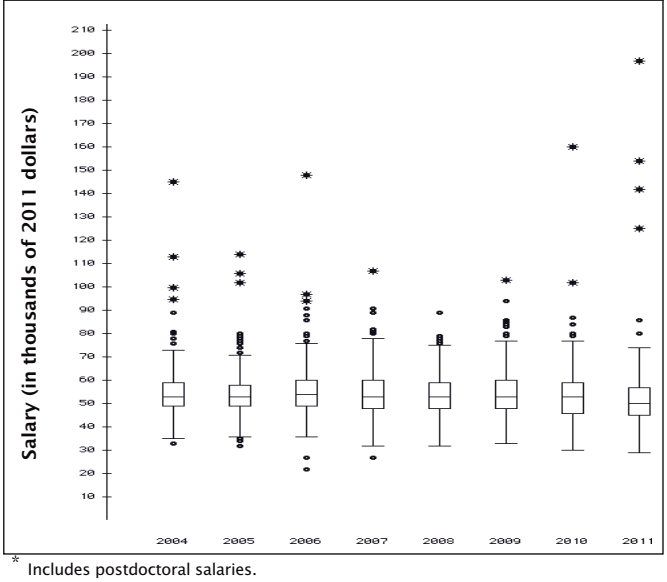
Starting Salaries of the 2010-2011 Doctoral Recipients

The starting salary figures were compiled from information gathered on the EENDR questionnaires sent to 1,289 individuals using addresses provided by the departments granting the degrees; 699 individuals responded between late October and April. Responses with insufficient data or from individuals who indicated they had part-time or non-U.S. employment were excluded. Numbers of usable responses for each salary category are reported in the following tables.

Readers should be warned that the data in this report are obtained from a self-selected sample, and inferences from them may not be representative of the full population.

Academic Teaching/Teaching and Research 9–10-Month Starting Salaries* (in thousands of dollars)

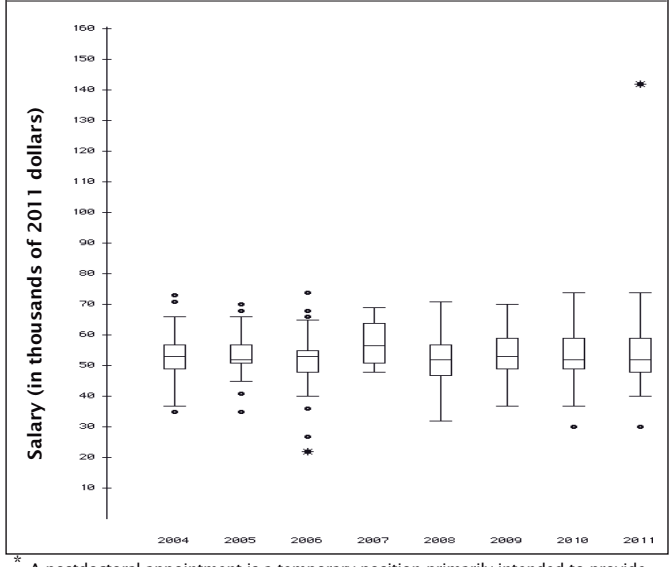
Ph.D. Year	Min	Q_1	Median	Q_3	Max
Total (165 male/73 female)					
2011 M	28.8	45.0	50.0	57.0	197.0
2011 F	36.0	46.0	51.0	60.0	154.0
One year or less experience (165 male/73 female)					
2011 M	28.8	45.0	50.0	57.0	197.0
2011 F	36.0	46.0	51.0	60.0	154.0



* Includes postdoctoral salaries.

Academic Postdoctorates Only* 9–10-Month Starting Salaries (in thousands of dollars)

Ph.D. Year	Min	Q_1	Median	Q_3	Max
Total (70 male/17 female)					
2011 M	30.0	48.0	52.0	58.5	74.2
2011 F	40.0	48.0	52.0	65.0	142.0
One year or less experience (70 male/17 female)					
2011 M	30.0	48.0	52.0	58.5	74.2
2011 F	40.0	48.0	52.0	65.0	142.0

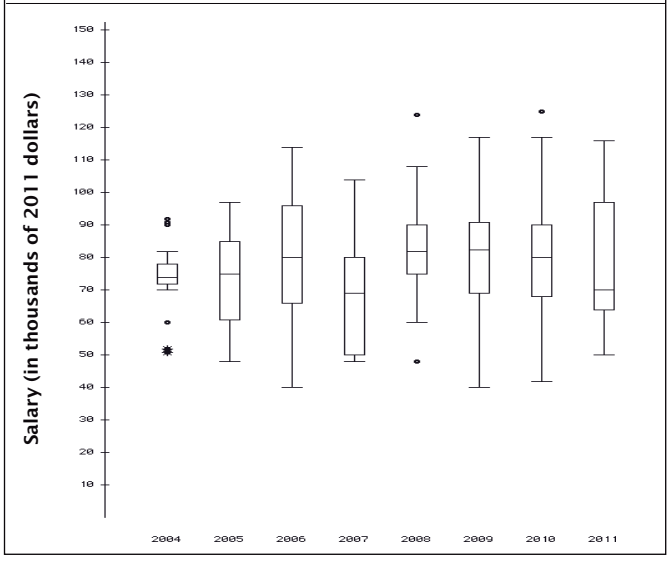


* A postdoctoral appointment is a temporary position primarily intended to provide an opportunity to extend graduate training or to further research experience.

Starting Salaries of the 2010-2011 Doctoral Recipients

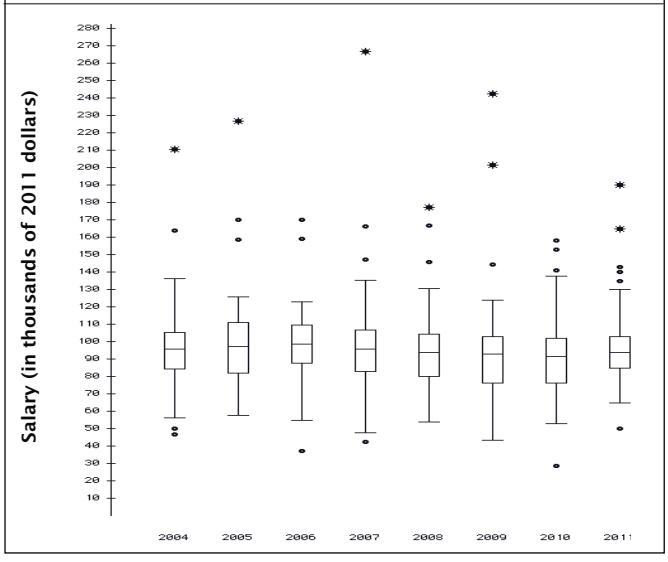
Government
11–12-Month Starting Salaries
(in thousands of dollars)

Ph.D. Year	Min	Q_1	Median	Q_3	Max
Total (18 male/14 female)					
2011 M	50.0	65.0	83.2	100.6	115.7
2011 F	52.0	63.9	68.5	85.0	105.0
One year or less experience (17 male/11 female)					
2011 M	50.0	65.0	81.4	97.0	115.7
2011 F	52.0	63.9	70.0	80.0	105.0



Business and Industry
11–12-Month Starting Salaries
(in thousands of dollars)

Ph.D. Year	Min	Q_1	Median	Q_3	Max
Total (60 male/18 female)					
2011 M	65.0	90.0	95.0	100.1	190.0
2011 F	50.0	85.0	91.0	106.8	165.0
One year or less experience (54 male/15 female)					
2011 M	65.0	90.0	95.0	100.0	190.0
2011 F	50.0	85.0	92.0	105.5	165.0



Remarks on Starting Salaries

Key to Tables and Graphs. Salaries are those reported for the fall immediately following the survey cycle. Years listed denote the survey cycle in which the doctorate was received—for example, survey cycle July 1, 2010–June 30, 2011, is designated as 2011. Salaries reported as 9–10 months exclude stipends for summer grants or summer teaching or the equivalent. M and F are male and female respectively. Male and female figures are not provided when the number of salaries available for analysis in a particular category was five or fewer. All categories of "Teaching/Teaching and Research" and "Research Only" contain those recipients employed at academic institutions only.

Graphs. The graphs show standard boxplots summarizing salary distribution information for the years 2004 through 2011. Values plotted for 2004 through 2011 are converted to 2011 dollars using the implicit price deflator prepared annually by the Bureau of Economic Analysis, U.S. Department of Commerce. These categories are based on work activities reported in EENDR. Salaries of postdoctorates are shown separately. They are also included in other academic categories with matching work activities.

For each boxplot the box shows the first quartile (Q1), the median (M), and the third quartile (Q3). The interquartile range (IQR) is defined as Q3–Q1. Think of constructing invisible fences 1.5 IQR below Q1 and 1.5 IQR above Q3. Whiskers are drawn from Q3 to the largest observation that falls below the upper invisible fence and from Q1 to the smallest observation that falls above the lower invisible fence. Think of constructing two more invisible fences, each falling 1.5 IQR above or below the existing invisible fences. Any observation that falls between the fences on each end of the boxplots is called an outlier and is plotted as ● in the boxplots. Any observation that falls outside of both fences either above or below the box in the boxplot is called an extreme outlier and is marked as ✱ in the boxplot.

Other Information

Survey Response Rates

Doctorates Granted
Departmental Response Rates

Group I (Pu)	25 of 25 including	0 with no degrees
Group I (Pr)	23 of 23 including	0 with no degrees
Group II	55 of 56 including	1 with no degrees
Group III	81 of 81 including	22 with no degrees
Group IV	90 of 93 including	10 with no degrees
Statistics	57 of 58 including	4 with no degrees
Biostatistics	33 of 35 including	6 with no degrees
Group Va	24 of 24 including	4 with no degrees

Doctoral Degrees Not Reported

The following mathematical sciences departments did not respond with their doctoral degrees awarded:

Baylor University, Department of Statistical Sciences

The University of Albany, SUNY, Department of Epidmiology & Biostatistics

University of Louisville, Department of Bioinformations & Biostatistics

University of Miami, Department of Mathematics

Group Descriptions

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

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

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

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

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

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

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

Listings of the actual departments which compose these groups are available on the AMS website at `www.ams.org/annual-survey/groups_des`.

U.S. Unemployment Rate Calculations

In the unemployment calculations provided in this report the individuals employed outside the U.S. have been removed from the denominator used in the calculation of the rate, in addition to the routine removal of all individuals whose employment status is unknown. This is a change from Annual Survey Reports prior to 2009. As a consequence, the unemployment rate now being reported more accurately reflects the U.S. labor market experienced by the new doctoral recipients. This change tends to increase the rate of unemployment over that reported in prior years.

In a further small change from prior years, those individuals reported as not seeking employment have also been removed from the denominator. The number of individuals so designated is small each year, and the impact of this change is to produce a slight increase in the rate over that reported in prior years.

The unemployment rates for years prior to 2009 shown in this report have been recalculated using this new method. One can view a comparison of the unemployment rates using the traditional method and the new method by visiting the AMS website at `www.ams.org/annual-survey/surveyreports.html`.

About the Annual Survey

The Annual Survey series, begun in 1957 by the American Mathematical Society, is currently under the direction of the Data Committee, a joint committee of the American Mathematical Society, the American Statistical Association, the Mathematical Association of America, and the Society of Industrial and Applied Mathematics. The current members of this committee are Pam Arroway, Richard Cleary (chair), Steven R. Dunbar, Susan Geller, Abbe H. Herzig, Ellen Kirkman, Joanna Mitro, James W. Maxwell (ex officio), Bart S. Ng, Douglas Ravanel, and Marie Vitulli. The committee is assisted by AMS survey analyst Colleen A. Rose. In addition, the Annual Survey is sponsored by the Institute of Mathematical Statistics. Comments or suggestions regarding this Survey Report may be directed to the committee.

Other Sources of Data

Visit the AMS website at `www.ams.org/annual-survey/other-sources` for a listing of additional sources of data on the Mathematical Sciences.

An Eloquent Formula for the Perimeter of an Ellipse

Semjon Adlaj

The values of complete elliptic integrals of the first and the second kind are expressible via power series representations of the hypergeometric function (with corresponding arguments). The complete elliptic integral of the first kind is also known to be eloquently expressible via an arithmetic-geometric mean, whereas (before now) the complete elliptic integral of the second kind has been deprived such an expression (of supreme power and simplicity). With this paper, the quest for a concise formula giving rise to an exact iterative swiftly convergent method permitting the calculation of the perimeter of an ellipse is over!

Instead of an Introduction

A recent survey [16] of formulae (approximate and exact) for calculating the perimeter of an ellipse is erroneously resuméd:

> There is no simple exact formula:
> There are simple formulas but they
> are not exact, and there are exact
> formulas but they are not simple.

No breakthrough will be required for a refutation, since most (if not everything!) had long been done by Gauss, merely awaiting a (last) clarification.

The Arithmetic-Geometric Mean and a Modification Thereof

Introduce a sequence of pairs $\{x_n,\ y_n\}_{n=0}^{\infty}$:

$$x_{n+1} := \frac{x_n + y_n}{2},\ y_{n+1} := \sqrt{x_n y_n}.$$

Define *the arithmetic-geometric mean* (which we shall abbreviate as AGM) of two positive numbers x and y as the (common) limit of the (descending) sequence $\{x_n\}_{n=1}^{\infty}$ and the (ascending) sequence $\{y_n\}_{n=1}^{\infty}$ with $x_0 = x$, $y_0 = y$.[1]

The convergence of the two indicated sequences is said to be quadratic [7, p. 588]. Indeed, one might readily infer that (and more) by putting

$$r_n := \frac{x_n - y_n}{x_n + y_n},\ n \in \mathbb{N},$$

and observing that

$$r_{n+1} = \left(\frac{\sqrt{x_n} - \sqrt{y_n}}{\sqrt{x_n} + \sqrt{y_n}}\right)^2 = \left(\frac{\sqrt{1+r_n} - \sqrt{1-r_n}}{\sqrt{1+r_n} + \sqrt{1-r_n}}\right)^2$$
$$= \left(\frac{1 - \sqrt{1-r_n^2}}{r_n}\right)^2 \approx \frac{r_n^2}{4},$$

where the sign for approximate equality $\approx$ might be interpreted here as an asymptotic (as r_n tends to zero) equality.

Next, introduce a sequence of triples $\{x_n,\ y_n,\ z_n\}_{n=0}^{\infty}$:

$$x_{n+1} := \frac{x_n + y_n}{2},\ y_{n+1} := z_n + \sqrt{(x_n - z_n)(y_n - z_n)},$$
$$z_{n+1} := z_n - \sqrt{(x_n - z_n)(y_n - z_n)}.$$

Define *the modified arithmetic-geometric mean* (which we abbreviate as MAGM) of two positive numbers x and y as the (common) limit of the (descending) sequence $\{x_n\}_{n=1}^{\infty}$ and the (ascending) sequence $\{y_n\}_{n=1}^{\infty}$ with $x_0 = x$, $y_0 = y$ and $z_0 = 0$.

Put

$$\xi_n := x_n - z_n,\ \eta_n := y_n - z_n,\ \rho_n := \frac{\xi_n + \eta_n}{x_n + y_n},\ n \in \mathbb{N}.$$

Each iteration for the AGM requires an addition, a division, a multiplication, and taking the square root. The first iteration for the MAGM coincides with the first iteration for the AGM. Each subsequent iteration for the MAGM requires three more (than an iteration for the AGM requires) additions,

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[1] *We need not impose the assumption that* $x_0 \geq y_0$.

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but with each iteration the speed of convergence for the MAGM (as compared with the speed of convergence, at the corresponding iteration, for the AGM) is greater by a ratio asymptotically coinciding with the ratio ρ_n. The latter claim is clarified by observing that

$$r_{n+1} = \frac{\xi_{n+1} - \eta_{n+1}}{x_{n+1} + y_{n+1}} = \frac{\xi_{n+1}}{x_{n+1} + y_{n+1}} \left(\frac{\sqrt{\xi_n} - \sqrt{\eta_n}}{\sqrt{\xi_n} + \sqrt{\eta_n}} \right)^2 \approx \frac{r_n^2}{4\rho_n}.$$

The ratio ρ_n is eventually (that is, asymptotically) doubled with each iteration.

An example considered (accurately) by Gauss [12] and (sloppily) provided in [7, p. 587] for demonstrating the convergence for the AGM uses the initial values $x = 1$ and $y = 0.8$. We list (chopping off digits) approximations corresponding to four consecutive iterations:

$$\begin{aligned}
x_1 &= 0.9,\\
r_1 &\approx 0.00310562001514185853949585134 8,\\
y_1 &\approx 0.89442719099991587856366946 74,\\
4r_1/r_0^2 &\approx 1.00622088490596216679665583 78,\\
x_2 &\approx 0.89721359549995793928183473 37,\\
r_2 &\approx 0.00000241123054763588033595666 9,\\
y_2 &\approx 0.89720926873273232514719393 64,\\
4r_2/r_1^2 &\approx 1.00000482246690930451452434 0728,\\
x_3 &\approx 0.89721143211634513221448706 51,\\
r_3 &\approx 0.00000000000145350818846733221 9,\\
y_3 &\approx 0.89721143211373692388775563 69,\\
4r_3/r_2^2 &\approx 1.00000000000290701637693677 712,\\
x_4 &\approx 0.89721143211504102805112135 10,\\
r_4 &\approx 0.00000000000000000000000052817 1,\\
y_4 &\approx 0.89721143211504102805112040 32,\\
4r_4/r_3^2 &\approx 1.00000000000000000000000010563 4.
\end{aligned}$$

The values at the first iteration coincide, of course, with those for the (introduced) MAGM. Now we list approximate values at the second, third, and fourth iterations for the MAGM:

$$\begin{aligned}
x_2 &\approx 0.89721359549995793928183473 37,\\
r_2 &\approx 0.00000120748664191622345062 7540,\\
y_2 &\approx 0.89721142875571123036605625 24,\\
4r_2\rho_1/r_1^2 &\approx 1.00000181216928520690775864 3674,\\
x_3 &\approx 0.89721251212783458482394549 30,\\
r_3 &\approx 0.00000000000009126819418554 3308,\\
y_3 &\approx 0.89721251212767081089238034 335,\\
4r_3\rho_2/r_2^2 &\approx 1.00000000000011412072150937 444,\\
x_4 &\approx 0.89721251212775269785816291 82,\\
r_4 &\approx 0.00000000000000000000000000 0260,\\
y_4 &\approx 0.89721251212775269785816291 77,\\
4r_4\rho_3/r_3^2 &\approx 1.00000000000000000000000000 0293,
\end{aligned}$$

along with the (tending to 2 as they ought to) ratios:

$$\begin{aligned}
\rho_1 &\approx 1.99689437998485814146050414865,\\
\rho_2/\rho_1 &\approx 2.00000060092645088170346112822,\\
\rho_3/\rho_2 &\approx 2.00000000000011397880639959476,\\
\rho_4/\rho_3 &\approx 2.00000000000000000000000000042.
\end{aligned}$$

Fix $\beta > 1$, let $\{x_n\}$ and $\{y_n\}$ denote the sequences converging to the AGM of $x_0 = \beta$ and $y_0 = 1$, and let $\{\xi_n\}$ denote the descending sequence converging to the MAGM of β^2 and 1 with $\xi_0 = \beta^2$. The following equalities hold:

$$x_n = \beta - \sum_{m=0}^{n-1} \frac{x_m - y_m}{2},\ \xi_n = \beta^2 - \sum_{m=0}^{n-1} 2^m \frac{x_m^2 - y_m^2}{2}.$$

Proceeding with another example of Gauss, considered in [17] as well, where $\beta = \sqrt{2}$, we write, for $1 \le n \le 4$, approximations for x_n:

$$x_1 \approx 1.2,\ x_2 \approx 1.19815,\ x_3 \approx 1.19814023479,\ x_4 \approx 1.19814023473559220744,$$

and, moving on, we supply approximations for ξ_n:

$$\xi_1 = 1.5,\ \xi_2 \approx 1.457,\ \xi_3 \approx 1.456946582,\ \xi_4 \approx 1.4569465810444636254.$$

Efficient Calculations of Complete Elliptic Integrals

Unfix β and assume, unless indicated otherwise, that β and γ are two positive numbers whose squares sum to one: $\beta^2 + \gamma^2 = 1$.

Gauss discovered a highly efficient (unsurpassable) method for calculating complete elliptic integrals of the first kind:

$$(1) \qquad \int_0^1 \frac{dx}{\sqrt{(1-x^2)(1-\gamma^2 x^2)}} = \frac{\pi}{2M(\beta)},$$

where $M(x)$ is the arithmetic-geometric mean of 1 and x. In particular, equality (1) holds if (in violation of the assumption, otherwise imposed) $\gamma^2 = -1$:

$$\int_0^1 \frac{dx}{\sqrt{1-x^4}} = \frac{\pi}{2M(\sqrt{2})} \approx 1.31102877714605990523.$$

The integral on the left-hand side of the latter equation is referred to as the lemniscate integral and is interpreted as the quarter length of the lemniscate of Bernoulli whose focal distance is $\sqrt{2}$. The precision of the numerical approximation given (assuming π is known with sufficient precision) is attained after four iterations, that is, at $\pi/(2x_4)$. The reciprocal of $M(\sqrt{2})$ is called the Gauss constant; Gauss, having calculated it to eleven decimal places, wrote in his diary [14] on May 30, 1799, that the discovery "opens an

entirely new field of analysis." Thereby, the beautiful field of elliptic functions and elliptic curves[2] intertwining analysis, algebra, and geometry was born.

The formula given via equation (1) signified a qualitative transition in connecting the study of elliptic integrals of the first kind with studying elliptic functions. Yet, a formula, analogous[3] to (1), for calculating elliptic integrals of the second kind had defied all subsequent efforts at attaining it, awaiting December 16, 2011, to be discovered. In fact (yet arguably), searching for an (unsurpassable) formula for calculating elliptic integrals of the second kind has been a great (often hidden) motivator and a driving force behind much of the genuine research on elliptic functions and elliptic curves. As is evidenced by the adjective "elliptic" tagging this field, which Gauss's discovery had once ignited, the problem of calculating the arc length of an ellipse has been its (most) central problem. The formula for calculating complete elliptic integrals of the second kind be now known:

$$\int_0^1 \sqrt{\frac{1-\gamma^2x^2}{1-x^2}}\,dx = \frac{\pi N(\beta^2)}{2M(\beta)}, \tag{2}$$

where $N(x)$ is the modified arithmetic-geometric mean of 1 and x. The integral on the left-hand side of equation (2) is interpreted as the quarter length of an ellipse with a semi-major axis of unit length and a semi-minor axis of length β (and eccentricity γ), whereas the swiftly converging ratio on the right-hand side is elementary enough to be presented in high or, perhaps, elementary school. This formula, unlike any other preceding formula for computing complete elliptic integrals of the second kind, aside from offering a calculating algorithm possessing both (sought-for features) iterativity and fast convergence, is lucent. On the other hand, the Euler formula and the (so-called) Gauss-Kummer series, which, in fact, is due to Ivory [13], aside from lacking simplicity, converge only linearly and particularly slowly for large eccentricities (near one).

The Legendre relation [10], relating complementary complete elliptic integrals of the first and the second kind to each other, might now be rewritten, yielding a parametric (uncountably infinite) family of identities for π:

$$\pi = \frac{2M(\beta)M(\gamma)}{N(\beta^2)+N(\gamma^2)-1} \tag{3}$$

and, in particular, yielding a countably infinite family of identities (where the ratio of $M(\gamma)$ to $M(\beta)$ is an integer power of $\sqrt{2}$), from which, setting $c := \sqrt{2}-1$, we list a few:

$$\pi = \frac{M(\sqrt{2})^2}{N(2)-1} = \frac{M\left(2\sqrt{\sqrt{2}}\,c\right)^2/2}{N\left(4\sqrt{2}\,c^2\right)-2c} = \frac{M\left(\sqrt{2c}\right)^2}{\sqrt{2}N(2c)-1}$$
$$= \frac{2M(c)^2}{\sqrt{2}N\left(c^2\right)-c} = \frac{2M\left(c^2\right)^2}{N\left(c^4\right)-c^2},$$

where the first of the latter chain of identities for π might be inferred from a special case (where $\beta=\gamma$) of the Legendre relation discovered by Euler [11]. Iteratively calculating (for $\beta=\sqrt{2}$) the sequences $\{x_n\}$ and $\{\xi_n\}$, of which we have already calculated the terms up to those whose indices do not exceed $n=4$, one arrives at the (so-called) Brent-Salamin algorithm for computing π [18].[4] Setting

$$\pi_n := \frac{x_n^2}{\xi_{n+1}-1} = \frac{\left(\sqrt{2}+1-\sum_{m=1}^{n-1}x_m-y_m\right)^2}{2\sqrt{2}-1-\sum_{m=1}^{n-1}2^m(x_m-y_m)^2},\ n\in\mathbb{N},$$

we enlist, for $n\le 4$, approximations for the ratios π_n (descendingly and quadratically converging to π):

$$\pi_1 \approx 3.18,\ \pi_2 \approx 3.1416,\ \pi_3 \approx 3.1415926538,$$
$$\pi_4 \approx 3.141592653589793238466.$$

A Few Examples

Although we aim to provide several applications of the formula attained for complete elliptic integrals of the second kind, we can hardly skip a classical demonstration from mechanics providing a shining example of the Gauss formula for calculating complete elliptic integrals of the first kind.

The Period of a Simple Pendulum

Had Appell known of the Gauss method (for calculating complete elliptic integrals of the first kind) he would not have had to "discover" a mechanical interpretation of the "imaginary period" [8] of a simple pendulum [9]. The (two-valued) period T of a simple pendulum[5] might be clearly and

[2] *We need not adhere to the rather common (and ridiculous) separation of the study of elliptic curves from the study of elliptic functions.*

[3] *The sought-for formula, aside from its desired simplicity, must give rise to an iterational and rapidly (faster than linearly) convergent algorithm.*

[4] *Evidently, "Gauss-Euler algorithm" would be a naming less exotic, yet restoring the credit to whom it rightfully belongs.*

[5] *T regarded as a function of $|g|$ – the modulus of g. The choice of the positive direction along the "vertical" is, after all, arbitrarily made, so, regardless of the choice, both signs of g must be accounted for.*

succinctly expressed as

$$T = 2\pi k\sqrt{\frac{l}{g}},\ k := k(\theta)$$
$$= \begin{cases} 1/M\,(\cos(\theta/2)) & \text{if } g > 0, \\ \sqrt{-1}/M\,(\sin|\theta/2|) & \text{if } g < 0, \end{cases}$$

where l is the length of the pendulum, g is the acceleration (due to gravity), θ is the angle of the maximal inclination from the pointing (in the positive direction) downwards vertical (as shown in Figure 1), $0 < |\theta| < \pi$.

The configuration space of the pendulum upon which an external force of constant magnitude and direction (presumably acting along the vertical) is being exerted is a circle. In other words, the weight of the pendulum is (holonomically) constrained to lie on a circle so that its radial component is counterbalanced by pivot reaction force.

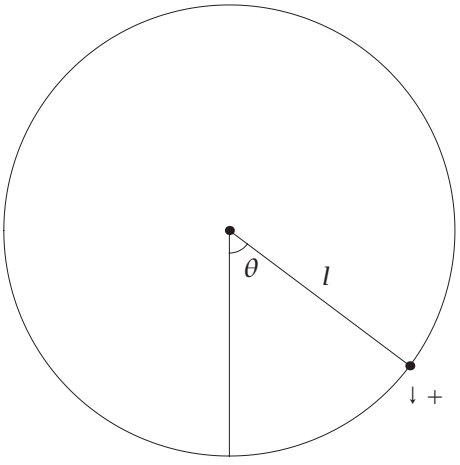

Figure 1. The pendulum.

The period corresponding to the (upper) value of k with g being positive corresponds to gravity pointing downwards (as is customarily assumed). The complementary period, corresponding to the (lower) value of k with g being negative, is then readily seen to correspond to reversing the direction of gravity. Surprisingly, too many (if not all!) "popular" references on elliptic functions, such as [15, pp. 59, 77], and "authoritative" references on mechanics, such as [19, p. 73], have missed (up to this day) these elegant and powerful expressions (for which Gauss must be solely credited), routinely providing, instead, either unfinished calculations or cumbersome power series representation (lacking iterativity and convergence expediency), hardly enabling an understanding of the double-valuedness of T. A particular (self-complementary) case to be pointed out corresponds to the (middle) value $\theta = \pi/2$, for which $|k| = \sqrt{2}/M(\sqrt{2})$. For a full appreciation of the Gauss formula, one must employ it for values of θ approaching π when traditional calculations of T via its power series representation eventually fail to converge at any reasonable time!

Perimeters of Ellipses for Five Values of Eccentricity

Denote by $l(\gamma)$ the ratio of the length of an ellipse of eccentricity γ to its major axis. Let L denote the semilength[6] of the lemniscate of Bernoulli whose focal distance is $\sqrt{2}$, whereas we use the letter M to denote, for brevity, $M(\sqrt{2})$, the reciprocal of the Gauss constant. Thus $L = \pi/M$, as calculated. We shall say that two ellipses are *complementary* if the squares of their eccentricities add up to one.

As defined, $l(0) = \pi$ is the aforementione d ratio for an ellipse whose eccentricity is zero, that is, a circle. The complementary ellipse, being an ellipse with eccentricity 1, is seen to be the (degenerate) ellipse whose semilength coincides with its major axis, so $l(1) = 2$. The latter equality might be alternatively expressed as a limiting equality:

$$\lim_{\beta\to 0}\frac{M(\beta)}{N(\beta^2)} = \frac{\pi}{2},$$

which one could have also attained as the limiting case of Legendre relation (3).

Supplementing formula (2) with formula (3), we shall calculate the perimeters of three more ellipses.

The self-complementary ellipse is confocal with the lemniscate, cocentered with the superscribing circle (Figure 2). It is the case to be considered first following the two preceding cases. Here, we have

$$l\left(1/\sqrt{2}\right) = \frac{L+M}{\sqrt{2}} \approx 2.7012877620953510050.$$

The latter equation might be viewed as, the discovered by Euler, special case of the Legendre relation (somewhat) disguised.[7] The precision of the numerical approximation given is attained at $(\pi/x_4 + x_4)/\sqrt{2}$ (with x_4 already calculated).

The two complementary ellipses (Figure 3) for which the eccentricities are c^2 (small) and $2\sqrt{\sqrt{2}}\,c$ (large) are:

$$l\left(c^2\right) = L + cM \approx 3.11834348914448577623,$$

$$l\left(2\sqrt{\sqrt{2}}\,c\right) = c\,(L+2M)$$
$$\approx 2.07866367001535595794.$$

[6] *The reader might be cautioned to observe that, according to the definition being given here, the constant L is twice the so-called lemniscate constant.*

[7] *One might also observe that the length of the "sine" curve over half a period, that is, the length of the graph of the function $t \mapsto \sin(t)$ from the point where $t = 0$ to the point where $t = \pi$, is $\sqrt{2}\,l\,(1/\sqrt{2}) = L + M$.*

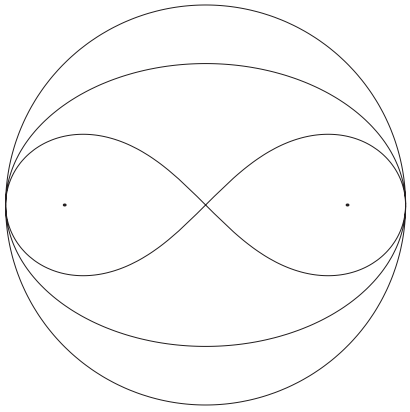

Figure 2. Confocal self-complementary ellipse and lemniscate inscribed in cocentered circle.

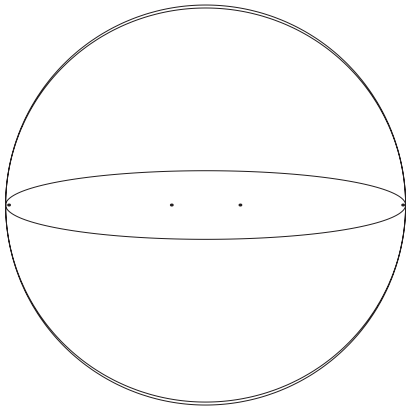

Figure 3. Two complementary ellipses and a circle sharing a single diameter.

The precision of the numerical approximation is attained at $\pi/x_4 + c\,x_4$ for the first ellipse (whose eccentricity is small) and at $c\,(\pi/x_4 + 2\,x_4)$ for the second (whose eccentricity is large).

We now exploit the latter approximation (of the perimeter of the elongated ellipse with $\beta = c^2$) in order to compare formula (2) with two well-known formulae. Put

$$F(a,b,x) := \sum_{n=0}^{\infty} \frac{(a)_n (b)_n}{(n!)^2}\, x^n,$$

where $(\cdot)_n$ is the Pochhammer symbol. The ratio $l(\gamma)/\pi$ might be calculated via either one of two formulae, due to Euler and Ivory, respectively:

$$\frac{l(\gamma)}{\pi} = \sqrt{\frac{2-\gamma^2}{2}}\, F\left(-\frac{1}{4}, \frac{1}{4}, \left(\frac{\gamma^2}{2-\gamma^2}\right)^2\right)$$

$$= \frac{1+\beta}{2}\, F\left(-\frac{1}{2}, -\frac{1}{2}, \left(\frac{1-\beta}{1+\beta}\right)^2\right).$$

Assuming exact arithmetic, 337 terms of the first (Euler) power series $\sqrt{3}\,c\,F(-1/4, 1/4, 8/9)$ are required to achieve the precision of the approximation given for the latter perimeter, whereas 55 terms of the second (Ivory) power series $\sqrt{2}\,c\,F\,(-1/2, -1/2, 1/2)$ are still necessary to achieve that precision. The Ivory formula, although faster than the Euler formula, is (still) linearly convergent and is (particularly) slow for large eccentricities when compared with formula (2), which, being quadratically convergent, is quite indifferent[8] to larger eccentricities. As was the case with the Gauss formula for complete elliptic integrals of the first kind, the presented formula, for complete elliptic integrals of the second kind must be employed for critical values of the elliptic modulus γ (nearing one), as all conventional power series representations fail to converge at any reasonable time before a fuller appreciation evolves. As γ approaches one, the corresponding value on the right-hand side of formula (2) remains bounded, unlike the corresponding value on the right-hand side of formula (1). Thereby, the convergence of formula (2) as traditional calculations fail makes it even more convincingly superior, being the only formula applicable for practically viable calculations at critical range.

We emphasize that Cayley's formula [10]:

$$l(\gamma) = 2 + \left(\ln\left(\frac{4}{\beta}\right) - \frac{1}{1\cdot 2}\right)\beta^2$$
$$+\frac{1\cdot 3}{2\cdot 4}\left(\ln\left(\frac{4}{\beta}\right) - \frac{2}{1\cdot 2} - \frac{1}{3\cdot 4}\right)\beta^4$$
$$+\frac{1\cdot 3^2\cdot 5}{2\cdot 4^2\cdot 6}\left(\ln\left(\frac{4}{\beta}\right) - \frac{2}{1\cdot 2} - \frac{2}{3\cdot 4} - \frac{1}{5\cdot 6}\right)\beta^6$$
$$+\frac{1\cdot 3^2\cdot 5^2\cdot 7}{2\cdot 4^2\cdot 6^2\cdot 8}\left(\ln\left(\frac{4}{\beta}\right) - \frac{2}{1\cdot 2} - \frac{2}{3\cdot 4} - \frac{2}{5\cdot 6} - \frac{1}{7\cdot 8}\right)\beta^8 + \cdots,$$

although traditionally regarded as the remedy for calculating the perimeters of elongated ellipses, does not truly eliminate the convergence problem of Ivory's formula, replacing it with a convergence problem for calculating values of the (transcendental) logarithmic function over an unbounded domain (or, equivalently, in a neighborhood of zero). Incidentally, if the precision of the approximation for the latter ellipse (with $\beta = c^2$) is required, then (presuming the difference $\ln(4) - \ln(\beta)$ is known with sufficient precision) all terms up to (and including) the term involving β^{26} from Cayley's formula become necessary. Many more terms are needed if higher precision is desired, with Cayley's formula being, again, another power series representation for the perimeter, with the power (of β) growing only linearly.[9]

[8] *Another formal definition is compelling here. Yet, avoiding digression, readers are urged to come up with one of their own.*

[9] *Even a polynomial growth (of the power of β) of high order would not suffice for matching the speed with which formula (2) converges; nothing less than an exponential growth would!*

Broad Concepts behind the Formula and an Epilogue

Fundamental research involving Tethered Satellite Systems at the Division of Stability of Motion and Mechanics of Controlled Systems at the CCRAS,[10] conducted by a team led by S. Ya. Stepanov,[11] has required extensive use of the elliptic functions apparatus. Two traditional approaches to studying elliptic functions (due to Jacobi and Weierstrass) were naturally united by adopting Sophus Lie's (algebraic) methodology for solving differential equations. The two groups of (linear fractional) transformations respectively fixing the differential equations, satisfied by the Weierstrass elliptic function and the Jacobi sine function, turn out to be isomorphic with each other (both being isomorphic with the Klein four-group). An essential elliptic function for which the corresponding transformations acquire the simplest form might then be (canonically) defined [3]. Halving values for such a function is far less cumbersome than halving the values of either Weierstrass or Jacobi elliptic functions, thus permitting, in particular, an attainment of exact values (expressed in quadratic radicals) at all eighth lattice points [4]. Exact special values of the modular invariant at the boundary of the fundamental domain were also (most) efficiently calculated. The formidable search for an explicit inverse of the modular invariant, initiated by Abel [1] and adamantly (yet unsuccessfully) pursued by Ramanujan, had then reached its destination on (the 212th anniversary of the Gauss discovery) May 30, 2011 [5]. Moreover, a canonical formula for halving points on elliptic curves (via efficiently inverting the doubling formula) and yielding an iterative algorithm for computing (incomplete) elliptic integrals (qualitatively revising the traditional view of the constructability of inverses for such integrals) was attained [6]. The formula for calculating the perimeter of an ellipse, presented in this paper, turned out to be next. The chapter "Elliptic Integrals" by L. M. Milne-Thomson [2, ch. 17] is highly recommended for an essential overview, and a quotation from [7, p. 591], referring to Landen transformations, seems appropriate for a conclusion: "Indeed, Landen himself evidently never realized the importance of his idea."

Agreeing, we must say that it took Gauss and over two centuries to be properly conveyed!

[10] *The Computing Centre of the Russian Academy of Sciences, Moscow, Russia.*

[11] *Sergey Yakovlevich Stepanov is one of the pioneering (in the 1960s) researchers of gyrostatic stability and stabilization of satellites.*

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Cop Number?

Anthony Bonato

The *cop number* is a simple notion originating from a game played on a graph. Despite this simplicity, consideration of the cop number leads to many questions in structural, probabilistic, and algorithmic graph theory. In the game of *Cops and Robbers*, there are two players, a set of *cops* and a single *robber*. We are given an undirected graph G with loops on each vertex. Players occupy vertices of G, and move along edges to neighboring vertices or remain on their current vertex. The cops move first by occupying a set of vertices; one cop can occupy only a single vertex, although more than one can occupy the same vertex. The robber then chooses a vertex to occupy, and the players move at alternate ticks of the clock. The game is played with perfect information, so the players see each others' moves. The cops win if they can *capture* the robber by moving to a vertex the robber occupies; otherwise, the robber wins. While many variations are possible (such as players moving at different speeds or playing with imperfect information), we focus on the game as described here. We consider only finite graphs, although the cop number is also studied in the infinite case. *Cops and Robbers* has found application to multiple-agent moving-target search in artificial intelligence, and variants of the game have been recently considered in fields such as robotics and mathematical counter-terrorism.

The *cop number of a graph* G, written $c(G)$, is the minimum number of cops needed to win in G. Placing a cop on each vertex clearly guarantees a win for the cops, so the cop number is well defined.

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If G is disconnected, then $c(G)$ is the sum of the cop numbers of the connected components; hence we consider only connected graphs. References for the results discussed here may be found in [1].

Cop-win graphs are those where only one cop is needed to win, and they form the first and simplest case to analyze. If one vertex is adjacent to all others as in cliques or wheels, then of course the graph is cop-win. *Trees* are graphs with no cycles. Trees are cop-win, since the cop chases the robber along the unique path connecting them until the robber reaches a vertex with degree one. A degree-one vertex u is a *corner* with a special property: there is vertex v such that v is adjacent to all the vertices adjacent to u (including u itself). By considering the second-to-last move of the cop before the cop captures the robber, it is evident that a cop-win graph must have at least one corner. Deleting this corner gives rise to another cop-win graph: whenever the robber moves to the corner u, the cop plays as if the cop were on v. This observation along with an induction proves that a graph is cop-win if and only if we may iteratively delete corners and end up with a single vertex.

A *planar graph* is one that can be drawn in the plane without edge crossings. The famous Four Color Theorem states that, for any planar graph, we need at most four colors to assign colors to the vertices in such a way that adjacent vertices receive different colors. Aigner and Fromme [2] introduced the cop number in 1984, and proved that a planar graph has cop number at most 3. For example, the dodecahedron is a planar graph with cop number 3. One of the main tools used in their proof was *isometric paths*: A path is isometric if distances between vertices in the path are the

same as in the graph. They showed that one cop can *guard* an isometric path, meaning that we can move a cop along vertices of the path in such a way that, if the robber moved onto the path, the robber would be captured. To guard an isometric path, the cop exploits a *retraction* (a graph homomorphism which is the identity on its image) onto the path: the cop simply captures the image of the robber on the path. Despite the characterization described earlier for cop-win graphs, there is no known characterization of cop-win planar graphs.

An equally enticing and challenging aspect is that existing graph parameters appear in only a few bounds for cop numbers. A *dominating set* S has the property that all vertices not in S are adjacent to some vertex of S. The *domination number* of G is the minimum order of a dominating set in G. The cop number is bounded above by the domination number, as the cops simply occupy a minimum order dominating set on their first move and catch the robber in the next round. Unfortunately, this bound is far from tight as the reader can check in the case of paths. The minimum order of a cycle in G is called its *girth*. If G has girth at least 5, then the cop number is bounded below by the minimum degree of G. The *genus* g of a graph G is the smallest k such that G can be drawn on a sphere with k handles so that distinct edges do not intersect except at common vertices. Schroeder proved that $c(G) \leq \left\lfloor \frac{3}{2}g \right\rfloor + 3$, and conjectured that $c(G) \leq g + 3$.

How large can the cop number be as a function of the order of the graph? Graphs arising from finite geometry provide some insight into this question. Consider a projective plane P of order q, and its incidence graph $G(P)$. The graph $G(P)$ has vertices the points and lines of P, and so has $2q^2 + 2q + 2$ vertices. No two points (or lines) are adjacent, and a point is adjacent to a line if it is on that line. For example, the Fano plane has incidence graph isomorphic to the Heawood graph, which has cop number 3. See Figure 1. As the girth of $G(P)$ is 6 and each vertex has degree $q+1$, it is not hard to see that the cop number is at least $q + 1$. Hence the cop number of a graph with n vertices can be as large as a constant multiple of $\sqrt{n}$.

Let $c(n)$ be the maximum value of $c(G)$, where G is a connected graph of order n. Meyniel's conjecture states that $c(n) = O(\sqrt{n})$. In other words, for n sufficiently large, the cop number is at most a constant multiple of $\sqrt{n}$ (as is the case for incidence graphs of projective planes). Frankl communicated the conjecture in his 1987 paper, where he used a greedy argument with isometric paths and the Moore bound to prove that $c(n) = O\left(n\frac{\log\log n}{\log n}\right)$. Meyniel's conjecture was

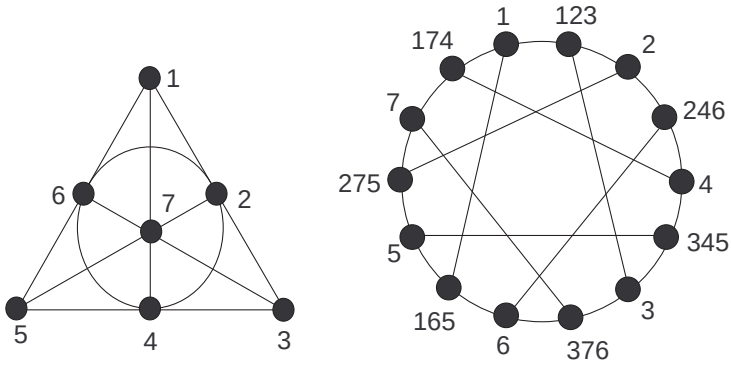

Figure 1. The Fano plane and its incidence graph. Points and lines of the plane are labelled on the graph.

largely forgotten until recently, and is now gathering much research attention. The best known upper bound is

$$c(n) = O\left(\frac{n}{2^{(1+o(1))\sqrt{\log_2 n}}}\right), \tag{1}$$

which was proven independently by three groups of researchers using the probabilistic method. The $n^{1-o(1)}$ bound in (1) is far from the conjecture, and even proving that $c(n) = O(n^{1-\varepsilon})$ for some $\varepsilon > 0$ remains open. At the present time, the jury is still out on whether Meyniel's conjecture holds. Partial evidence in favor of the conjecture comes from its having been proved for binomial random graphs $G(n,p)$ for a wide range of $p = p(n)$.

We finish by highlighting some algorithmic aspects of the cop number. If k is a fixed integer and G is given as input, then one can determine whether $c(G) \leq k$ by doing a polynomial-time computation with running time $O(n^{2k+2})$. Unfortunately, because this bound is exponential in k, it is therefore impractical for large k. If k is not fixed (and so may be a function of n), then determining if $c(G) \leq k$ is **NP**-hard. We do not know, however, if this problem is in **NP**. It is conjectured that computing the cop number when k is not fixed is **EXPTIME**-complete, which would imply that it is among the hardest problems solvable in exponential time.

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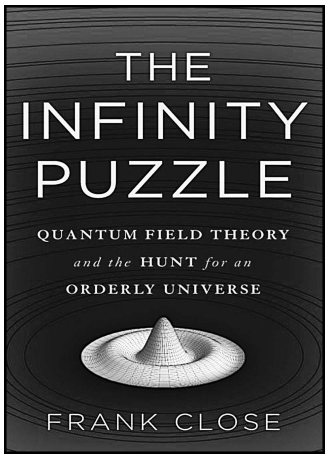

The Infinity Puzzle: Quantum Field Theory and the Hunt for an Orderly Universe

Reviewed by Brian E. Blank

The Infinity Puzzle: Quantum Field Theory and the Hunt for an Orderly Universe
Frank Close
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The first quantum field theory (QFT), quantum electrodynamics (QED), originated in Paul Dirac's 1927 paper concerning the emission and absorption of radiation. Although Dirac's work describing the electromagnetic force was the logical sequel to a brief but intense development of the new quantum theory, it promptly gave rise to seemingly insurmountable difficulties. In a letter written in February 1928, Wolfgang Pauli suggested to Dirac that a fundamental change in perspective would likely be needed. Working with Werner Heisenberg, Pauli had calculated the self-energy of a single electron interacting with its own electromagnetic field. The value, they were chagrined to learn, turned out to be infinite. "What do you think about this?" Pauli challenged.

During the 1930s, QFT was the instrument for important developments such as Enrico Fermi's theory of beta decay (1934) and, at the end of the decade, Pauli's derivation of the connection between spin, Bose-Einstein statistics, and Fermi-Dirac statistics. Despite such successes, physicists remained disturbed by the divergent integrals that arose when many basic physical quantities were calculated. Rather than being explained, the infinities proliferated as the particle zoo expanded. "New divergence sorrows" were the words with which Hendrik Kramers mentioned the meson theory of nuclear forces at the 1947 Shelter Island conference devoted to quantum physics.

The title of Frank Close's new book, *The Infinity Puzzle*, is the author's metaphor for the forty-five-year struggle to formulate quantum field theories in which the calculations can be made meaningful even when they involve divergent integrals. Although the task of explaining the mathematical conundrums of sophisticated physical theories to a reader who is not assumed to know calculus might seem daunting or even quixotic, Close has the expertise and experience to attempt it: not only is he a theoretical physicist at Oxford with a background in particle physics that includes stints at the Stanford Linear Accelerator Center (SLAC) and at CERN, he is also a prolific author who specializes in explaining physics to the lay person. Some fifteen years ago, he was awarded the Kelvin Medal for "outstanding contributions to the public understanding of physics."

The subtitle of *The Infinity Puzzle* relates QFT to the hunt for an orderly universe. Paradoxically, the union of quantum theory and special relativity seems to portend anything but order. According to the Uncertainty Principle of quantum mechanics, highly erratic fluctuations of energy occur over small intervals of time. According to the theory of special relativity, these vacillations in energy result in the creation and annihilation of mass. As a result, the vacuum in QFT is no simple void: it teems with bits of matter so ephemeral that they are called *virtual particles*. To model such phenomena, a quantum field is not taken to be the garden variety vector field of classical electrodynamics, but an operator-valued map on spacetime. The reigning theories of quantum fields are the electroweak theory (EWT), which is the unified framework for the electromagnetic force and the

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weak force, and quantum chromodynamics (QCD), the framework for the strong force. Close prefers the arcane term *quantum flavordynamics* (QFD) to EWT. The first two times he refers to QFD (p. 255 and p. 258), his wording may lead a reader to the understanding that QFD is a theory of the weak force, which is in agreement with a standard text on particle physics [4, p. 55]. Thereafter, Close uses QFD to signify the theory of the combined weak and electromagnetic forces, in agreement with the meaning he gives in his glossary.

The first three chapters of *The Infinity Puzzle* are devoted to QED. Close begins his discussion with effective, qualitative explanations of self-energy and vacuum polarization, the two basic sources of divergent integrals. These mathematical malignancies would eventually be cured by *renormalization* theory, the first hints of which appeared in the 1930s in the work of Heisenberg, Victor Weisskopf, and, especially, Kramers, who promoted the renormalization process at the Shelter Island conference. Renormalization began with the realization that the "bare" quantities appearing in the formulas of QFT were theoretical, unphysical parameters. The first step was to assign them values based on observable, physical quantities. For example, the electron's physical mass m is equal to its bare mass m_0 augmented by m_{QF}, the infinite mass that the electron acquires by interacting with its magnetic field and the vacuum. If m_0 is allowed to have some finite value, as intuition suggests, then the left side of the equation $m = m_0 + m_{QF}$ has a finite, experimentally measured value, whereas the right side is infinite. Instead, the bare mass, which cannot be measured, is assigned an infinite value by the equation $m_0 = m - m_{QF}$. In the renormalization calculus, the infinities of m_0 and m_{QF} cancel, resulting in the same finite observed value on both sides of the equation $m = m_0 + m_{QF}$.

Granting that this arithmetic can be made sensible, we are left with two questions. By transferring the infinity from m to m_0 (and carrying out a similar shell game for charge), can we eliminate all the infinities of QED? And if we change the length scale of our measurement of m, that is, if we change the depth to which we probe the cloud of virtual particles surrounding the electron, thereby obtaining a different observed value for m, does our theory remain consistent? Using a toy multiplicative renormalization, Close answers this way: "The key discovery was that whatever you calculated, the way that infinity emerged from the mathematics was the same from one process to the next. For example, when physicists calculated one quantity, they found a horrible infinite thing.…Then they calculated some other quantity and found the very same horrible infinite thing, but this time multiplied by, let's suppose 2.…If an experiment had already measured the true (finite!) value for the first quantity, QED could then confidently predict the magnitude of the second as being twice as great." Close does caution that the actual process of renormalization is a delicate mathematical technique: "So finely balanced are the infinities that extracting finite numbers by canceling them is like walking a tightrope over Niagara Falls."

Renormalization theory not only received advocacy at the Shelter Island conference, it also found an important numerical test. It was at Shelter Island that Willis Lamb reported his measurement of a minute energy difference between the $2\,S_{1/2}$ and $2\,P_{1/2}$ levels of a hydrogen atom, a shift resulting from the vacuum fluctuations predicted by QED. On the train ride back from the conference, Hans Bethe used a primitive form of renormalization to derive an approximation to the Lamb shift. By April 1948, Richard Feynman, Julian Schwinger, and Sin-itiro Tomonaga had, independently, developed more sophisticated techniques to handle the divergent integrals of QED. In 1949, Freeman Dyson demonstrated that their theories were essentially equivalent. He also obtained renormalizability criteria that could be applied to field theories other than QED.

The modern slant on renormalization is that existing field theories are low-energy approximations of more comprehensive physical laws yet to be determined. Because there are presumably limits beyond which the current theories are inapplicable, the integrations of QFT are now performed with unspecified cutoffs. This strategy changes the shell game. Although the cutoffs prevent the divergences, the finite values of the resulting proper integrals depend on the cutoffs. The job of renormalization is to formulate a computational scheme in which the calculated quantities of QFT lose these dependencies when the observable parameters of the theory are assigned measured values. These ideas are appropriately relegated to a brief endnote in *The Infinity Puzzle*. (An entertaining explication of this approach can be found in Zee's textbook [7, pp. 145–153]. A treatment at a mathematical level that splits the difference between Close and Zee is provided by [6].)

The success of renormalization in QED did not directly carry over to the weak and strong forces, which had their own divergence issues. The immediate obstacle was that the physics of nuclear interactions was poorly understood in the 1950s. In 1951, Paul Matthews and Abdus Salam devised a renormalizable theory of the strong interaction. Although their theory was correct according to the facts known at the time, it was refuted three years later by the detection

of a new particle—the strongly interacting, or hadronic, Delta baryon—in a University of Chicago cyclotron. The manner in which Close relates this episode illustrates the puzzling juxtapositions that sometimes occur in the torrent of information he effuses. Whereas Matthews and Salam, Close tells us, "thought that they had explained the whole strong force, discoveries soon showed that they had mapped but a mere corner of a vast land." The immediate continuation is a paragraph that mentions the discovery of "strange particles" and muons in cosmic rays. The muon, which does not feel the strong force, had no role in undermining the Matthews-Salam theory. It is only after this interposition that Close comes to the Delta particle.

Without mathematics it is inevitable that a reader will gain only a murky notion of a quantum field and a still murkier notion of the field's gauge transformations and symmetries. Having both hands tied behind his back, Close resorts to analogies. As examples of invariants, he uses the message conveyed by his book, which is the same whether it is read in English or in translation, and the duration of a transatlantic flight, which is the same whether the measuring watch is set to the time zone of departure or arrival. Analogies are helpful, and Close, like many other physicists, is good at finding them. Nevertheless, he seems to have sensed that the gauges and invariances of QFT will be nebulous to his readers. Adopting a time-honored method for communicating with a person who speaks a different language, Close turns to repetition. Once on each of pages 79, 81, 84, 108, and 113 and twice in one paragraph on page 85, he recounts an observation that Schwinger made at Shelter Island: gauge invariance implies both the existence of the electromagnetic interaction and the masslessness of its carrier, the photon. The emphasis Close places on mass in these pages foreshadows the key role it will soon assume in his story of QFT.

In a gauge theory, interactions among elementary particles are mediated by the exchange of particles, which are often virtual, known as *gauge bosons*. The photon is the gauge boson of the electromagnetic force. In general, whether a particle is fundamental or composite, it possesses a property known as *spin*, which is measured in integer multiples of $1/2$, the unit $\hbar$ being omitted or set equal to 1. By the Spin-Statistics Theorem mentioned earlier, bosons, the particles that obey Bose-Einstein statistics, are the particles that have integral spin. Zero spin particles, such as pions, are known as *scalar bosons*. A spin 1 particle, such as the photon, is called a *vector boson*.

Inspired by Schwinger's insight, Chen-Ning Yang and Robert Mills developed a gauge invariant theory of nucleons in 1953. However, because their theory predicted that the strong force is carried by massless charged bosons, particles that do not exist, it was dismissed as a failure even before its publication. Indeed, a graduate student of Salam, Ronald Shaw, who formulated Yang-Mills theory independently, elected to let his work rest unpublished in his Cambridge dissertation. In the rare instances in which Shaw is not entirely ignored, he receives only passing notice: among the references for this review, a line in [1], a footnote in [5]. Close's effort at publicizing Shaw's contribution is therefore welcome, but he is not persuasive when he refers to Shaw's priority on the basis of Shaw's private discussions with Salam in January 1954, one month before Yang publicly launched Yang-Mills theory at a Princeton seminar chaired by J. Robert Oppenheimer, with Pauli in the audience to heckle. On page 88, Close has Pauli asking Yang, "What is the mass of these vector bosons?" However, on page 189, Close renders Pauli's question from the floor as, "Where are these massless vector mesons?" Mesons are bosonic, so the inconsistency is one of paraphrase, not of physics. Nevertheless, an entry for "meson" in either the glossary or the index could have straightened this out for the nonspecialist reader.

In 1956, Schwinger postulated the existence of two charged, massive carriers of the weak force, the W^+ and W^- bosons. Suspecting the existence of a combined theory of the electromagnetic and weak forces, he instructed his thesis student, Sheldon Glashow, to investigate such a possibility. Glashow published a model of the electroweak force in 1961. His theory required a third hypothetical particle, the massive, neutral Z^0 boson, to mediate the weak force. In addition to the three W^+, W^-, and Z^0 particles not yet known, each with massiveness not yet explained, Glashow's electroweak theory relied on an interaction, the neutral weak current, not yet observed. He concluded that his model seemed to be "without decisive experimental consequence," and it was largely ignored.

Close's narrative is, for the most part, chronological. As his story unfolds, we become aware that some of the beliefs harbored by the theorists required correction. With the apparent necessity of massive weak force carriers, Schwinger, in 1962, reexamined his earlier reasoning that gauge invariance implies the masslessness of a gauge boson. It turns out, as we finally learn on page 147, that Schwinger's principle, believed by many physicists to be the indubitable law expressed so frequently between pages 79 and 113 of *The Infinity Puzzle*, was merely an article of faith, not a mathematical implication. Finding that

his conclusions depended on a physical assumption he had made, Schwinger announced that, in general, "There is no such necessary implication." In a paper that appeared in 1963, Philip Anderson provided empirical confirmation of Schwinger's reassessment.

The recognition that gauge invariance can coexist with massive gauge bosons clarified the mass problem on one front, but papers of Yoichiro Nambu and Jeffrey Goldstone in 1960 and 1961 had already opened up a troubling second front. Their work showed that whatever the gauge bosons might be, whether massive or massless, the phenomenon of spontaneous symmetry breaking necessitates an additional boson that is massless and scalar. In the opinion of many physicists, the pion, a scalar boson that is massive but light, served as an acceptable approximation of the Nambu-Goldstone boson for the strong force. However, in the case of the weak force, the Nambu-Goldstone boson, because of its charge, would have been easily detected. And yet no such boson had ever been observed. As Philip Anderson remarked in his 1963 article, it seemed as if the expected zero-mass Yang-Mills gauge boson and the zero-mass Nambu-Goldstone boson were "capable of 'cancelling each other out' and leaving finite mass bosons only."

A year after this suggestion of cancellation, a triangular number of physicists published three relativistic versions of Anderson's mechanism for the creation of massive vector bosons: Peter Higgs, whose paper was received by *Physics Letters* in July 1964; François Englert and Robert Brout, whose paper, the first of the three, was received by *Physical Review Letters* in June 1964; and Gerald Guralnik, Carl Richard Hagen, and Thomas Kibble, whose paper was received by *Physical Review Letters* in October 1964. These papers set forth a process, now called the *Higgs mechanism*,[1] by which particles acquire mass. When applied to EWT, the idea is that, at sufficiently high energy, symmetry is unbroken and all gauge bosons are massless. When condensation causes the electroweak symmetry to become hidden, the $W^{\pm}$ and Z^0 bosons absorb (or "eat") the Nambu-Goldstone bosons, acquiring mass in the process. Additionally, a *massive* scalar boson, known as the Higgs boson, emerges from the process. So many bosons! The massless particle to which this review refers as the Nambu-Goldstone boson is more frequently called the Goldstone boson. As Goldstone observed (and Close pinpoints), the equations of his 1961 paper give rise to a second scalar boson, but "the other Goldstone boson," as Close wryly describes it, is the *massive* particle now known as the Higgs boson.

In 1964, Salam and John Ward published a combined theory of the electromagnetic and weak forces that, like the one Glashow published in 1961, had $\mathrm{SU}(2) \times \mathrm{U}(1)$ as the gauge group. These attempts to model a unified electroweak force did not fully succeed, because they did not account for the contrast between the massive gauge bosons of the weak force and the massless gauge boson of the electromagnetic force. In 1967, Steven Weinberg found the desired unification by using the idea of spontaneous symmetry breaking to explain the mass asymmetry of the four electroweak gauge bosons. In 1968, half a year after Weinberg's paper had appeared in print, Salam, writing without his previous coauthor Ward, incorporated spontaneous symmetry breaking into the Salam-Ward model and arrived somewhere near the same point as Weinberg, who alone had considered the masses of the $W^{\pm}$ and Z^0 bosons.

At the end of 1967, there was a viable model for a unified electroweak theory, but the Infinity Puzzle was not yet solved. Close's statement on page 142 that "Salam and Weinberg would be invoking hidden symmetry as the panacea for solving the Infinity Puzzle in the case of the weak force" seems careless: perhaps he meant "mass problem" rather than "Infinity Puzzle". In fact, having examined Salam's notebooks and having interviewed Weinberg, Close reports that "Salam's notebooks showed no signs that he made serious efforts, let alone any inroads toward solving the problem [of infinities]. Weinberg also tried and failed." In particular, Weinberg's 1967 paper asserts only that "The model may be renormalizable." In his Nobel lecture, Weinberg attributed his lack of success to the choice of a gauge that made renormalizability "totally obscure" [5, p. 165].

Weinberg's article has become the most cited paper in particle physics, and the number of citations is apparently growing rapidly: on page 197 Close mentions "more than 7,100 citations," but on page 297 it is "more than 8,000." Compare the eventual impact Weinberg's work had with the attention it received in the years 1967–1970, when its citation score was 0,0,0,1. Everything changed in 1971, the year Gerard 't Hooft, then a doctoral student of Martinus Veltman, used mathematical techniques developed by Veltman to solve the Infinity Puzzle for EWT and prove the renormalizability of the Glashow-Salam-Weinberg $\mathrm{SU}(2) \times \mathrm{U}(1)$ model.

Contemporaneously with the evolution of EWT, physicists made substantial progress toward a renormalizable Yang-Mills theory of the strong

[1] *In view of the shared provenance of this mass mechanism, Close prefers to enclose Higgs's mechanism in quotation marks. Higgs himself refers to the ABEGHHKtH mechanism, the tH referring to Gerard 't Hooft, who will make his appearance in this review momentarily.*

force. In 1961, Murray Gell-Mann and, independently, Yuval Ne'eman proposed a scheme that organized hadrons into families on the basis of parity and spin. The "Eightfold Way", as Gell-Mann dubbed the classification, succeeded spectacularly in predicting the Ω^- baryon, which was detected in a bubble chamber at Brookhaven National Laboratory (BNL) in 1964. The realization that hadrons could be grouped according to a pattern that was both descriptive and predictive was a major step forward, but physicists sensed that there were too many hadrons for them all to be fundamental. In 1964, Gell-Mann and, independently, George Zweig explained SU(3) symmetry of the Eightfold Way by introducing a small number of fractionally charged building blocks which, when combined in certain pairs and triplets, would yield hadronic matter. These constituents, named quarks and antiquarks by Gell-Mann, remained entirely hypothetical until 1968, when a team at SLAC used James Bjorken's theory of deep inelastic scattering to demonstrate that nucleons have substructure.[2] Even then, the quark model presented a serious problem. Inside a nucleon, quarks seemed to act as free particles. However, in the deep inelastic scattering of electrons from nucleons, no free quark had ever been pried loose. This concern was resolved in 1973 when David Gross and Frank Wilczek, and, separately, David Politzer, demonstrated that a Yang-Mills theory can enjoy a property known as *asymptotic freedom*: in QCD, as distance becomes vanishingly small, so does the strong force. The analogy of an elastic band that holds quarks inside a hadron is sometimes made.

By the end of the 1970s, the Standard Model of elementary particles and their interactions was substantially complete. In the years that followed, experimental physicists used high-energy particle accelerators to detect the particles predicted by the Standard Model. The $W^{\pm}$ and Z^0 bosons, for example, were discovered in 1983. The Higgs boson, however, proved to be more elusive. Close devotes his last two chapters to CERN's Large Hadron Collider (LHC), the gargantuan proton-proton collider assembled at great cost in a twenty-seven kilometer ring tunneled under France and Switzerland near Geneva. All throughout his book, Close handles the crucial interplay between theory and experiment adroitly. As his story winds down, he turns his attention to a new component of high-energy physics: the political machinations needed to secure funding for the colossal new machines essential to experimental physics. That this important aspect of modern physics is actually a focus of *The Infinity Puzzle* can be seen from the subtitle of the edition published by Oxford University Press for sale in the United Kingdom: *How the Quest to Understand Quantum Field Theory Led to Extraordinary Science, High Politics, and the World's Most Expensive Experiment*. Along the way, Close brings up the sad history of the abandoned Superconducting Super Collider (SSC), fifteen miles of which had been hollowed out in Ellis County, Texas, before the project's cancellation in October 1993. In a few paragraphs and a long endnote, Close makes it seem as if the key to the demise of the SSC was the failure to secure a $2 billion contribution from the Japanese and that this failure was somehow tied to President George H. W. Bush vomiting at a state banquet in Japan and President Clinton not enacting vehicle import concessions. Many factors influenced the termination of the SSC, among them congressional politics (with references to "quark-barrel projects"); vocal opposition from prominent physicists such as Philip Anderson, who argued that support for disciplines such as condensed matter physics would better serve the public; and a host of issues that may be summed up as *Zeitgeist*: concern over the national debt, which had ballooned thanks to a foreign war; a lack of confidence in big science thanks to an incapacitating problem with the Hubble Space Telescope's primary mirror; and a desire for an assured return on taxpayer investment thanks to the perceived aimlessness of the space program.[3] Some will think that Close has shed new light on an old debacle. Others will think, "Phooey!"

In 1986, opponents of the SSC protested the imprudence of committing a large fortune—the projected expenditure would exceed $11 billion by 1993—to the search for a particle that might not exist. Lobbyists countered by portraying the project as a no-lose proposition: it would either confirm the Higgs mechanism or expose a Higgsless mechanism. Close's valedictory assessment echoes their argument: "Either the Higgs Boson will be found…or the real explanation, a total surprise, will be revealed. Only nature now knows. Soon humans will too." His optimism appears to have been justified. On July 4, 2012, CERN

[2] *Gell-Mann had postulated three quarks: up, down, and strange. The experiments at SLAC in 1967–1968 provided evidence for these quark flavors. In the 1970s, theorists completed the list of quarks with three additional flavors: charm, bottom, and top. The charm quark was discovered simultaneously at BNL and SLAC in 1974. The bottom and top quarks were discovered at Fermilab in 1977 and 1995, respectively.*

[3] *Six weeks after the cancellation of the SSC, in December 1993, the Hubble Telescope's optical system was repaired in a servicing mission by Space Shuttle* Endeavour. *For further discussion of the cancellation of the SSC, including the role of the International Space Station, refer to Steven Weinberg's recent article, "The Crisis of Big Science" in* The New York Review of Books, *May 10, 2012.*

announced the discovery of a scalar boson with mass around 125 GeV (about 133 protons) that is consistent with the Higgs boson. At the time of this writing, the exact nature of this newly discovered particle has not been determined. As the CERN announcement asks, "Are its properties as expected for the long-sought Higgs boson, the final missing ingredient in the Standard Model of particle physics? Or is it something more exotic?"

If the Higgs mechanism is confirmed, then the Nobel committee may be faced with a difficult decision. Although the six physicists who proposed the mechanism in 1964 were jointly awarded the 2010 J. J. Sakurai Prize for Theoretical Particle Physics, no more than three recipients can share a Nobel Prize.[4] The Nobel committee has struggled with such a quandary in the past, and the resulting decisions form a thread that runs through *The Infinity Puzzle*. Close highlights the exclusions of Dyson, Ward, and Bjorken from the Nobel Prizes that were awarded for advances to which they made essential contributions. He also thoroughly investigates the inclusion of Salam, who shared the 1979 prize with Glashow and Weinberg.

The case against Salam is threefold: (1) he did not write his Nobel Prize-winning 1968 EWT paper until after he had seen Weinberg's published article; (2) His paper, unlike Weinberg's, did not relate the $W^{\pm}$ and Z^0 masses and so did not point the way to the confirmation of EWT by experiment; (3) his paper, having been slipped into the proceedings of a symposium, did not undergo peer review and was based on the 1964 Salam-Ward article, the publication of which was questionable because it merely duplicated a model Glashow had advanced three years earlier. The strongest case for Salam is the testimony of his occasional collaborator, Robert Delbourgo, who recalls having drawn Salam's attention to Weinberg's paper after his colleague had already given lectures on EWT at Imperial College London in 1967 ([2], [3, p. 219], and interviews quoted in *The Infinity Puzzle*). Close offers an even-handed analysis that allows his readers to reach their own conclusions. Some will agree with Salam's biographer, Gordon Fraser, who complained, "Having assigned credit where he sees fit, Close also confiscates much of that accorded to Salam" (*CERN Courier*, January 25, 2012). Others may feel that Close is too diplomatic. Indeed, while an advance copy of *The Infinity Puzzle* was in circulation, one of the physicists Close interviewed Web-posted a manuscript that makes a decidedly more explicit call for the confiscation of credit [2].

[4]*Robert Brout died in 2011 and is therefore ineligible for the Nobel Prize, which is awarded only to persons believed alive at the time of the announcement. C. R. Hagen, who was born in 1937, is the youngest of the five surviving members of "The Gang of Six".*

There are rather a lot of slips in *The Infinity Puzzle*. They are all inconsequential, but some are potentially confusing. On page 24, Balmer's formula is expressed in terms of $1/m^2 - 1/n^2$, but in the accompanying endnote, the negative of this difference is used. Additionally, in the same discussion, the symbol m that denotes a quantum number in Balmer's formula is also used to denote a mass. When Close tells us, "In 1912 Niels Bohr found the explanation courtesy of quantum theory. In quantum theory any particle can take on a wavelike character," he seems to be saying that Bohr anticipated matter waves a decade before Louis-Victor de Broglie had his Nobel Prize-winning insight. A few pages later Close states that Pauli realized in 1929 that he would have to take into account the effects of antimatter. The problem here is that the effects Pauli confronted were not then known to be due to antimatter—it was not until 1931 that Dirac predicted the anti-electron (or positron, as it became known). Commenting on a remark Salam inserted into a 1971 paper, Close writes on page 224, "Salam is claiming priority [with Ward] for the $\mathrm{SU}(2)\times\mathrm{U}(1)$ model, which is justified." What justification are we to understand, given that priority for the $\mathrm{SU}(2)\times\mathrm{U}(1)$ model belongs to Glashow? On page 112, Close informs us that Glashow was a Ph.D. student at Harvard, but on page 120 he writes, "Glashow's thesis, in 1958, was not public knowledge outside Cal Tech." After attributing the Z^0 boson to Glashow, Close groups it with W^+ and W^- as Schwinger's "invisible instruments" (p. 313).

In field theory, if μ is a scale parameter and $g = g(\mu)$ is the "running" coupling constant of the interaction, then the beta function is defined by $\beta(g) = \partial g/\partial(\ln(\mu))$. In QED, as in most field theories, beta is positive. By contrast, in QCD asymptotic freedom is reflected by negative beta. It will be noted from its formula that β is a slope. When Close first mentions beta (p. 44), he misleadingly asserts that, "In QED *the slope of* beta is positive," the reviewer having italicized the words that do not belong. Throughout the eighteen pages that Close devotes to the beta function of QCD, the terms "beta slope", "slope for beta", and "beta" are used interchangeably.

In an attempt to explain the alphanumeric asymmetries in the factors of $\mathrm{SU}(2)\times\mathrm{U}(1)$, Close tries, "Elie Cartan…classified mathematical groups, among which were a set known as the special unitary (hence 'SU') groups with size N, where N is any integer. The case $N = 1$ is just the collection of simple numbers. To a mathematician this is so 'unspecial' that it is classified simply as $\mathrm{U}(1)$." Readers of the *Notices* will guess for

themselves the meanings of the last two quoted sentences.

The index to the Oxford University Press edition of *The Infinity Puzzle* has 228 entries for "boson". There would have been many more had the indexer been aware that gluons, mesons, and photons are bosonic. In the version of *The Infinity Puzzle* issued by Basic Books, which owns the publication rights outside the United Kingdom, there are only three index entries for "boson". Two of these fall under the subentry "penguin analogy". It is somehow instructive to note that the indexer, who overlooked *so* much, was charmed by Close's amusing analogy: "Fermions…act like cuckoos. Bosons, by contrast, are like penguins." The third index entry for "boson" is subindexed as "known bosons". This misleading reference is to a figure that lists the gauge bosons but none of the other known bosons. Some bosons, such as the $W^{\pm}$ and Z^0 particles, do have their own index entries, but several other bosons, such as the σ-meson, the ϕ-meson, and the J/ψ particle, are not indexed at all. In both versions of *The Infinity Puzzle*, the index cannot be used to find the definition of "boson": the endnotes amount to 12 percent of the book, but neither Basic Books nor Oxford University Press saw fit to index the important material therein.

Many texts already cover much of Close's story. Of these works, *The Infinity Puzzle* might be compared with *The Second Creation* [1], a wonderful book cited frequently by Close. *The Infinity Puzzle* does not replace *The Second Creation*, but it is a welcome addition to be considered alongside its predecessor. Although the two books share the same core subject matter, namely, the physics that led to the formulation of the Standard Model, there are significant differences in detail. Whereas Crease and Mann, the authors of *The Second Creation*, are more comprehensive, starting their story with the discovery of radioactivity in 1896, the year before the electron was detected, Close, by focusing on QFT, begins his account in the late 1920s, by which time the electron, proton, and photon had been discovered and special relativity, the new quantum mechanics, and spin were proven physical theories. By way of compensation for the material he quickly skips over, Close offers a deeper treatment of topics such as the Higgs mechanism and the development of QCD. Both books rely on the first-hand testimony that the authors industriously procured: Crease and Mann interviewed some one hundred twenty-five physicists and Close interviewed or corresponded with about eighty.

Of course, Close has a trump card. When *The Second Creation* was written, lobbying for the SSC was only just under way, the Large Electron–Positron Collider occupied the tunnel that now houses the LHC, and BNL's director could say, "America is a place you *do* things" without fear of contradiction [1, p. 255]. Now, a quarter century later, CERN's discovery of the long-awaited Higgs boson has been heralded on the front pages of newspapers around the world. *The Infinity Puzzle* is the most up-to-date resource for the layperson who wonders, Why all the fuss?

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Jack Warga (1922–2011)

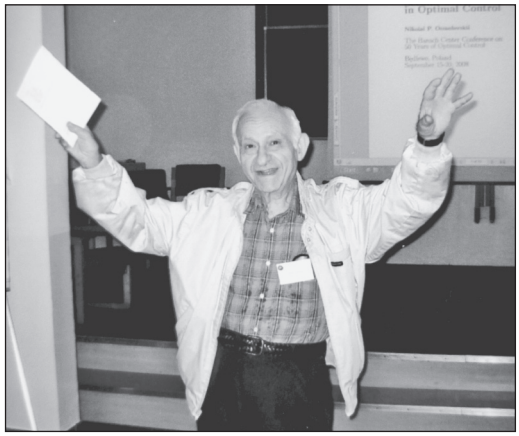
Boris Mordukhovich and Qiji Zhu

Jack Warga, a pioneer in optimal control theory and nonsmooth analysis, passed away unexpectedly on June 26, 2011, in Boynton Beach, Florida. Despite his almost eighty-nine years of age, Jack was in remarkable physical and mental condition and was actively engaged in mathematical research until he had a fall in his garage a few days prior to his death. He was preceded in death by Faye, his wife of more than sixty years, and is survived by his son Arthur, daughter Charna, and their families.

Jack was born to a Jewish family in Warsaw, Poland, on September 20, 1922. In 1938 he was sent by his father to Belgium for his education. During World War II he became separated from his family, narrowly escaped the Holocaust, arrived in the United States in 1943, and participated in the war as an officer in the U.S. Army. In the meantime, most of his immediate family perished in Nazi concentration camps.

After receiving his Ph.D. degree in mathematics from New York University in 1950, Jack worked in industry for sixteen years. His deep involvement in problems related to the control of satellites led to his interest in optimal control theory. Jack joined Northeastern University in 1966 as a professor of mathematics and remained there until his retirement in July 1993. He was an invited speaker at numerous meetings in the United States, Canada, Europe, and Israel.

It is hard to overstate Jack's seminal contributions to optimization, control theory, and nonsmooth analysis. He introduced the concept of a relaxed control and used the method of relaxation systematically in analyzing optimal control problems in a two-part paper in 1962. Since then the scheme of relaxation has been applied by many researchers to various control systems governed by ordinary, functional, and partial differential equations. Jack himself further developed this method in his 1972 classical monograph *Optimal Control of Differential and Functional Equations*. Jack's study of nonsmooth control systems led him to the discovery in 1975 of a generalized derivative now known as the Warga derivate containers. This concept and its extensions have played a crucial role in nonsmooth and variational analysis as one of the most delicate and effective tools.



Jack Warga

Jack also actively served the applied mathematics community at large. In particular, from 1964 to 1989 he served on the editorial board of *SIAM Journal on Control and Optimization* and he was the co-managing and managing editor of the journal from 1967 through 1978. He was a force in establishing the journal's international reputation and high standard of scholarship.

Besides being an outstanding mathematician and extremely deep researcher, Jack also had a wide range of interests in the intellectual pursuit of history, philosophy, poetry, music, and languages. Jack was exceptionally kind and generous, especially towards young mathematicians. Anonymously, Jack also worked extensively for human rights for scientists throughout the world. He will be sorely missed by his students, colleagues, and the mathematical community at large.

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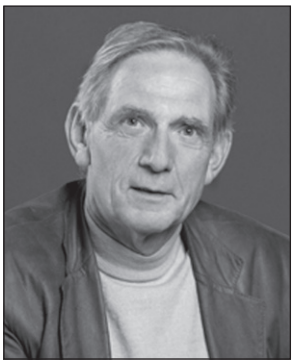
2011 Ostrowski Prize Awarded

IB MADSEN of the University of Copenhagen, KANNAN SOUNDARARAJAN of Stanford University, and DAVID PREISS of the University of Warwick have been awarded the 2011 Ostrowski Prize, which recognizes outstanding achievement in pure mathematics or in the foundations of numerical mathematics. The prize carries a monetary award of 75,000 Swiss francs (approximately US$78,000).

Citation for Ib Madsen

Ib Madsen received his Ph.D. from the University of Chicago in 1970. He was a member of the faculty at the University of Aarhus from 1971 through 2008 and was very influential in building a strong topology group there. He has been a professor at the University of Copenhagen since 2008. He has held visiting positions at the University of Chicago, Stanford University, and Princeton University. He has been an invited speaker at the 1978 International Congress of Mathematicians (ICM) in Helsinki and a plenary speaker at the 2006 ICM in Madrid. He was chair of the topology panel for speaker selection to the 2002 ICM in Beijing, and he served as managing editor of *Acta Mathematica* from 1988 to 2000. He is a member of the Royal Danish Academy of Sciences and Letters, the Royal Swedish Academy of Sciences, and the Royal Norwegian Academy.



Ib Madsen

Madsen has been instrumental in developing topological cyclic homology theory. This theory was developed as a tool for understanding Waldhausen's universal space $A(X)$, the only known way to approach the homotopy theory of diffeomorphism groups of high-dimensional manifolds. Topological cyclic theory is also, at present, the only known way to approach algebraic K-theory of nonsmooth rings and varieties. It is also the main tool for understanding the K-theory of symmetric ring spectra. Madsen has also accomplished breakthrough work on the stable moduli space of Riemann surfaces. The prize citation states, "Ib Madsen is an enormously significant figure in the world of mathematics and through his research and leadership has made a huge impact on the fields of geometry and topology."

DOI: http://dx.doi.org/10.1090/noti889

Citation for Kannan Soundararajan

Kannan Soundararajan received his Ph.D. from Princeton University in 1998, has taught at the University of Michigan, and is currently a professor at Stanford University. He has done groundbreaking work in number theory and analysis. In 2003 he was awarded the Salem Prize, in 2005 the SASTRA Ramanujan Prize, and in 2011 the Infosys Prize in Mathematical Sciences. He was an invited speaker at the 2010 ICM in Hyderabad, India.

Kannan Soundararajan

Soundararajan's work has involved the quantum unique ergodicity conjecture of Rudnick and Sarnak; the behavior of L-functions within the critical strip; and pretentious characters, jointly with A. Granville. Also with Granville, he established an uncertainty principle for multiplicative functions that vastly extends the results of Maier on irregularities of distribution in the primes. Together with Konyagin, he improved the best known estimates for the number of solutions, in terms of the cardinality of a set of primes S, of the S-unit equation $a + b = c$ with a, b, and c coprime integers, all of whose prime factors are from S. He has also given "the sharpest results to date, subject to the Riemann hypothesis, on partial sums of the Möbius function." The prize citation says "Soundararajan has produced a cornucopia of fundamental results in the last five years to go along with his brilliant earlier work."

Citation for David Preiss

David Preiss received his undergraduate and advanced degrees from Charles University in Prague, Czechoslovakia. In 1990 he became Astor Professor of Mathematics at University College in

London. He has been at the University of Warwick since 2006. He is a Fellow of the Royal Society and received the London Mathematical Society's Pólya Prize in 2008.

According to the prize citation, "Preiss is undoubtedly the leading researcher in the world in geometric measure theory, where his major achievement was solving the density problem that had been stimulating the development of the theory since the time it was founded by Besicovitch and Federer." His early work in real analysis and descriptive set theory includes the positive solution of a problem of Klee. In functional analysis he is best known for his breakthrough result that every Lipschitz function on a Banach space with separable dual is Fréchet differentiable on a dense set. In recent years his research has focused on developing ideas initiated in his proof of Fréchet differentiability of Lipschitz functions. He reached a breakthrough by showing the existence of points of Fréchet differentiability of complex-valued Lipschitz functions on real Hilbert spaces. Jointly with G. Alberti and M. Csörnyei, he discovered new classes of exceptional sets that are described by the possibility of decomposing them into sets negligible on many curves.

David Preiss

About the Prize

The Ostrowski Foundation was created by Alexander Ostrowski, for many years a professor at the University of Basel. He left his entire estate to the foundation and stipulated that the income should provide a prize for outstanding recent achievements in pure mathematics and the foundations of numerical mathematics. The prize is awarded every other year. The prize jury consists of representatives from the universities of Basel, Jerusalem, and Waterloo and from the academies of Denmark and the Netherlands. Previous recipients of the Ostrowski Prize are Louis de Branges (1989), Jean Bourgain (1991), Miklos Laczkovich (1993), Marina Ratner (1993), Andrew Wiles (1995), Yuri Nesterenko (1997), Gilles Pisier (1997), Alexander Beilinson (1999), Helmut Hofer (1999), Henryk Iwaniec (2001), Peter Sarnak (2001), Richard L. Taylor (2001), Paul D. Seymour (2003), Ben Green (2005), Terence Tao (2005), Oded Schramm (2007), and Sorin Popa (2009).

— Elaine Kehoe

Undergraduate Research in Mathematics Has Come of Age

Joseph A. Gallian

You say you want a revolution
John Lennon

With 2012 being the 25th anniversary of the first NSF REU programs, this is a good time to assess their impact. "Paradigm shift" is a phrase that is frequently overused, but I think it is appropriate to describe a change in the mathematics culture over the past twenty-five years for which REUs have been the catalyst. In 1995 John Greever and I published an article [4] with the title "Challenging a myth: Has undergraduate research in mathematics come of age?" That article concluded with the following paragraph.

> *Presently, a small but influential group of mathematicians is challenging the myth that undergraduates can't do serious research in mathematics. Our goal is to change the mathematics culture by destroying the myth. When that has been accomplished, we will be able to say with confidence that undergraduate research has indeed come of age."*

I think we can now say with confidence that the goal of that group has been achieved.

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Members of the Editorial Board for Doceamus *are: David Bressoud, Roger Howe, Karen King, William McCallum, and Mark Saul.*

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Want evidence?

- At the January joint AMS-MAA mathematics meetings in 1991 there were 12 exhibits at the poster session on research by undergraduates. At the same session in 2012 there were 310 posters representing the research of 525 students.

- At the 1993 joint meetings, the first at which the number of undergraduates was tracked, 71 were registered. At the 2012 joint meetings 948 undergraduates were registered.

- In 1995 15 NSF REU supplements in mathematics were active,[1] in 2012 89 were active, including ten at the University of Michigan Ann Arbor and five at the University of Minnesota-Twin Cities.

- At the 1996 joint meetings, the first at which the number of talks by undergraduates was tracked, there were six (three from the same REU). At the 2012 joint meetings, 152 undergraduates gave talks. (Since many

[1] *Anyone with an NSF grant is eligible for an REU supplement to support undergraduate students.*

of these talks were on work that involved multiple undergraduates, the number of students contributing to these talks is much larger than 152).

- Since 2003 nearly 5,500 undergraduates have given talks on their research at MAA-NSF sponsored regional conferences. Undergraduate attendance at these conferences exceeds 17,000.

- At an undergraduate research conference in 2009 at Brigham Young University, 95 undergraduates gave talks with 50 of them from BYU.

- Over the past 18 years more than 1,000 mathematicians have taken a four-hour minicourse at the Project NExT summer workshops or the joint mathematics meetings on how to involve undergraduates in research. The 2012 minicourse at the joint mathematics meetings was filled to its capacity of 50.

- In recent years nearly half of the 125 or so applicants for Project NExT mentioned involving undergraduates in research as one of their career interests.

- Internally funded programs to support research by undergraduates during the academic year and summer at liberal arts colleges, state universities, and Ph.D.-granting institutions are now commonplace. MIT funds summer and academic year research for their undergraduate mathematics students. They also fund a high-level summer research program for high school students with superior talent in mathematics.

- Solo authored papers by undergraduates are being published in leading professional journals: *Annals of Mathematics, Annals of Probability, Journal für die reine und angewandte Mathematik (Crelle's Journal), Journal of Algebra, Journal of Combinatorial Theory, Journal of Number Theory, Geometry & Topology, Journal of Differential Geometry, Transactions of the American Mathematical Society, Proceedings of the American Mathematical Society, Communications in Algebra,* and the *SIAM Journal of Discrete Mathematics*.

When I became president of the MAA in 2007, I publicly stated that one of my goals was that, by 2015 (the 100th anniversary of the MAA), the number of undergraduates at MAA summer Mathfest would exceed 500 and the number at the joint meetings would exceed 1,000. We are on pace to reach the first goal and the second was too conservative.

The impact of REUs at the joint mathematics meetings is not just being felt at the poster sessions and the short talks. Two of the one-hour invited speakers at the 2011 joint mathematics meetings, Melanie Matchett Wood and Scott Sheffield, got their starts in research at the same REU. The same was true for Manjul Bhargava and Amie Wilkinson at the 2010 joint meetings. In fact, the content of the 2010 invited talk by Bhargava was an extension of the work he had done in an REU in 1995 (see [2] and [3]). Kannan Soundararajan, another invited speaker at the 2011 joint meetings, was a winner of the Morgan Prize for research by an undergraduate. Bhargava gave the three Hedrick lectures at the 2011 MAA Mathfest.

A number of research prizes have gone to REU alumni. Among these are: Manjul Bhargava—the Cole Prize in Number Theory, the Clay Research Prize, the Fermat Prize, and the SASTRA Ramanujan Prize; Davesh Maulik, Daniel Biss, and Manjul Bhargava—the Clay Research Fellowships; Melanie Matchett Wood, Kirsten Graham Wickelgren, Travis Schedler, Jacob Lurie, Mike Develin, Lenhard Ng—American Institute of Mathematics Five-Year Fellowships; Amie Wilkinson—the Satter Prize; and Scott Sheffield—the Loéve International Prize in Probability.

What are the benefits of undergraduate research? Students who engage in research

- gain self confidence,

- improve their writing and speaking skills,

- learn teamwork,

- develop an understanding of what professional mathematicians do,

- receive an introduction to the profession,

- are more likely to enter graduate school ([1] and [5]),

- are more likely to get into a better graduate school,

- are more likely to do better research in graduate school,
- are more likely to get a Ph.D.,
- are more likely to get a better job offer, and
- are better prepared to do projects required by employers.

Although REUs are showcases for undergraduate research and were the wedge in changing the opinions of many skeptics, they represent only a small fraction of the undergraduates engaged in mathematical research.

What is on the horizon for undergraduate research? More, more, more, and more. More REU-like summer programs, more academic year opportunities for undergraduates to engage in research, more undergraduates attending conferences and presenting, and more research prizes going to people who began doing research as an undergraduate.

It would not surprise me to see an REU alumnus receive a Fields medal before long.

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Google Books[1] vs. MathSciNet[2]

Scott Guthery

Introduction

For over 150 years progress in mathematics has been guided by the twin values of generalization and abstraction. Mathematical research is, as a result, characterized by a short memory and even shorter bibliographies. And yet exactly because mathematics has been guided by generalization and abstraction, mathematical constructs have very long histories.

While academic mathematicians need only consider the current version of a construct to begin building the next, there are mathematics communities—for the most part wholly ignored by the American Mathematical Society—that benefit from considering the long tail of mathematics, including but by no means limited to mathematical practitioners, independent scholars, students,[3] and authors writing for the general science reader.

Until very recently, the long tail of mathematics was inaccessible to these nonacademic mathematicians. Books, manuscripts, and journals containing the history of mathematics were locked away in research libraries and off-site, faculty-only depositories. On the theory that today's publications encapsulate all of the past, it is not unknown that these works disappear altogether. The American Mathematical Society remaindered the Society's mathematics library so carefully collected and curated by the Society's librarians.[4]

Fortunately, this situation is being rectified. Google Books is the most widely known but by no means the only on-line, full-text, open-access, searchable archive of the long tail of mathematics. In this short note we consider, by way of example only, why the long tail of mathematics is so keenly of interest to two particular communities, practitioners and independent scholars.

Practitioners

Mathematical practitioners use mathematics to erect "jigs" to hold nonmathematical problems. The mathematical constructs in the jig enable the practitioner to represent, study, and manipulate key aspects of the problem. Insights gained by casting a problem mathematically and seeing how facets of the problem connect to one another surprisingly often lead the way to a solution.[5]

The most compelling and most efficient solutions to a problem turn on grasping, understanding, and harnessing critical aspects of the problem

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[1]Google Books is used here as a generic term for all open-access, full-view resources containing mathematics literature including but by no means limited to Haithi Trust, Gallica, GDZ, and WDML.

[2]MathSciNet is used here to refer specifically to the restricted-access database of telegraphic summaries of scholarly mathematics maintained by the American Mathematical Society.

[3]See Ranjan Roy, "Learning by Reading Original Mathematics", *Notices of the AMS* **58** (2011), 1285-1287.

Members of the Editorial Board for Scripta Manent *are: Jon Borwein, Thierry Bouche, John Ewing, Andrew Odlyzko, Ann Okerson.*

DOI: http://dx.doi.org/10.1090/noti883

[4]See "The Library", 90–95 in R. C. Archibald, *A Semicentennial History of the American Mathematical Society: 1888–1938*, American Mathematical Society, 1938.

[5]See I. Grattan-Guinness, "Solving Wigner's mystery: The reasonable (though perhaps limited) effectiveness of mathematics in the natural sciences", *The Mathematical Intelligencer* **30** (2008), 7–17.

specifics. The mathematical practitioner is laser-focused on particulars, not generalities. From the point of view of the practitioner, the problem at hand is the problem to be solved. It is not a special case of a more general problem.

A practitioner accessing the mathematical literature in order to "stand on the shoulders of giants" is faced with two challenges: First, does a mathematical construct found in the literature capture the problem at hand? Second, are the results associated with the construct relevant to a solution?

From the practitioner's point of view, a discouraging side effect of mathematical abstraction, generalization, and condensation is that scholarly mathematics has to be decompressed before its possible application to a problem at hand can be considered. This decompression process must be carried out in two steps: First, a special case of the abstract space has to be crafted to fit the problem into. Second, the general results in the abstract space have to be down-translated into this special-case space.

Rather than becoming entangled in this mathematical puzzle, the practitioner has found an alternative strategy. Using Google Books, today's practitioners can search through uncondensed mathematical constructs of yesteryear. They can consider the readily understood formulations of Lagrange, Laplace, and Sylvester. They can look for signs of their problem in works of Whitaker, Hildebrand, and Todhunter. They can turn the crank on numerical algorithms of de Prony, Shanks, and Glaisher.

The practitioner doesn't have to decipher arcane language or scrape away layers of gratuitous generality in order to try to find the shoulders of today's mathematicians. Using Google Books, today's practitioner can easily, efficiently, and productively climb up on the shoulders of yesterday's giants.

Independent Scholars

Perhaps more than professionals in any other discipline, academic mathematicians marginalize independent scholars. That an independent scholar might make a worthy contribution to mathematics is simply unimaginable to today's academic mathematician. But there are many disciplines, scientific and otherwise, which actively encourage amateur participation and can cite with ease examples of benefits from having done so.[6] For the purposes of the current discussion it is useful to consider the case of astronomy.

Amateur astronomers are easily differentiated from professional astronomers. They scan the sky in their spare time. Their instruments cost orders of magnitude less to build and operate. They publish their findings in blogs and popular literature. Nevertheless, there is general acknowledgment among professional astronomers that what amateur astronomers are doing is astronomy. It is not unknown that an original sighting by an amateur astronomer is acknowledged, appreciated and even pursued by the professionals.[7]

One reason that the professional astronomers don't shun the amateurs is that the sky is big, the questions are many, and telescope time is limited. Amateur astronomers look in places that the professionals can't afford to look and pursue questions that may not be of grant-worthy interest. The archive of mathematical literature being opened by Google Books is the big sky of mathematics. Independent scholars are reading literature that the professionals have left behind, and they are pursuing topics, conjectures, and open problems that are not of current academic interest. Independent scholars have contributed to mathematics[8] and will continue to do so.[9]

Summary

Generalization and abstraction are linear concepts. Their intrinsic nature is to generate a lock-step sequence of results. Mathematics is not a linear endeavor. One can start with a paper by Lagrange or Glaisher and head off into a myriad of fascinating directions, only a few of which will have been chosen for pursuit by academia.

These untraveled paths are not accessible from today's mathematics literature. The only paths one can see—and even then often dimly—are the paths that led to today's frontiers. Opening up the mathematical literature of the past enables us to go back and explore paths untaken.

Not only are the constructs in the long tail of mathematics of immediate use to today's practitioners and of abiding interest to today's independent scholars, but unearthing these constructs enables everyone to more readily understand and appreciate the work of today's professional mathematicians.

The open access being provided to the mathematics literature of the past by Google Books and others is a positive development for all mathematics communities.

[6] See `www.ebird.org` for an example from ornithology.

[7] The amateur astronomer Michael Oates has discovered over 130 comets and has one named after him. See `www.mikeoates.org`.

[8] See J. L. Coolidge, *The Mathematics of Great Amateurs, Second Edition*, Oxford University Press, 1990.

[9] See `arxiv.org`, `eprint.iacr.org`, `vixra.org`, and `integers-ejcnt.org` as examples of many of the type.

Mathematics People

2012 Gödel Prize Awarded

Three groups of researchers have been awarded the 2012 Gödel Prize of the Association for Computing Machinery's (ACM) Special Interest Group on Algorithms and Computation Theory (SIGACT), together with the European Association for Theoretical Computer Science (EATCS). ELIAS KOUTSOUPIAS of the University of Athens and CHRISTOS H. PAPADIMITRIOU of the University of California Berkeley; TIM ROUGHGARDEN of Stanford University and ÉVA TARDOS of Cornell University; and NOAM NISAN of the Hebrew University of Jerusalem and AMIR RONEN of IBM Research in Haifa, Israel, were honored "for their contributions to understanding how selfish behavior by users and service providers impacts the behavior of the Internet and other complex computational systems." The prize citation reads in part:

"In their paper 'Worst-case Equilibria', Koutsoupias and Papadimitriou introduced the 'price of anarchy' concept, a measure of the extent to which competition approximates cooperation. It quantifies how much behavior is lost due to selfish behaviors on the Internet, which operates without a system designer or monitor striving to achieve the 'social optimum'. Their research examines how much performance is lost due to these selfish behaviors by Internet users and service providers who act in their own interest. Their answer, surprisingly often, is 'not that much'.

"Roughgarden and Tardos revealed the power and depth of the 'price of anarchy' concept as it applies to routing traffic in large-scale communications networks to optimize the performance of a congested network. Their paper 'How bad is selfish routing?' revisits an old conundrum in transportation science known as 'Braess's paradox' and provides remarkably complete results on the relationship between centralized optimization and selfish routing in network traffic.

"Nisan and Ronen coined the term 'algorithmic mechanism design' in their paper of the same title, presenting a whole new range of applications of the theory of mechanism design within computer science. Combining ideas from economics and game theory with concepts and techniques from computer science, they enriched both mechanism design and the theories of algorithms and complexity."

The Gödel Prize includes an award of US$5,000 and is named in honor of Kurt Gödel, who was born in Austria-Hungary (now the Czech Republic) in 1906. Gödel's work has had immense impact on scientific and philosophical thinking in the twentieth century. The award recognizes his major contributions to mathematical logic and the foundations of computer science.

—From an ACM announcement

Hodgson Receives Wright Award

BERNARD HODGSON of the University of Laval has been named the recipient of the 2012 Graham Wright Award for Distinguished Service by the Canadian Mathematical Society (CMS). The award recognizes individuals who have made sustained and significant contributions to the Canadian mathematical community and in particular to the CMS. Hodgson has been involved with the Canadian Mathematics Education Study Group, helping to increase collaboration between education specialists and mathematicians. Within the CMS he has served as vice president, as a member of the education committee, and as a member of the board of directors.

—From a CMS announcement

Mathematical Sciences Awards at ISEF

The 2012 Intel International Science and Engineering Fair (ISEF) was held May 13-18, 2012, at the David L. Lawrence Convention Center in Pittsburgh, Pennsylvania. This year more than 1,500 students in grades nine through twelve from about seventy countries, regions, and territories participated in the fair. The Society for Science and the Public, in partnership with the Intel Foundation, selects a Best in Category contestant, who receives a cash award of US$5,000. The student chosen this year in the Mathematical Sciences category was AISHWARYA A. VARDHANA, seventeen, of Jesuit High School, Portland, Oregon, for a

project titled "Small geometric progressions modulo N for deterministic polynomial selection". Vardhana also received a First Award, which carries a cash prize of US$3,000. In addition, a grant of US$1,000 was given to Jesuit High School. Other award winners and the titles of their projects follow.

First Award: FABIAN HENNEKE, nineteen, XIANGHUI ZHONG, eighteen, and DANIAL SANUSI, nineteen, all from Kippenberg-Gymnasium, Bremen, Germany, "(Almost) unit-distance points in the polychromatic plane: Colorings of the n-dimensional space".

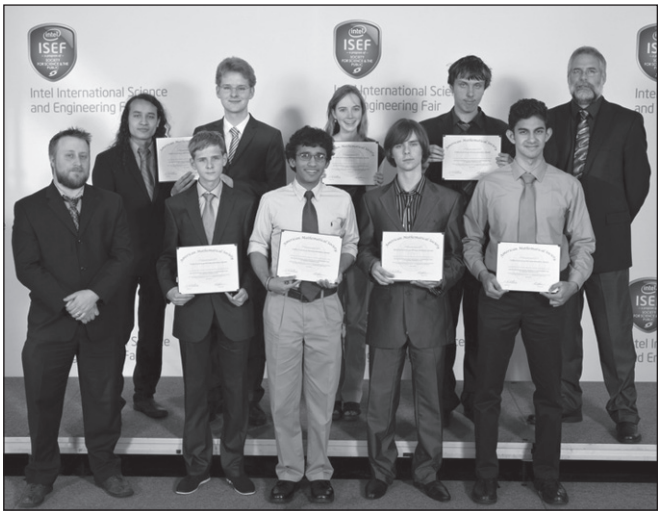
Second Award (US$1,500): KATHERINE LEIGH CORDWELL, sixteen, Manzano High School, Albuquerque, New Mexico, "Completing graphs"; MADHURIMA DAS, fifteen, Plymouth High School, Canton, Michigan, "Fractal dimension analysis to predict cancer"; SIDHARTH DHAWAN, eighteen, Westview High School, Portland, Oregon, "Complexity of interlocking polyominoes".

Third Award (US$1,000): MARKUS ROBERT WOLTJER, seventeen, Wilsonville High School, Wilsonville, Oregon, "Graph theory and locality sensitive hashing for DICOM image analysis"; ANIRUDH PRABHU, seventeen, West Lafayette Junior/Senior High School, West Lafayette, Indiana, "A unitary group relaxation of the traveling salesman problem and its applications"; JUNDA HUANG, seventeen, James Madison High School, Brooklyn, New York, "A relationship between quadratic character and repeating decimals"; PRATHEEK NAGARAJ, eighteen, Marjory Stoneman Douglas High School, Parkland, Florida, "Novel optimized Runge-Kutta methods to increase computational accuracy in numerical integration of differential equations"; JONAH MILTON KALLENBACH, seventeen, Germantown Academy, Fort Washington, Pennsylvania, "Novel graph theory algorithms for protein structure prediction and design".

—From an ISEF announcement

AMS Menger Awards at the 2012 ISEF

The 2012 Intel International Science and Engineering Fair (ISEF) was held May 13–18, 2012, at the David L. Lawrence Convention Center in Pittsburgh, Pennsylvania. This year more than 1,500 students in grades nine through twelve from about seventy countries, regions, and territories participated in the world's largest pre-college science research competition, which was first organized in 1950 and has included international participants since 1958. Student finalists who compete at the ISEF go through a multistep process to qualify and have won an all-expense-paid trip to the fair. They qualify by winning local, regional, and state fairs in the United States or national science fairs abroad. In addition to numerous grand awards presented by the ISEF, more than eighty federal agencies, professional and educational organizations, including the American Mathematical Society (AMS), participated by giving special awards. Prizes given by the AMS included cash, certificates, AMS tote bags, and a booklet about Karl Menger given to each award winner.



AMS Menger Awards. Back row (l-r): Danial Sanusi, Fabian Henneke, Katherine Cordwell, Viachaslau Murshka, Greg Fasshauer (committee chair). Front row (l-r): Andrew Annis (AMS), Danila Baygushev, Anirudh Prabhu, Raman Birulia, Sidharth Dhawan.

For the AMS this was the twenty-fourth year of participation, and it was the twenty-second year of the presentation of the Karl Menger Awards. The members of the 2012 AMS Menger Prize Committee and AMS Special Awards Judges were Greg Fasshauer, Illinois Institute of Technology (chair); Moon Duchin, Tufts University; and Jonathan King, University of Florida. The panel of judges initially reviewed all fifty-seven projects in mathematics, as well as a number of mathematically oriented projects in computer science, physics, and engineering. From these entries they selected a subset of students who were interviewed for further consideration for a Menger Prize. The AMS gave awards to one first-place winner, two second-place winners, four third-place winners, and honorable mentions to five others.

The Karl Menger Memorial Prize winners for 2012 (listed alphabetically in each category) are as follows:

First-Place Award (US$1,000): FABIAN HENNEKE, DANIAL SANUSI, and XIANGHUI ZHONG, Kippenberg-Gymnasium, Bremen, Germany, "(Almost) Unit-Distance Points in the Polychromatic Plane: Colorings of the N-Dimensional Space".

Second-Place Awards (US$500): RAMAN A. BIRULIA, School No. 41, Minsk, Belarus, "The Probability of Generating the Symmetric Group with a Commutator Condition"; KATHERINE LEIGH CORDWELL, Manzano High School, Albuquerque, New Mexico, "Completing Graphs".

Third-Place Awards (US$250): DANILA ALEXANDROVICH BAYGUSHEV, Lyceum "Vtoraia shkola", Moscow, Russia, "(C, B, A)-Permutations, Their Young Diagrams and Arnold Discrete Dynamic Systems"; SIDHARTH DHAWAN, Westview High School, Portland, Oregon, "Complexity of Interlocking Polyominoes"; VIACHASLAU I. MURASHKA, Gymnasium No. 71, Gomel, Belarus, "Partially Conjugate-Permutable Subgroups and Their Applications"; ANIRUDH PRABHU, West Lafayette Junior/Senior High School, West Lafayette,

Indiana, "A Unitary Group Relaxation of the Traveling Salesman Problem and Its Applications".

Honorable Mention Awards: RASHAD ABDULLA, West Shore Junior/Senior High School, Melbourne, Florida, "On the Fine Classification of Periodic Orbits of Continuous Endomorphisms on the Real Line with Application in Chaos Theory"; FREDERIK BENZING, Landesgymnasium für Hochbegabte, Schwäbisch Gmünd, Germany, "Continued Fractions and *e*"; MARK ALAN HOLMSTROM and THERESA MCLAUGHLIN, Live Oak High School and Ann Sobrato High School, Morgan Hill, California, "Neighbors with Prescribed Prime Factors"; YOUKOW HOMMA and LYNDON JI, Carmel High School, Carmel, Indiana, "Counting Zeros of Rational Harmonic Functions: Parameter Spaces"; ANITA KUMMAMURI RAO, Glenda Dawson High School, Pearland, Texas, "Lorenz & Modular Flows are Knot Similar".

Forty-one individual students and sixteen 2- or 3- member teams from fifteen different countries competed in the mathematics category, with fifty-two of the participants being male and twenty-three female. As indicated by the titles of the award-winning projects listed above, the student research covered a wide range of topics. The panel of judges was impressed by the quality, breadth and originality of the work, and the dedication and enthusiasm of the students. Many of the projects contained original research one would usually expect to see only from graduate students. For the first time in recent history the Menger Award judges selected a team of students (Fabian Henneke, Danial Sanusi, and Xianghui Zhong) as recipients of the First Prize Award. Two more teams received Honorable Mention Awards. Anirudh Prabhu (Third-Place Award) was the only 2012 winner who was able to repeat his success from 2011. This year's youngest winner was Danila Alexandrovich Baygushev (fourteen, Third-Place Award).

In an effort to promote the outreach activities of the AMS, a number of this year's contestants were interviewed by Greg Fasshauer. These short videos, produced by Andrew Annis (AMS), can be viewed at `http://www.youtube.com/amermathsoc`.

The Society for Science and the Public (`http://www.societyforscience.org/`), a nonprofit organization based in Washington, DC, owns and has administered the ISEF since 1950. Intel became the title sponsor of ISEF in 1996. The Intel ISEF is the premiere science competition in the world and annually provides a forum for more than 1,500 high school students from more than seventy countries, regions, and territories. The 2013 Intel ISEF finals will be held May 12–17 in Phoenix, Arizona.

The AMS's participation in the Intel-ISEF is supported in part by income from the Karl Menger Fund, which was established by the family of the late Karl Menger. The income from the donation by the Menger family covers less than the amount of the awards. The balance, including the travel expenses of the judges, comes from the AMS's general fund. For more information about this program or to make contributions to this fund, contact the AMS Development Office, 201 Charles Street, Providence, RI 02904-2294; or send email to `development@ams.org`; or phone 401-455-4103.

Greg Fasshauer, Professor of Applied Mathematics, Illinois Institute of Technology

Mathematics Opportunities

AMS Travel Grants for MCA 2013, August 5–9, 2013, in Guanajuato, Mexico

The American Mathematical Society has applied to the National Science Foundation (NSF) for funds to permit partial travel support for up to sixty U.S. mathematicians attending the inaugural meeting of the Mathematics Congress of the Americas (MCA) that will take place August 5–9, 2013, in Guanajuato, Mexico. Subject to the award decision by the NSF, the Society is preparing to administer the selection process.

Instructions on how to apply for support are available on the AMS website at `http://www.ams.org/programs/travel-grants/mca` . The application period will be September 15–October 31, 2012. This travel grants program, if funded, will be administered by the Membership and Programs Department, AMS, 201 Charles Street, Providence, RI 02904-2294. For questions or more information, contact Steven Ferrucci at `sxf@ams.org`, 800-321-4267, ext. 4113, or 401-455-4113.

This program is open to U.S. mathematicians (those who are affiliated with a U.S. institution, and applicants must be affiliated with a U.S. institution at the time of travel). It is expected that this travel grant program will provide travel support for both U.S.-based invited speakers (senior mathematicians) and early-career mathematicians. Early-career mathematicians (those within six years of their doctorate), women, and members of U.S. groups underrepresented in mathematics are especially encouraged to apply. Invited speakers from U.S. institutions to MCA 2013 should submit applications if funding is desired.

Applications will be evaluated by a panel of mathematical scientists under the terms of a proposal submitted to the National Science Foundation (NSF) by the Society.

Should the proposal to the NSF be funded, the following conditions will apply: mathematicians accepting grants for partial support of the travel to MCA 2013 may not supplement them with any other NSF funds. Currently, it is the intention of the NSF's Division of Mathematical Sciences to provide no additional funds on its other regular research grants for travel to MCA in 2013. However, an individual mathematician who does not receive a travel grant may use regular NSF grant funds, subject to the usual restrictions and prior approval requirements.

All information currently available about the MCA 2013 program, organization, and registration procedure is located on the MCA 2013 website: http://www.mca2013.org/.

American Mathematical Society Centennial Fellowships

Invitation for Applications for Awards for 2013–2014
Deadline December 1, 2012

Description: The AMS Centennial Research Fellowship Program makes awards annually to outstanding mathematicians to help further their careers in research. The number of fellowships to be awarded is small and depends on the amount of money contributed to the program. The Society supplements contributions as needed. One fellowship will be awarded for the 2013–2014 academic year. A list of previous fellowship winners can be found at http://www.ams.org/profession/prizes-awards/ams-awards/centennial-fellow.

Eligibility: The eligibility rules are as follows. The primary selection criterion for the Centennial Fellowship is the excellence of the candidate's research. Preference will be given to candidates who have not had extensive fellowship support in the past. Recipients may not hold the Centennial Fellowship concurrently with another research fellowship such as a Sloan or NSF Postdoctoral Fellowship. Under normal circumstances, the fellowship cannot be deferred. A recipient of the fellowship shall have held his or her doctoral degree for at least three years and not more than twelve years at the inception of the award (that is, received between September 1, 2001, and September 1, 2010). Applications will be accepted from those currently holding a tenured, tenure-track, postdoctoral, or comparable (at the discretion of the selection committee) position at an institution in North America. Applications should include a cogent plan indicating how the fellowship will be used. The plan should include travel to at least one other institution and should demonstrate that the fellowship will be used for more than reduction of teaching at the candidate's home institution. The selection committee will consider the plan in addition to the quality of the candidate's research and will try to award the fellowship to those for whom the award would make a real difference in the development of their research careers. Work in all areas of mathematics, including interdisciplinary work, is eligible.

Deadline: The deadline for receipt of applications is **December 1, 2012**. The award recipient will be announced in February 2013 or earlier if possible.

Application information: Find Centennial information and the application form via the Internet at http://www.ams.org/ams-fellowships/. For paper copies of the form, write to the Membership and Programs Department, American Mathematical Society, 201 Charles Street, Providence, RI 02904-2294; prof-serv@ams.org; 401-455-4105.

—AMS announcement

Call for Nominations for Clay Research Fellowships

The Clay Mathematics Institute (CMI) invites nominations for its competition for the 2013 Clay Research Fellowships. Fellows are selected for their research achievements and their potential to become leaders in research mathematics. All are recent Ph.D.'s, and most are selected as they complete their thesis work. Most recent appointees were finishing graduate students at the time of their selection, though other mathematicians under age thirty occasionally have been appointed. Terms range from one to five years, with most given in the upper range of this interval. The primary selection criteria for the Fellowship are the exceptional quality of the candidate's research and the candidate's promise to become a mathematical leader. Selection decisions are made by the Scientific Advisory Board. Nominations should be submitted by October 30, 2012, and should include a letter of nomination, names and contact information for two other references, curriculum vitae, and list of publications. Nominations should be sent to to the attention of Nick Woodhouse, Office of the President, Clay Mathematics Institute, 24-29 St. Giles, Oxford OX1 3LB, U.K. Electronic nominations are also accepted at nwoodh@maths.ox.ac.uk, copied to Naomi Kraker at kraker@maths.ox.ac.uk.

Current and alumni Clay Research Fellows are Mohammed Abouzaid, Spyros Alexakis, Timothy Austin, Artur Avila, Roman Bezrukavnikov, Manjul Bhargava, Daniel Biss, Alexei Borodin, Maria Chudnovsky, Ivan Corwin, Dennis Gaitsgory, Soren Galatius, Daniel Gottesman, Ben Green, Sergei Gukov, Adrian Ioana, Bo'az Klartag, Elon Lindenstrauss, Ciprian Manolescu, Davesh Maulik, Maryam Mirzakhani, Sophie Morel, Mircea Mustata, Sam Payne, Igor Rodnianski, Sucharit Sarkar, Peter Scholze, David Speyer, Terence Tao, Jack Thorne, András Vasy, Akshay Venkatesh, Teruyoshi Yoshida, and Xinyi Yuan.

—Clay Mathematics Institute announcement

AWM Travel Grants for Women

The National Science Foundation (NSF) and the Association for Women in Mathematics (AWM) sponsor travel grant programs for women mathematicians.

AWM Travel Grants for Women Researchers enable women to attend research conferences in their fields, thereby providing scholars valuable opportunities to advance their research activities and their visibility in the research community. A Mathematics Travel Grant provides full or partial support for travel and subsistence for a meeting or conference in the grantee's field of specialization, awarding funds of up to US$1,500 for domestic travel and US$2,000 for foreign travel.

The Mathematics Education Research Travel Grants provide full or partial support for travel and subsistence in math/math education research for mathematicians attending a math education research conference or math education researchers attending a math conference. The grants provide up to US$1,500 for domestic travel and US$2,000 for foreign travel

AWM Mathematics Mentoring Travel Grants are designed to help junior women develop long-term working and mentoring relationships with senior mathematicians. A mentoring travel grant funds travel, subsistence, and other expenses for an untenured woman mathematician to travel to an institute or a department to do research with a specified individual for one month. Up to seven grants will be awarded in amounts up to US$5,000 each. Mathematics Education Research Mentoring Travel Grants encourage collaboration between mathematicians and researchers in education and related fields in order to improve the education of teachers and students. Women mathematicians who wish to collaborate with an educational researcher or to learn about educational research may use the mentoring grants to travel to collaborate with or be mentored by a mathematics education researcher. Up to seven grants will be awarded in amounts up to $5,000 each.

The final deadline for the Travel Grants program for 2012 is **October 1, 2012**. The deadlines for 2013 are **February 1, 2013**; **May 1, 2013**; and **October 1, 2013**. For the Mathematics Education Research Travel Grant program, the deadlines are **October 1, 2012**; **February 1, 2013**; **May 1, 2013**; **and October 1, 2013**. For the Mathematics Mentoring Travel Grants program, the deadline is **February 1, 2013**. For the Mathematics Education Research Mentoring Travel Grants program, the deadline is **February 1, 2013**. For further information and details on applying, see the website `https://sites.google.com/site/awmmath/programs/travel-grants`, telephone: 703-934-0163, email: `awm@awm-math.org`; or contact Association for Women in Mathematics, 11240 Waples Mill Road, Suite 200, Fairfax, VA 22030.

—From an AWM announcement

News from the CIRM

The Centro Internazionale per la Ricerca Matematica (CIRM), Trento, Italy, announces the continuation and expansion of its activities in the field of mathematics research in collaboration with the Department of Mathematics of the University of Trento. Following are the planned activities.

Conferences: Proposals for conferences must contain (1) a scientific proposal, with names of tentative speakers; (2) a detailed financial budget, of which up to 50 percent will be supported by the CIRM; (3) specification of the other available or planned financial resources. Applications for the year 2013 should be sent before **September 15, 2012**, by mail to Fondazione Bruno Kessler (FBK), Centro Internazionale per la Ricerca Matematica, Via Sommarive n. 14-Povo, 38123 Trento, Italy, or via electronic mail to the address `micheletti@fbk.eu`.

Postdoctoral Fellowships: One annual postdoctoral position is available for a researcher in mathematics for the year 2012–2013 to study at the CIRM. The fellowship offers support in the amount of 23,500 euros (approximately US$29,000) per year. The deadline for applications is **September 15, 2012**. Applications may be sent to the preceding postal or email addresses. For more information see the website `http://cirm.fbk.eu/en/node/134`.

Visiting Positions and Research in Pairs: The CIRM is seeking applications for visiting professor and visiting scholar positions, as well as for the Research in Pairs program. Applications for these two programs must be sent by mail or email to the aforementioned addresses. They can be submitted at any time and must contain a specific indication of the proposed dates for the visit; it would be well to send applications at least three months before the planned stay. For further information please visit the websites `http://cirm.fbk.eu/en/Visiting+Professors` and `http://cirm.fbk.eu/en/node/122`.

—Marco Andreatta
Director, CIRM

AIM Workshops

The American Institute of Mathematics (AIM) seeks proposals for workshops in all areas of the mathematical sciences. Proposals should include (1) a plan for the workshop, including a description of the workshop focus and goals; (2) a list of at least two and at most four organizers; (3) a list of potential participants; and (4) the mathematics subject classification and a list of references. Workshops generally last four or five days and can support up to twenty-eight participants.

Proposals for workshops may be submitted online at `www.aimath.org`; the deadline for submissions is **November 1, 2012**. The AIM workshop format is designed to encourage new collaborations to make plans or progress toward a research goal: there are two talks each morning of the workshop and structured group activities each afternoon, including research in small groups.

Further details and a list of upcoming workshops are available at www.aimath.org.

—From an AIM announcement

PIMS Conferences and Fellowships

The Pacific Institute for the Mathematical Sciences (PIMS) is currently welcoming applications for support of conferences, workshops, summer schools, distinguished visitors, special focus periods, collaborative research groups, and related activities in the mathematical sciences, to occur after April 1, 2013. Proposals must be received by **October 1, 2012**. Please note that PIMS is a participant in "Mathematics of Planet Earth 2013", and proposals for activities that are aligned with that theme are welcomed. For further information and application instructions, see the website http://www.pims.math.ca/scientific/call-proposals.

PIMS invites nominations of outstanding young researchers in the mathematical sciences for postdoctoral fellowships for the year 2013–2014. Candidates must be nominated by at least one scientist or by a department (or departments) affiliated with PIMS. The fellowships are intended to supplement support provided by the sponsor and are tenable at any of its Canadian member universities: Simon Fraser University, the University of Alberta, the University of British Columbia, the University of Calgary, the University of Lethbridge, the University of Victoria, the University of Regina, and the University of Saskatchewan, as well as at the PIMS affiliate the University of Northern British Columbia.

For the 2013–2014 competition, to be held in January of 2013, the amount of the award will be at least C$20,000 (approximately US$19,400) and the sponsor(s) is (are) required to provide additional funds to finance a minimum total stipend of C$40,000 (approximately US$38,800). Rankings of candidates are made by the PIMS PDF Review Panel based on the qualifications of the candidate, his or her potential for participation in PIMS programs, and his or her potential involvement with PIMS partners. PIMS postdoctoral fellows will be expected to participate in all PIMS activities related to the fellow's area of expertise and will be encouraged to spend time at more than one site. To ensure that PIMS postdoctoral fellows are able to participate fully in institute activities, they may not teach more than two single-term courses per year.

Nominees must have a Ph.D. or equivalent (or expect to receive a Ph.D. by December 31, 2013) and be within three years of the Ph.D. at the time of the nomination (i.e., the candidate must have received her or his Ph.D. on or after January 1, 2010). The fellowship may be taken up at any time between September 1, 2013, and January 1, 2014. The fellowship is for one year and is renewable for at most one additional year.

The PIMS PDF nomination/application process takes place entirely online, utilizing the MathJobs service provided by the American Mathematical Society. Having selected their nominees, sponsors direct them to apply online at mathjobs.org/jobs/PIMS. Nominees are required to upload two letters of reference, a curriculum vitae, and a statement of research interests. Sponsors must upload their own reference letters (these are in addition to the two reference letters mentioned above) and a statement of financial support. They will receive instructions as to how to proceed from their nominees via email from MathJobs. Detailed instructions regarding all aspects of the MathJobs application procedure may be found in the online MathJobs user guides. Please note that application is by nomination only; unsolicited applications will not be considered. Please note that all nominees must apply through MathJobs; this includes nominees from PIMS Collaborative Research Groups.

Complete applications must be uploaded to MathJobs by **December 1, 2012**. For further information, visit the website http://www.pims.math.ca/scientific/postdoctoral or contact: assistant.director@pims.math.ca.

—PIMS announcement

For Your Information

Heidelberg Laureate Forum

Young researchers in physics, chemistry, medicine, and economics have had opportunities to interact closely with Nobel laureates in their fields in Lindau each year through the Lindau Nobel Laureate Meetings that were established more than sixty years ago. No analogous meetings existed in mathematics and computer science until now.

In 2013 the Klaus Tschira Stiftung will launch an annual series of meetings called the Heidelberg Laureate Forum. The forum will bring a select group of highly talented young researchers together with recipients of the most prestigious scientific awards in mathematics and computer science: Abel Prize winners, Fields Medalists, and Turing Award winners. The meeting will be held in Heidelberg, the location of the Klaus Tschira Stiftung and its research institute, the Heidelberg Institute for Theoretical Studies.

Collaborating on the organization of the forum are the Association for Computing Machinery, which grants the Turing Award; the International Mathematical Union, which grants the Fields Medal; and the Norwegian Academy of Science and Letters, which grants the Abel Prize. The first meeting of the Heidelberg Laureate Forum will take place September 23–27, 2013.

The Klaus Tschira Stiftung is a German foundation that promotes natural sciences, mathematics, and computer science.

—From an International Mathematical Union announcement

Inside the AMS

Deaths of AMS Members

LOUIS GARFIN, of Oceanside, California, died on May 18, 2012. Born on June 7, 1917, he was a member of the Society for 70 years.

CHAOHAO GU, professor, Fudan University, died on June 24, 2012. Born on May 15, 1926, he was a member of the Society in 1979.

WILLIAM G. LISTER, of New York, New York, died on April 18, 2011. Born on September 17, 1924, he was a member of the Society for 63 years.

JEAN-LOUIS LODAY, professor, Institute de Rec Mathematical Avan, France, died on June 6, 2012. Born on January 12, 1946, he was a member of the Society for 35 years.

RICHARD METZLER, of Albuquerque, New Mexico, died on June 2, 2012. Born on October 19, 1937, he was a member of the Society for 50 years.

JOHN PETERS, of Scituate, Massachusetts, died on June 22, 2012. Born on August 18, 1925, he was a member of the Society for 11 years.

JOHN A. POLUIKIS, of Rochester, New York, died on May 28, 2012. Born on April 11, 1923, he was a member of the Society for 24 years.

DANUTA PRZEWORSKA-ROLEWICZ, of Warsaw, Poland, died on June 23, 2012. Born on May 25, 1931, she was a member of the Society for 38 years.

JEANNE-MARIE SILK, of Ashland, Wisconsin, died on June 22, 2012. Born on August 23, 1924, she was a member of the Society for 41 years.

ARTHUR STEGER, of Albuquerque, New Mexico, died on November 16, 2011. Born on November 18, 1921, he was a member of the Society for 55 years.

EDWARD A. TRABANT, of Newark, Delaware, died on July 20, 2012. Born on February 28, 1920, he was a member of the Society in 1947.

A. A. YUSHKEVICH, of Charlotte, North Carolina, died on March 18, 2012. Born on November 19, 1930, he was a member of the Society for 31 years.

AMS American Mathematical Society

MATHEMATICAL IMAGERY

MATHEMATICAL IMAGERY

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The connection between mathematics and art goes back thousands of years. Mathematics has been used in the design of Gothic cathedrals, Rose windows, oriental rugs, mosaics and tilings. Geometric forms were fundamental to the cubists and many abstract expressionists, and award-winning sculptors have used topology as the basis for their pieces. Dutch artist M.C. Escher represented infinity, Möbius bands, tessellations, deformations, reflections, Platonic solids, spirals, symmetry, and the hyperbolic plane in his works.

Mathematicians and artists continue to create stunning works in all media and to explore the visualization of mathematics--origami, computer-generated landscapes, tesselations, fractals, anamorphic art, and more.

> A mathematician, like a painter or poet, is a maker of patterns. If his patterns are more permanent than theirs, it is because they are made with ideas.
>
> —G. H. Hardy, A Mathematician's Apology

Explore the world of mathematics and art, send an e-postcard, and bookmark this page to see new featured wo

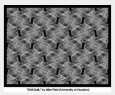
2009 Mathematical Art Exhibition

The Mathematical Art Exhibition held at the 20 Fathauer was the curator of the exhibition, and along with Nat Friedman and Reza Sarhangi. Mathematical Society and the Mathematical A (32), 2006;" Second Prize to Carlo Séquin, for No. 1, 2008." The Prize "for aesthetically pleas to the American Mathematical Society by an a mathematics expressed in a visual art form. T

Crocheted Lorenz Manifolds

Dr. Hinke Osinga and Professor Bernd Krausk (Engineering Mathematics,University of Bristol) have turned the famous Lorenz equations into a beautiful real-life object, by crocheting computer-generated instructions of the Lorenz manifold.

Mike Field : Realizations



An aspect of my art work that I particularly enjoy is that I write the software for all the programs I use and build the computers that run the software. In this sense, I like to feel that theory (mathematics), art (outcome), software (algorithms) and engineering (hardware) are integrated and interdependent and that no part survives without the others.

—Mike Field

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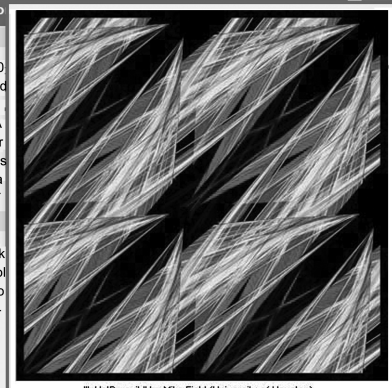

"InHotPursuit," by Mike Field (University of Houston)

Dear Bill,

Here's one of the e-postcards from the site.

Annette

GALLERIES & MUSEUMS

- Bridges: Mathematical Connections in Art, Music, and Science
- M.C. Escher: the Official Website
- Images and Mathematics, MathArchives
- The Institute for Figuring
- Kalendar, by Herwig Hauser
- The KnotPlot Site
- Mathematical Imagery by Jos Leys
- Mathematics Museum (Japan)
- Visual Mathematics Journal

ARTICLES & RESOURCES

- Art & Music, MathArchives
- Geometry in Art & Architecture, by Paul Calter (Dartmouth College)
- *Harmony and Proportion*, by John Boyd-Brent
- International Society of the Arts, Mathematics and Architecture
- *Journal of Mathematics and the Arts*
- *Mathematics and Art*, the April 2003 Feature Column by Joe Malkevitch
- *Maths and Art: the whistlestop tour*, by Lewis Dartnell
- Mathematics and Art, (The theme for Mathematics Awareness Monthin 2003)
- Viewpoints: Mathematics and Art, by Annalisa Crannell (Franklin & Marshall College) and Marc Frantz (Indiana University)

www.ams.org/mathimagery

AMS Presents the Book Series *Pure and Applied Undergraduate Texts*

High-quality and substantial undergraduate courses are critical to the advancement of mathematics. The instruction of students at this level begins their training as future mathematicians; furthermore, these courses are the primary means by which scientists and engineers learn the essential mathematical tools for their disciplines. Unfortunately, the current textbook market does not reflect the importance of high quality and substantial courses as part of undergraduate education in mathematics: in recent years, growing numbers of commercial publishers have been abandoning the publication of some upper-level undergraduate textbooks, leaving societies and university presses to fill the void left by their exodus.

With its series *Pure and Applied Undergraduate Texts* series, the AMS assumes a key role in this process by producing first-class undergraduate textbooks available at moderate prices. The series was founded on the realization that there is intrinsic value in involving mathematicians in the publication of such textbooks. The intent behind the series is to provide quality books covering a wide variety of areas in pure and applied mathematics to mathematics classrooms at all colleges and universities. Each area will have texts at varying levels of difficulty, allowing professors to select books best suited for their distinct courses.

The goal of the AMS is to produce a complete series of texts that are fundamental to the development of undergraduate education in mathematics in the twenty-first century. We encourage teachers to consider our textbooks for their courses and to inquire about adoption by visiting `http://ams.org/bookstore/textbooks`. We also welcome suggestions for new books that may be appropriate for the series and invite the submission of manuscripts by authors who write books with a lively style and rigorous approach to their subjects.

The current Editorial Committee of the series comprises Paul J. Sally Jr. (University of Chicago), Chair; Joseph H. Silverman (Brown University); Francis Edward Su (Harvey Mudd College); and Susan Tolman (University of Illinois at Urbana-Champaign).

The following is a list of currently available publications.

Current Titles

Analysis

- *Introduction to Analysis*, Edward D. Gaughan
- *Foundations of Analysis*, Joseph L. Taylor
- *Fourier Analysis and Its Applications*, Gerald B. Folland
- *Advanced Calculus*, Patrick M. Fitzpatrick
- *Introduction to Classical Analysis*, Peter Duren

Complex Analysis

- *An Introduction to Complex Analysis and Geometry*, John P. D'Angelo
- *Complex Variables*, Joseph L. Taylor

Algebra

- *Abstract Algebra*, Ronald Solomon
- *Algebra*, Mark R. Sepanski

Geometry/Topology

- *Geometry for College Students*, I. Martin Isaacs
- *Beginning Topology*, Sue E. Goodman

Paul Sally Jr. is chair of the Editorial Committee. His email address is sally@math.uchicago.edu.

Sergei Gelfand is the AMS publisher. His email address is sxg@ams.org.

DOI: http://dx.doi.org/10.1090/noti891

About the Cover

The legacy of Benoît Mandelbrot

Benoît Mandelbrot died in 2010, and this issue of the *Notices* and the next contain memorial articles about him. What he is most famous for, in the world at large and also in mathematics, is his exploration of fractal phenomena (in the process coining the now ubiquitous word "fractal"). His computer illustrations of the Mandelbrot set (a term first applied in work of Douady and Hubbard) became extraordinarily popular among a huge range of people not otherwise particularly knowledgeable about complex dynamics. Deservedly so—it is very easy and satisfying to write programs that expose a wide variety of intriguing phenomena which are not even now completely understood on a rigorous level.

Mandelbrot's exact role in the early days of the Mandelbrot set seems a bit murky, and has stimulated some controversy. Accounts by Mandelbrot in *Fractals and Chaos* and the preface by John Hubbard in *The Mandelbrot Set, Theme and Variations* are not in accord. Also, as the Wikipedia article on the Mandelbrot set points out, it was in an article by Brooks and Matelski in *Riemann Surfaces and Related Topics* (edited by Kra and Maskit), in which a computer-drawn picture of it, albeit crude and not very suggestive, first appeared. Did this play a role in subsequent development? In any event, it seems clear that the remarkable detailed pictures produced by Mandelbrot in 1980 with the help of machines at Harvard and the IBM Watson Research Center were ultimately responsible for the set's fame beyond the world of professional mathematicians.

The Mandelbrot set itself is marked in the cover images by black pixels. The shading is explained in the Wikipedia article on it. Simple instructions for coding can be found at

`http://warp.povusers.org/Mandelbrot/`

One great feature of drawing the Mandelbrot set is that zooming in on selected parts, which has spectacular effect, is not necessarily expensive in run-time. This has undoubtedly been significant for its attraction.

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

Ordinary and Partial Differential Equations

- *Introduction to Differential Equations*, Michael E. Taylor
- *Partial Differential Equations and Boundary-Value Problems with Applications*, Mark A. Pinsky

Probability and Statistics

- *Probability: The Science of Uncertainty with Applications to Investments, Insurance, and Engineering*, Michael A. Bean
- *Foundations and Applications of Statistics: An Introduction Using* **R**, Randal Pruim

Others

- *Numerical Analysis: Mathematics of Scientific Computing*, David Kincaid and Ward Cheney
- *A Discrete Transition to Advanced Mathematics*, Bettina Richmond and Thomas Richmond
- *The Mathematics of Finance: Modeling and Hedging*, Victor Goodman and Joseph Stampfli

The preface, table of contents, and selected material from these texts may be found at: `http://www.ams.org/bookstore/amstextseries`.

Paul Sally Jr.
University of Chicago
Chair of the Editorial Committee

Sergei Gelfand
AMS Publisher

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.wustl.edu in the case of the editor and smf@ams.org in the case of the managing editor. The fax numbers are 314-935-6839 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. Contact information for *Notices* editors and staff may be found on the *Notices* website, http://www.ams.org/notices.

Upcoming Deadlines

August 17, 2012: Letters of intent for NSF Focused Research Groups. See http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5671.

August 22, 2012: Full proposals for REU sites. See http://www.nsf.gov/pubs/2009/nsf09598/nsf09598.htm.

September 15–October 31, 2012: Applications for AMS Travel Grants for the Mathematics Conference of the Americas (MCA) 2013. See "Mathematics Opportunities" in this issue.

September 15, 2012: Proposals for conferences and applications for postdoctoral fellowships at the Centro Internazionale per la Ricerca Matematica (CIRM). See "Mathematics Opportunities" in this issue.

September 15, 2012: Nominations for Sloan Research Fellowships. See http://www.sloan.org/fellowships or write to: Sloan Research Fellowships, Alfred P. Sloan Foundation, 630 Fifth Avenue, Suite 2550, New York, New York 10111-0242.

September 15, 2012: Applications for spring 2013 semester of Math in Moscow. See http://www.mccme.ru/mathinmoscow, or write to: Math in Moscow, P.O. Box 524, Wynnewood, PA 19096; fax: +7499-795-10-15; e-mail: mim@mccme.ru. Information

Where to Find It

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

AMS Bylaws—*January 2012, p. 73*

AMS Email Addresses—*February 2012, p. 328*

AMS Ethical Guidelines—*June/July 2006, p. 701*

AMS Officers 2010 and 2011 Updates—*May 2012, p. 708*

AMS Officers and Committee Members—*October 2011, p. 1311*

Conference Board of the Mathematical Sciences—*September 2011, p. 1128*

IMU Executive Committee—*December 2011, p. 1606*

Information for *Notices* Authors—*June/July 2012, p. 851*

Mathematics Research Institutes Contact Information—*August 2012, p. 979*

National Science Board—*January 2012, p. 68*

NRC Board on Mathematical Sciences and Their Applications—*March 2012, p. 444*

NRC Mathematical Sciences Education Board—*April 2011, p. 619*

NSF Mathematical and Physical Sciences Advisory Committee—*May 2012, p. 697*

Program Officers for Federal Funding Agencies—*October 2011, p. 1306 (DoD, DoE); December 2011, p.1606 (NSF Mathematics Education)*

Program Officers for NSF Division of Mathematical Sciences—*November 2011, p. 1472*

and application forms for the AMS scholarships are available on the AMS website at http://www.ams.org/programs/travel-grants/mimoscow, or by writing to: Math in Moscow Program, Membership and Programs Department, American Mathematical Society, 201 Charles Street, Providence RI 02904-2294; email student-serv@ams.org.

September 17, 2012: Full proposals for DMS/NIGMS Initiative for Research in Biological and Mathematical Sciences. See http://www.nsf.gov/pubs/2012/nsf12561/nsf12561.htm?WT.mc_id=USNSF_25&WT.mc_ev=click or http://tinyurl.com/7e2sk3c.

September 21, 2012: Full proposals for NSF Focused Research Groups. See http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5671.

September 28, 2012: Deadline for 5-day workshops and summer school proposals for 2014, Banff International Research Station for Mathematical Innovation and Discovery (BIRS). Application date for Research in Teams and Focused Research Groups programs. See "Mathematics Opportunities" in this issue.

October 1, 2012: Applications for support of Pacific Institute for the Mathematical Sciences (PIMS) activities to occur after April 1, 2013. See "Mathematics Opportunities" in this issue.

October 1, 2012: Applications for AWM Travel Grants. See http://www.awm-math.org/travelgrants.html#standard; or contact Association for Women in Mathematics, 11240 Waples Mill Road, Suite 200, Fairfax, VA 22030; 703-934-0163; awm@awm-math.org.

October 15, 2012: Proposals for NSA Mathematical Sciences Program grants for research. See http://www.nsa.gov/research/math_research/index.shtml.

October 17, 2012: Applications for NSF Postdoctoral Research Fellowships. See http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5301.

November 1, 2012: Proposals for American Institute of Mathematics (AIM) workshops. See "Mathematics Opportunities" in this issue.

November 1, 2012: Nominations for 2013 Clay Research Fellowships. See "Mathematics Opportunities" in this issue.

November 1, 2012: Applications for National Academies Research Associateship Programs. See http://sites.nationalacademies.org/PGA/RAP/PGA_050491 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.

November 15, 2012: Nominations for 2013 Vasil A. Popov Prize. See http://imi.cas.sc.edu/popov-prize-call-nominations/.

December 1, 2012: Applications for 2013–2014 AMS Centennial Fellowships. See "Mathematics Opportunities" in this issue.

December 3, 2012: Entries for Ferran Sunyer i Balaguer Prize. See http://ffsb.iec.cat.

December 31, 2012: Nominations for Otto Neugebauer Prize of the EMS. See the website http://www.euro-math-soc.eu/otto_neugebauer_prize.html.

April 15, 2013: Applications for fall 2013 semester of Math in Moscow. See http://www.mccme.ru/mathinmoscow, or write to: Math in Moscow, P.O. Box 524, Wynnewood, PA 19096; fax: +7499-795-10-15; e-mail: mim@mccme.ru. Information and application forms for the AMS scholarships are available on the AMS website at http://www.ams.org/programs/travel-grants/mimoscow, or by writing to: Math in Moscow Program, Membership and Programs Department, American Mathematical Society, 201 Charles Street, Providence RI 02904-2294; email student-serv@ams.org.

Conference Board of the Mathematical Sciences

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202-293-1170
http://www.cbmsweb.org/

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410-730-1426 (Home–try this first)
Fax: 202-293-3412

Lisa R. Kolbe
Administrative Coordinator
202-293-1170
Fax: 202-293-3412

Member Societies:
American Mathematical Association of Two-Year Colleges (AMATYC)
American Mathematical Society (AMS)
Association of Mathematics Teacher Educators (AMTE)
American Statistical Association (ASA)
Association for Symbolic Logic (ASL)
Association for Women in Mathematics (AWM)
Association of State Supervisors of Mathematics (ASSM)
Benjamin Banneker Association (BBA)
Institute of Mathematical Statistics (IMS)
Mathematical Association of America (MAA)
National Association of Mathematicians (NAM)
National Council of Supervisors of Mathematics (NCSM)
National Council of Teachers of Mathematics (NCTM)
Society for Industrial and Applied Mathematics (SIAM)
Society of Actuaries (SOA)
TODOS: Mathematics for ALL

Book List

The Book List highlights recent books that have mathematical themes and are aimed at a broad audience potentially including mathematicians, students, and the general public. 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.

Adventures in Group Theory: Rubik's Cube, Merlin's Machine, and Other Mathematical Toys, by David Joyner. Johns Hopkins University Press (second edition), December 2008. ISBN-13: 978-08018-9013-0.

The Beginning of Infinity: Explanations That Transform the World, by David Deutsch. Viking Adult, July 2011. ISBN-13: 978-06700-227-55. (Reviewed April 2012.)

The Best Writing on Mathematics: 2010, edited by Mircea Pitici. Princeton University Press, December 2010. ISBN-13: 978-06911-484-10. (Reviewed November 2011.)

Bibliography of Raymond Clare Archibald by Scott Guthery. Docent Press, April 2012. ISBN-13: 978-0983700425.

The Blind Spot: Science and the Crisis of Uncertainty, by William Byers. Princeton University Press, April 2011. ISBN-13: 978-06911-468-43.

Calculating Curves: The Mathematics, History, and Aesthetic Appeal of T. H. Gronwall's Nomographic Work, by Thomas Hakon Gronwall, with contributions by Ron Doerfler and Alan Gluchoff, translation by Paul Hamburg, and bibliography by Scott Guthery. Docent Press, April 2012. ISBN-13: 978-09837-004-32.

The Calculus of Selfishness, by Karl Sigmund. Princeton University Press, January 2010. ISBN-13: 978-06911-427-53. (Reviewed January 2012.)

Chasing Shadows: Mathematics, Astronomy, and the Early History of Eclipse Reckoning, by Clemency Montelle. Johns Hopkins University Press, April 2011. ISBN-13: 978-08018-969-10. (Reviewed March 2012.)

Classic Problems of Probability, by Prakash Gorroochurn. Wiley, May 2012. ISBN: 978-1-1180-6325-5.

The Crest of the Peacock: Non-European Roots of Mathematics, by George Gheverghese Joseph. Third edition. Princeton University Press, October 2010. ISBN-13: 978-0-691-13526-7.

The Crossing of Heaven: Memoirs of a Mathematician, by Karl Gustafson. Springer, January 2012. ISBN-13: 978-36422-255-74.

Cycles of Time: An Extraordinary New View of the Universe, by Roger Penrose. Knopf, May 2011. ISBN-13: 978-03072-659-06.

Divine Machines: Leibniz and the Sciences of Life, by Justin E. H. Smith. Princeton University Press, May 2011. ISBN-13: 978-06911-417-87.

Elegance with Substance, by Thomas Colignatus. Dutch University Press, 2009. ISBN-13: 978-90361-013-87.

Elliptic Tales: Curves, Counting, and Number Theory, by Avner Ash and Robert Gross. Princeton University Press, March 2012. ISBN-13: 978-06911-511-99.

Emmy Noether's Wonderful Theorem, by Dwight E. Neuenschwander. Johns Hopkins University Press, November 2010. ISBN-13: 978-08018-969-41.

Excursions in the History of Mathematics, by Israel Kleiner. Birkhäuser, 2012. ISBN-13: 978-08176-826-75.

Experimental and Computational Mathematics: Selected Writings, by Jonathan Borwein and Peter Borwein. PSIpress, 2011. ISBN-13: 978-19356-380-56.

Fascinating Mathematical People: Interviews and Memoirs, edited by Donald J. Albers and Gerald L. Alexanderson. Princeton University Press, October 2011. ISBN-13: 978-06911-482-98.

Galileo's Muse: Renaissance Mathematics and the Arts, by Mark Austin-Peterson. Harvard University Press, October 2011. ISBN-13: 978-06740-597-26.

Gösta Mittag-Leffler: A Man of Conviction, by Arild Stubhaug (translated by Tiina Nunnally). Springer, November 2010. ISBN-13: 978-36421-167-11.

Gottfried Wilhelm Leibniz: The Polymath Who Brought Us Calculus, by M. B. W. Tent. A K Peters/CRC Press, October 2011. ISBN-13: 978-14398-922-20.

In Pursuit of the Traveling Salesman: Mathematics at the Limits of Computation, by William J. Cook. Princeton University Press, December 2011. ISBN-13: 978-06911-527-07.

In Pursuit of the Unknown: 17 Equations That Changed the World, by Ian Stewart. Basic Books, March 2012. ISBN-13: 978-04650-297-30.

In Service to Mathematics: The Life and Work of Mina Rees, by Amy Shell-Gellasch. Docent Press, December 2010. ISBN-13: 978-0-9837004-1-8.

The Infinity Puzzle: Quantum Field Theory and the Hunt for an Orderly Universe, by Frank Close. Basic Books, November 2011. ISBN-13: 978-04650-214-44. (Reviewed in this issue.)

The Information: A History, a Theory, a Flood, by James Gleick. Pantheon, March 2011. ISBN-13: 978-03754-237-27.

The Irrationals: A Story of the Numbers You Can't Count On, by Julian Havil. Princeton University Press, June 2012. ISBN-13: 978-0691143422.

Knots Unravelled: From String to Mathematics, by Meike Akveld and Andrew Jobbings. Arbelos, October 2011. ISBN-13: 978-09555-477-20.

Late Style: Yuri I. Manin Looking Back on a Life in Mathematics. A DVD documentary by Agnes Handwerk and Harrie Willems. Springer, March 2012. ISBN NTSC: 978-3-642-24482-7; ISBN PAL: 978-3-642-24522-0.

**Lemmata: A Short Mathematical Thriller,* by Sam Peng. CreateSpace, December 2011. ISBN-13: 978-14681-442-39.

Lost in a Cave: Applying Graph Theory to Cave Exploration, by Richard L. Breisch. National Speleological Society, January 2012. ISBN-13: 978-1-879961-43-2.

The Lost Millennium: History's Timetables Under Siege, by Florin Diacu. Johns Hopkins University Press (second edition), November 2011. ISBN-13: 978-14214-028-88.

Magical Mathematics: The Mathematical Ideas That Animate Great Magic Tricks, by Persi Diaconis and Ron Graham. Princeton University Press, November 2011. ISBN-13: 978-06911-516-49. (Reviewed August 2012.)

The Man of Numbers: Fibonacci's Arithmetic Revolution, by Keith Devlin. Walker and Company, July 2011. ISBN-13: 978-08027-781-23. (Reviewed May 2012.)

Math Girls, by Hiroshi Yuki (translated from the Japanese by Tony Gonzalez). Bento Books, November 2011. ISBN-13: 978-09839-513-15. (Reviewed August 2012.)

**Math is Murder,* by Robert C. Brigham and James B. Reed. Universe, March 2012. ISBN-13: 978-14697-972-81.

A Mathematical Nature Walk, by John A. Adam. Princeton University Press, October 2011 (paperback edition). ISBN-13: 978-06911-526-53.

The Mathematical Writings of Évariste Galois, edited by Peter M. Neumann. European Mathematical Society, October 2011. ISBN-13: 978-3-03719-104-0.

A Mathematician Comes of Age, by Steven G. Krantz. Mathematical Association of America, December 2011. ISBN-13: 978-08838-557-82.

**Mathematics in Popular Culture: Essays on Appearances in Film, Fiction, Games, Television and Other Media,* edited by Jessica K. Sklar and Elizabeth S. Sklar. McFarland, February 2012. ISBN-13: 978-07864-497-81.

Mathematics in Victorian Britain, by Raymond Flood, Adrian Rice, and Robin Wilson. Oxford University Press, October 2011. ISBN-13: 978-019-960139-4.

The Mathematics of Life, by Ian Stewart. Basic Books, June 2011. ISBN-13: 978-04650-223-80. (Reviewed December 2011.)

Mathematics, Religion and Ethics: An Epistemological Study, by Salilesh Mukhopadhyay. Feasible Solution LLC, September 2010. ISBN-13: 978-1-4507-3558-2.

Newton and the Counterfeiter: The Unknown Detective Career of the World's Greatest Scientist, by Thomas Levenson. Houghton Mifflin Harcourt, June 2009. ISBN-13: 978-01510-127-87.

The Noether Theorems: Invariance and Conservation Laws in the Twentieth Century, by Yvette Kosmann-Schwarzbach. Springer, December 2010. ISBN-13: 978-03878-786-76.

Numbers: A Very Short Introduction, by Peter M. Higgins. Oxford University Press, February 2011. ISBN-13: 978-0-19-958405-5. (Reviewed January 2012.)

**On the Formal Elements of the Absolute Algebra,* by Ernst Schröder (translated and with additional material by Davide Bondoni; with German parallel text). LED Edizioni Universitarie, 2012. ISBN: 978-88-7916-516-7.

One, Two, Three: Absolutely Elementary Mathematics (hardcover), David Berlinski. Pantheon, May 2011. ISBN-13: 978-03754-233-38.

The Philosophy of Mathematical Practice, Paolo Mancosu, editor. Oxford University Press, December 2011. ISBN-13: 978-01996-401-02. (Reviewed March 2012.)

Pricing the Future: Finance, Physics, and the 300-Year Journey to the Black-Scholes Equation, by George G. Szpiro. Basic Books, November 2011. ISBN-13: 978-04650-224-89.

Proof and Other Dilemmas: Mathematics and Philosophy, edited by Bonnie Gold and Roger A. Simons. Mathematical Association of America, July 2008. ISBN-13: 978-08838-556-76. (Reviewed December 2011.)

The Proof Is in the Pudding: A Look at the Changing Nature of Mathematical Proof, by Steven G. Krantz. Springer, May 2011. ISBN-13: 978-03874-890-87.

**Proving Darwin: Making Biology Mathematical,* by Gregory Chaitin. Pantheon, May 2012. ISBN: 978-03754-231-47.

Riot at the Calc Exam and Other Mathematically Bent Stories, by Colin Adams. AMS, July 2009. ISBN-13: 978-08218-481-73.

Scientific Reflections: Selected Multidisciplinary Works, by Richard Crandall. PSIpress, 2011. ISBN-13: 978-19356-380-87.

Six Gems of Geometry, by Thomas Reale. PSIpress, 2010. ISBN-13: 978-19356-380-25.

Sources in the Development of Mathematics: Series and Products from the Fifteenth to the Twenty-first Century, by Ranjan Roy. Cambridge University Press, June 2011. ISBN-13: 978-05211-147-07.

A Strange Wilderness: The Lives of the Great Mathematicians, by Amir D. Aczel. Sterling, October 2011.ISBN-13: 978-14027-858-49.

The Strangest Man, by Graham Farmelo. Basic Books, August 2009. ISBN-13: 978-04650-182-77. (Reviewed October 2011.)

Taking Sudoku Seriously: The Math behind the World's Most Popular Pencil Puzzle, by Jason Rosenhouse and Laura Taalman. Oxford University Press, January 2012. ISBN-13: 978-01997-565-68.

The Theory That Would Not Die: How Bayes' Rule Cracked the Enigma Code, Hunted Down Russian Submarines, and Emerged Triumphant from Two Centuries of Controversy, by Sharon Bertsch McGrayne. Yale University Press, April 2011. ISBN-13: 978-03001-696-90. (Reviewed May 2012.)

Top Secret Rosies: The Female Computers of World War II. Video documentary, produced and directed by LeAnn Erickson. September 2010. Website: `http://www.topsecretrosies.com`. (Reviewed February 2012.)

Towards a Philosophy of Real Mathematics, by David Corfield. Oxford University Press, April 2003. ISBN-13: 0-521-81722-6. (Reviewed November 2011.)

Turbulent Times in Mathematics: The Life of J.C. Fields and the History of the Fields Medal, by Elaine McKinnon Riehm and Frances Hoffman. AMS, November 2011. ISBN-13: 978-08218-691-47.

Uneducated Guesses: Using Evidence to Uncover Misguided Education Policies, by Howard Wainer. Princeton University Press, August 2011. ISBN-13: 978-06911-492-88. (Reviewed June/July 2012.)

The Universe in Zero Words: The Story of Mathematics as Told through Equations, by Dana Mackenzie. Princeton University Press, April 2012. ISBN-13: 978-06911-528-20.

Viewpoints: Mathematical Perspective and Fractal Geometry in Art, by Marc Frantz and Annalisa Crannell. Princeton University Press, August 2011. ISBN-13: 978-06911-259-23.

Vilim Feller, istaknuti hrvatsko-americki matematicar/William Feller, Distinguished Croatian-American Mathematician, by Darko Zubrinic. Bilingual Croatian-English edition, Graphis, 2011. ISBN-13: 978-953-279-016-0.

What's Luck Got to Do with It? The History, Mathematics and Psychology of the Gambler's Illusion, by Joseph Mazur. Princeton University Press, July 2010. ISBN-13: 978-0-691-13890-9. (Reviewed February 2012.)

Who's #1?: The Science of Rating and Ranking, by Amy N. Langville and Carl D. Meyer. Princeton University Press, February 2012. ISBN-13: 978-06911-542-20.

Why Beliefs Matter: Reflections on the Nature of Science, by E. Brian Davies. Oxford University Press, June 2010. ISBN-13: 978-01995-862-02. (Reviewed April 2012.)

Why Cats Land on Their Feet (and 76 Other Physical Paradoxes and Puzzles), by Mark Levi. Princeton University Press, May 2012. ISBN-13: 978-0691148540.

SPECIAL SECTION

2012 American Mathematical Society Elections

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2012 AMS Elections

Special Section

List of Candidates–2012 Election

Vice President
(one to be elected)
Chuu-Lian Terng
Christoph Thiele

Board of Trustees
(one to be elected)
Joel Spencer
Karen Vogtmann

Member at Large of the Council
(five to be elected)
Jesús A. De Loera
Paul Goerss
Allan Greenleaf
Brendan Hassett
David Marker
Nataša Pavlović
Amber L. Puha
Kenneth A. Ribet
Benjamin Sudakov
Yuri Tschinkel

Nominating Committee
(three to be elected)
Jeffrey F. Brock
John B. Etnyre
Craig Huneke
Ken Ono
Amie Wilkinson
Deane Yang

Editorial Boards Committee
(two to be elected)
Walter Craig
Jonathan I. Hall
Walter D. Neumann
Edward Scheinerman

Ballots

AMS members will receive email with instructions for voting online by August 20, or a paper ballot by September 15. If you do not receive this information by that date, please contact the AMS (preferably before October 1) to request a ballot. Send email to `ballot@ams.org` or call the AMS at 800-321-4267 (within the U.S. or Canada) or 401-455-4000 (worldwide) and ask to speak with Member Services. The deadline for receipt of ballots is November 2, 2012.

Write-in Votes

It is suggested that names for write-in votes be given in exactly the form that the name occurs in the *Combined Membership List* (`www.ams.org/cml`). Otherwise the identity of the individual for whom the vote is cast may be in doubt and the vote may not be properly credited.

Replacement Ballots

For a paper ballot, the following replacement procedure has been devised: A member who has not received a ballot by September 15, 2012, or who has received a ballot but has accidentally spoiled it, may write to `ballot@ams.org` or Secretary of the AMS, 201 Charles Street, Providence, RI 02904-2294, USA, asking for a second ballot. The request should include the individual's member code and the address to which the replacement ballot should be sent. Immediately upon receipt of the request in the Providence office, a second ballot, which will be indistinguishable from the original, will be sent by first class or airmail. Although a second ballot will be supplied on request and will be sent by first class or airmail, the deadline for receipt of ballots cannot be extended to accommodate these special cases.

Biographies of Candidates

The next several pages contain biographical information about all candidates. All candidates were given the opportunity to provide a statement of not more than 200 words to appear at the end of their biographical information.

Description of Offices

The **vice president** and the **members at large of the AMS Council** serve for three years on the Council. That body determines all scientific policy of the Society, creates and oversees numerous committees, appoints the treasurers and members of the Secretariat, makes nominations of candidates for future elections, and determines the chief editors of several key editorial boards. Typically, each of these new members of the Council also will serve on one of the Society's five policy committees.

The **Board of Trustees**, of whom you will be electing one member for a five-year term, has complete fiduciary responsibility for the Society. Among other activities, the trustees determine the annual budget of the Society, prices of journals, salaries of employees, dues (in cooperation with the Council), registration fees for meetings, and investment policy for the Society's reserves. The person you select will serve as chair of the Board of Trustees during the fourth year of the term.

The candidates for **vice president**, **members at large**, and **trustee** were suggested to the Council either by the Nominating Committee or by petition from members.

While the Council has the final nominating responsibility, the groundwork is laid by the **Nominating Committee**. The candidates for election to the Nominating Committee were nominated by the current president, Eric M. Friedlander. The three elected will serve three-year terms. The main work of the Nominating Committee takes place during the annual meeting of the Society, during which it has four sessions of face-to-face meetings, each lasting about three hours. The Committee then reports its suggestions to the spring Council, which makes the final nominations.

The **Editorial Boards Committee** is responsible for the staffing of the editorial boards of the Society. Members are elected for three-year terms from a list of candidates named by the president. The Editorial Boards Committee makes recommendations for almost all editorial boards of the Society. Managing editors of *Journal of the AMS*, *Mathematics of Computation*, *Proceedings of the AMS*, and *Transactions of the AMS*; and Chairs of the *Collquium*, *Mathematical Surveys and Monographs*, and *Mathematical Reviews* editorial committees are officially appointed by the Council upon recommendation by the Editorial Boards Committee. In virtually all other cases, the editors are appointed by the president, again upon recommendation by the Editorial Boards Committee.

Elections to the **Nominating Committee** and the **Editorial Boards Committee** are conducted by the method of approval voting. In the approval voting method, you can vote for as many or as few of the candidates as you wish. The candidates with the greatest number of the votes win the election.

A Note from AMS Secretary Robert J. Daverman

The choices you make in these elections directly affect the direction the Society takes. If the past election serves as a reliable measure, about 13 percent of you will vote in the coming election, which is comparable with voter participation in other professional organizations which allow an online voting option. This is not mentioned as encouragement for you to throw the ballot in the trash; instead, the other officers and Council members join me in urging you to take a few minutes to review the election material, fill out your ballot, and submit it. The Society belongs to its members. You can influence the policy and direction it takes by voting.

Also, let me urge you to consider other ways of participating in Society activities. The Nominating Committee, the Editorial Boards Committee, and the Committee on Committees are always interested in learning of members who are willing to serve the Society in various capacities. Names are always welcome, particularly when accompanied by a few words detailing the person's background and interests. Self-nominations are probably the most useful. Recommendations can be transmitted through an online form (`www.ams.org/committee-nominate`) or sent directly to the secretary (`secretary@ams.org`) or Office of the Secretary, American Mathematical Society, Department of Mathematics, 237 Ayres Hall, University of Tennessee, 1403 Circle Drive, Knoxville, TN 37996-1320.

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Biographies of Candidates 2012

Biographical information about the candidates has been supplied and verified by the candidates.

Candidates have had the opportunity to make a statement of not more than 200 words (400 words for presidential candidates) on any subject matter without restriction and to list up to five of their research papers.

Candidates have had the opportunity to supply a photograph to accompany their biographical information.

Candidates with an asterisk (*) beside their names were nominated in response to a petition.

Abbreviations: American Association for the Advancement of Science (AAAS); American Mathematical Society (AMS); American Statistical Association (ASA); Association for Computing Machinery (ACM); Association for Symbolic Logic (ASL); Association for Women in Mathematics (AWM); Canadian Mathematical Society, Société Mathématique du Canada (CMS); Conference Board of the Mathematical Sciences (CBMS); Institute for Advanced Study (IAS), Institute of Mathematical Statistics (IMS); International Mathematical Union (IMU); London Mathematical Society (LMS); Mathematical Association of America (MAA); Mathematical Sciences Research Institute (MSRI); National Academy of Sciences (NAS); National Academy of Sciences/National Research Council (NAS/NRC); National Aeronautics and Space Administration (NASA); National Council of Teachers of Mathematics (NCTM); National Science Foundation (NSF); Society for Industrial and Applied Mathematics (SIAM).

Vice President

Chuu-Lian Terng

Professor in Mathematics, University of California, Irvine.

Born: February 1, 1949, Hua-Lian, Taiwan, ROC.

Ph.D.: Brandeis University, 1976.

AMS Offices: Member at Large of the Council, 1986–1989.

AMS Committees: Program Committee for National Meetings, 1995–1998; Committee on Publications, 2001; Committee on Committees, 2003–2005; Satter Prize Committee, 2004–2006; Western Section Program Committee, 2009–2012.

Selected Addresses: AMS Invited Address, Mathfest, Eugene, Oregon, 1984; AMS Invited Address, Joint Mathematics Meetings, San Antonio, TX, 1999; AWM-MAA Invited Address, Mathfest, Providence, RI, 1999; Invited Address, International Congress of Mathematicians, Madrid, 2006; AMS-MAA Invited Address, Joint Mathematics Meetings, New Orleans, LA, 2011.

Additional Information: Sloan Fellowship, 1982–1984; NSF Advisory Panel for Mathematics, 1986–1989; Humboldt Research Award, 1995; Co-organizer, Mentoring Program for Women Mathematicians, IAS, 1994–2011; AWM President, 1995–1997; Steering Committee, IAS Summer Institute, 1998–2001; Scientific Advisory Committee, MSRI, 2003–2006.

Selected Publications: 1. Isoparametric submanifolds and their Coxeter groups, J. Differential Geom., **21** (1985), 79–107. MR**0806704 (87e:53095)**; 2. with R. S. Palais, A general theory of canonical forms, Trans. Amer. Math. Soc., **300** (1987), 771–789. MR**0876478 (88f:57069)**; 3. with K. Uhlenbeck, Backlund transformations and loop group actions, Comm. Pure Appl. Math., **53** (2000), 1–75. MR**1715533 (2000k:37116)**; 4. with B. Dai and K. Uhlenbeck, On the space-time monopole equations, Surv. Differ. Geom., **10** (2006), 1–30. MR**2408220 (2009f:53033)**; 5. with X. Liu, The mean curvature flow on isoparametric submanifolds, Duke Math. J., **147** (2009), 157–179. MR**2494459 (2010a:53140)**.

Statement by Candidate: The AMS has had a long and successful history performing its mission of promoting mathematical research, education, and outreach, and it is an honor to be asked to run for the position of AMS Vice President. I hope to be able to serve the Society by working with colleagues to strengthen its core missions, to promote inclusiveness, and to help young mathematicians in these difficult economic times.

Christoph Thiele

Professor of Mathematics, University of California, Los Angeles.

Born: September 10, 1968, Darmstadt, Germany.

Ph.D.: Yale University, 1995.

AMS Offices: Council, 2010–2013.

AMS Committees: Committee on Education, 2010–2013; AMS-Simons Travel Grants Committee, 2011–2012; Associate Editor for Bulletin Articles, 2012–2014.

Selected Addresses: Invited Speaker, ICM, Beijing, 2002; Invited Address, AMS Sectional Meeting, Los Angeles, 2004; Principal Speaker, CBMS Conference, Atlanta, 2004.

Additional Information: Salem Prize, 1996; Chair, UCLA Department of Mathematics, 2006–2009; Humboldt Research Award, 2010; Hausdorff Chair, Bonn University, 2012–present.
Selected Publications: 1. with M. Lacey, Lp estimates for the bilinear Hilbert transform for $2 < p < \infty$, Ann. of Math., **146** (1997), No. 3, 693–724. MR**1491450 (99b:42014)**; 2. A uniform estimate, Ann. of Math., **156** (2002), No. 2, 519–563. MR**1933076 (2003i:47036)**; 3. with T. Tao, Nonlinear Fourier Analysis, Lecture notes, to appear in IAS Park City Mathematics Series, 2003. 4. with C. Muscalu and T. Tao, A Carleson theorem for a Cantor group model of the scattering transform, Nonlinearity, **16** (2003), No. 1, 219–246. MR**1950785 (2004i:34227)**; 5. with C. Demeter, M. Lacey and T. Tao, Breaking the duality in the return times theorem, Duke Math. J., **143** (2008), No. 2, 281–355. MR**2420509 (2009f:42013)**.
Statement by Candidate: The AMS is an outstanding organization that offers superb services to the mathematics community. It affects mathematicians' daily lives and is a public face of the profession. If elected Vice President of the AMS, I would view my service as a chance to give back to this wonderful organization and to help extend its mission in to the future. Building on its strong programs, and wisely following new initiatives, I envision a bright future for the AMS, and a critical role for mathematics as an ever growing and increasingly vital component of modern life.

Trustee

Joel Spencer

Mathematics Professor, Courant Institute, New York University.
Born: April 20, 1946, Brooklyn, New York.
Ph.D.: Harvard University, 1970.
AMS Offices: Council, 1997–2001; Executive Committee, 1998–2001.
AMS Committees: AMS-SIAM Committee on Applied Mathematics, 1990–1992; Liaison Committee with AAAS, 1994–1997; Committee on Meetings and Conferences, 1997–1999 (chair); Committee on Committees, 1999–2001; Young Scholars Committee, 1999–2003 (chair); Agenda and Budget, 2001–2002; Nominating Committee, 2004–2006.
Selected Addresses: NSF-CBMS Lecturer, Durango, 1986; ICM Invited Lecture, Zurich, 1994; Erdös Memorial Lectures, Jerusalem, 2001; Midwest Probability Colloquium, Northwestern, 2009; Vera Sos Birthday Conference, Budapest, 2010.
Additional Information: Putnam Winner, 1962; Sloan Fellow, 1977–1981; Ford Award, 1984; Golden Dozen Teaching Award, 1999; Member of MAA and SIAM.
Selected Publications: 1. with R. Graham and B. Rothschild, Ramsey Theory, John Wiley & Sons, Inc., New York, 1980, 1990. MR**1044995 (90m:05003)**; 2. with S. Shelah, Zero-one laws for sparse random graphs, J. Amer. Math. Soc., **1** (1988), 97–115. MR**0924703 (89i:05249)**; 3. with N. Alon, The Probabilistic Method, John Wiley & Sons, Inc., New York, 1992, 2000, 2008. MR**2437651 (2009j:60004)**; 4. with R. van der Hofstad, Counting connected graphs asymptotically, European J. Combin., 27 (2006), 1294–1320. MR**2260122 (2007f:05085)**; 5. with N. Wormald, Birth control for giants, Combinatorica, **27** (2007), 587–628. MR**2375718 (2008m:05270)**.
Statement by Candidate: I look with great pride at the establishment of the Young Scholars program, aka The Epsilon Fund. This program, using contributions from AMS members, supports Summer Math Camps for talented high school students. I helped set up this program and served as the first chair of the committee selecting the recipients of this support. Beyond the financial support, the AMS is able to bestow its "stamp of approval" on these programs. This experience convinced me of what the AMS, as an organization, could do.

To be sure, the Board of Trustees must exercise its fiduciary responsibilities and be certain that the AMS remains in a good financial position. Money must be spent wisely. But I personally take objection to those here nameless individuals that conflate responsibility and stinginess—the AMS must proactively search for situations in which it can use its position and, yes, its financial resources.

Mathematics is my world and it is your world. As individuals struggling with a Lemma we need only a pad of paper and a quiet place. The AMS plays a central role in the design of a framework in which the community of mathematicians can work and prosper.

Karen Vogtmann

Goldwin Smith Professor of Mathematics, Cornell University.
Born: July 13, 1949, Pittsburg, California.
Ph.D.: University of California, Berkeley, 1977.
AMS Offices: Member at Large of the Council, 1997–2000; Executive Committee, 1999–2003; Vice President, 2003–2006; Trustee, 2008–2013.
AMS Committees: Fellowship Committee, 1989–1990 (chair, 1990); Committee on Meetings and Conferences, 1997–2003 (chair, 2000–2003); Committee on Education, 2003–2006; Science Policy Committee, 2008–2011; Committee on Publications, 2012–present.
Selected Addresses: International Congress of Mathematicians, Madrid, Spain, August, 2006; AWM Noether Lecture, New Orleans, LA, January, 2007; Felix Klein Lectures, Hausdorff Institute for Mathematics, Bonn, Germany, May–June, 2010; Plenary Address, British Mathematical Colloquium, Leicester, England, April, 2011; 2011 European Mathematical Society Lecturer, Barcelona, Oxford, Stockholm.
Selected Publications: 1. with M. Culler, Moduli of graphs and automorphisms of free groups, Invent. Math., **84** (1986), 91–119. MR**0830040 (87f:20048)**; 2. with A. Hatcher, Cerf theory for graphs, J. London Math. Soc., **58** (1998), No. 3, 633–655. MR**1678155 (2000e:20041)**; 3. with L. Billera and S. Holmes, Geometry of the space

of phylogenetic trees, Adv. in Appl. Math., **27** (2001), 733–767. MR**1867931 (2002k:05229)**; 4. with J. Conant, On a theorem of Kontsevich, Algebr. Geom. Topol., 3 (2003), 1167–1224. MR**2026331 (2004m:18006)**; 5. with M. Bridson, Actions of automorphism groups of free groups on spheres and acyclic manifolds, Comment. Math. Helv., **86** (2011), No. 1, 73–90. MR**2745276 (2011j:20104)**.

Statement by Candidate: It has been an honor to serve on the Board of Trustees of the American Mathematical Society for the past five years, and I would be happy to return for a second term.

Over the years I have had a number of different roles in the AMS and have developed a good overall sense of how the Society functions. It is not a static organization, but continually evolves to better support mathematics and mathematicians. Since I started with the AMS it has introduced and developed many programs, including MathJobs, the Young Scholars program, and the Public Awareness office, has made continual improvements to MathSciNet, and has found new ways to honor the achievements of mathematicians and help mathematics gain recognition in the wider community. In addition to developing new programs, the AMS continues to support its already successful activities, such as its program of meetings and conferences and its extensive publishing program, while at the same time looking for new ways to improve these programs. If re-elected to the Board of Trustees, I will work to ensure that the AMS remains financially healthy so that it can continue these successful programs, respond to new needs of the mathematics community as they arise, and seek to broaden the participation of all groups in this community.

Member at Large

Jesús A. De Loera

Professor of Mathematics and the graduate groups of Applied Mathematics and Computer Science, University of California, Davis.

Born: January 18, 1966, Mexico City, Mexico.

Ph.D.: Cornell University, 1995.

Selected Addresses: Plenary Speaker, MAA Mathfest, Knoxville, Tennessee, 2006; Plenary Speaker, Fourth International Symposium of Combinatorial Computing (4ICC), University of Auckland, New Zealand, December 2008; Plenary Speaker, Second Canadian Discrete and Algorithmic Mathematics Conference (CanaDAM), Montreal, May 2009; Plenary Invited Topical Speaker, SIAM annual meeting, Pittsburgh, July 12– 16, 2010; Keynote Lecturer, Rocky Mountain Mathematics Consortium Summer School, Laramie, Wyoming, June 20–July 1, 2011.

Additional Information: UC Davis, Chancellor's Fellow Award, 2003–2008; Alexander Von Humboldt Fellowship, 2004; Award for Excellence in Service to Graduate Students, UC Davis Graduate Student Association, 2007; INFORMS Computing Society Prize, 2010. Editorial boards: SIAM Journal of Discrete Mathematics and Discrete Optimization; program committees of various conferences and workshops. Member: AMS, SIAM, MAA, INFORMS, and the Mathematical Optimization Society.

Selected Publications: 1. with A. Below and J. Richter-Gebert, The complexity of finding small triangulations of convex 3-polytopes, J. Algorithms, **50** (2004), No. 2, 134–167. MR**2049790 (2005d:68061)**; 2. with R. Hemmecke, M. Köppe, and R. Weismantel, Integer polynomial optimization in fixed dimension, Math. Oper. Res. 31 (2006), No. 1, 147–153. MR**2205524 (2006i:90036)**; 3. with J. Lee, S. Margulies, and S. Onn, Expressing combinatorial optimization problems by systems of polynomial equations and Hilbert's Nullstellensatz, Combin. Probab. Comput. **18** (2009), No. 4, 551–582. MR**2507737 (2010g:05374)**; 4. with F. Santos and J. Rambau, Triangulations: Structure for Algorithms and Applications, Algorithms and Computation in Mathematics, vol. 25, Springer-Verlag, Berlin, 2010. MR**2743368 (2011j:52037)**; 5. with V. Baldoni, N. Berline, M. Köppe, and M. Vergne, How to integrate a polynomial over a simplex, Math. Comp., **80** (2011), No. 273, 297–325. MR**2728981 (2011m:68294)**.

Statement by Candidate: I believe AMS members should be concerned about the following issues:

Improving the image of Mathematics: Recent attempts to close the Math department at the University of Nevada, Reno, akin to those at the University of Rochester several years ago, remind us of our low standing in the eyes of policy makers and the public. How do we convince others that Mathematics truly matters?

Supporting the infrastructure for Mathematics: The AMS must play new and improved roles in the use of technology for education and research (e.g., Webwork, MIT.x, mathoverflow, polymath collaborations, etc.), in the affordable distribution of Mathematics (over the internet and other media, e.g., video-clips), in fostering international and interdisciplinary collaboration, and in the support of Mathematics in developing countries.

Recruitment, Education, and Employment: It is alarming that so few students learn Mathematics beyond calculus. In particular, the failure to attract underrepresented groups threatens the sustainability of a high-tech economy. I believe low recruitment is related to continuing problems in Mathematics education and the weak job market for mathematicians. Is it enough to train mathematicians or should we be more pro-active in creating new job options and networks for our graduates?

Member at Large

Paul Goerss

Professor of Mathematics, Northwestern University.

Born: August 28, 1957, Cleveland, Ohio.

Ph.D.: Massachusetts Institute of Technology, 1983.

AMS Committees: Chair, Simons Travel Grant Committee, 2011–2013.

Selected Addresses: Qualitative phenomena in stable homotopy theory, Lecture Series, Strasbourg,

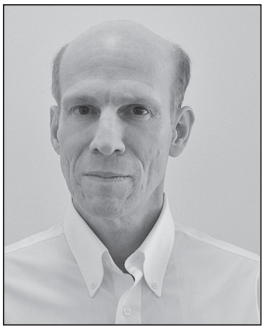
2007; The moduli stack of formal groups, Lecture Series, Fields Institute, 2007; Topological Algebraic Geometry, Lecture Series, Copenhagen, 2008; Topological Modular Forms, Seminar Bourbaki, Paris, 2009; Spheres, formal groups and derived algebraic geometry, Colloquium, University of Bonn, 2010.

Additional Information: Chair, Department of Mathematics, Northwestern University, 2003–2006; Director of Graduate Studies, Department of Mathematics, Northwestern University, 2010–2013.

Selected Publications: 1. On the André-Quillen cohomology of commutative $\mathbf{F}_2$-algebras, Astérisque, **186** (1990). MR**1089001 (92b:18012)**; 2. with J. Lannes and F. Morel, Vecteurs de Witt noncommutatifs et représentabilité de l'homologie modulo p, Invent. Math., **108** (1992), 163–227. MR**1156389 (93e:55014)**; 3. with M. Hopkins, Moduli spaces of commutative ring spectra, Structured Ring Spectra, London Math. Soc. Lecture Note Ser., 315 (2004), pp. 151–200, Cambridge Univ. Press, Cambridge. MR**2125040 (2006b:55010)**; 4. with H.-W. Henn, M. Mahowald and C. Rezk, A resolution of the K(2)-local sphere at the prime 3, Ann. of Math., **162** (2005), No. 2, 777–822. MR**2183282 (2006j:55016)**; 5. Topological modular forms [after Hopkins, Miller, and Lurie], Astérisque, **332** (2010), 221–256. MR**2648680 (2011m:55003)**.

Statement by Candidate: Over a thirty year career, I've been a research mathematician and teacher at Wellesley College, the University of Washington, and Northwestern University. I've been Director of Undergraduate Studies at Washington, and the Chair of the Department and Director of Graduate Studies at Northwestern. I've been on many grant and infrastructure committees, on thesis committees in the US, France, and Germany, and on the editorial boards of journals. All of this has given me an overview of mathematics as an exciting and broad intellectual project. Vital new research feeds and drives the profession, and how we tell the story through writing and instruction keep it healthy and growing. The purpose of the AMS is to foster the entire project—research and instruction together —and I would welcome the chance to help out by serving on the Council.

Allan Greenleaf



Professor of Mathematics and Chairman, University of Rochester.

Born: 1959, Portsmouth, New Hampshire.

Ph.D.: Princeton University, 1981.

Selected Addresses: Chelluri Lecture, Cornell University, 2008; Mini-course, US-German Summer School, Penn State, 2010; Knowledge Transfer Lecture, ICMS, Edinburgh, 2011.

Additional Information: NSF Postdoctoral Fellowship, 1981–1983; Sloan Fellowship, 1990–1992; Member, MSRI, Fall 1987 and 2010; Co-organizer, MRC on Inverse Problems, Snowbird, 2009.

Selected Publications: 1. Nonlocal inversion formulas for the X-ray transform, with G. Uhlmann, Duke Math. J., **58** (1989), 205–240. MR**1016420 (91b:58251)**; 2. Fourier integral operators with fold singularities, with A. Seeger, J. Reine Angew. Math., **455** (1994), 35–56. MR**1293873 (95h:58130)**; 3. On nonuniqueness for Calderón's inverse problem, with M. Lassas and G. Uhlmann, Math. Res. Lett., **10** (2003), 685–693. MR**2024725 (2005f:35316)**; 4. Invisibility and inverse problems, with Y. Kurylev, M. Lassas and G. Uhlmann, Bull. Amer. Math. Soc., **46** (2009), 55–97. MR**2457072 (2010d:35399)**; 5. Fourier integral operators with open umbrellas and seismic inversion for cusp caustics, with R. Felea, Math. Res. Lett., **17** (2010), 867–886. MR**2727615 (2012e:58044)**.

Statement by Candidate: The mathematics profession is currently being buffeted from many directions. Fiscal retrenchment at the federal level makes it likely that overall research funding will be decreasing in the near future. What funds that are available will be heavily drawn upon to support previous commitments for infrastructure, including institutes. Unless new funding models are introduced, this will put traditional PI funding out of reach for many worthy mathematicians. At the local level, university budget cutbacks have put incredible stress on math departments and prompted administrators to look at alternative methods of providing mathematics instruction. As a result, the job market for new Ph.D.s is very difficult and, at the tenure-track level, the worst in living memory. The AMS needs to represent the interests of all of its members, in both junior and senior ranks and at all kinds of institutions. The current environment, combining economic austerity with political hostility to science, means that the AMS must forcefully advocate to the society at large for the support of mathematical research and education, while fighting at the funding agency, university and college level to preserve and improve working conditions of all of its members.

Brendan Hassett

Professor and Chair of the Department of Mathematics, Rice University.

Born: April 1, 1971, Chicago, IL.

Ph.D.: Harvard University, 1996.

AMS Committees: Central Section Program Committee, 2010–2012.

Selected Addresses: Lectures at the summer school Aspects arithmétiques des courbes rationnelles, Institut Fourier, University of Grenoble, 2010; Complex Algebraic Geometry conference, Centre Emile Borel-Institut Henri Poincaré, Paris, 2010; Ramification in Algebra and Geometry, Emory University, Atlanta, Georgia, 2011; AGNES (Algebraic Geometry, Northeastern Series) meeting, Amherst, Massachusetts, 2012; Invited Address, AMS Western Sectional meeting, Boulder, Colorado, 2013.

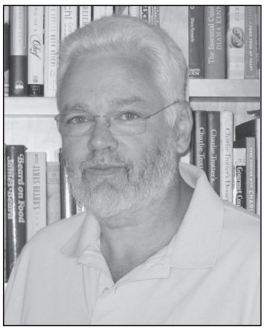
Additional Information: NSF CAREER Grant, 2002–2008; Alfred P. Sloan Research Fellow, 2003–2006; Founding organizer, Texas Algebraic Geometry Seminar, 2003-present; Professeur Invité, Université Paris-Sud, Orsay, 2005; Organizer, Clay Mathematics Institute Summer School

on Arithmetic Geometry, University of Göttingen, 2006; Co-chair, MSRI semester program in Algebraic Geometry, 2009; Charles W. Duncan Jr. Achievement Award for Outstanding Faculty, Rice University, 2009; Chair, Rice Department of Mathematics, 2009–present. Editorial boards: Experimental Mathematics, 2008–present, Journal of Algebraic Geometry, 2012–present.

Selected Publications: 1. Special cubic fourfolds, Compositio Math., **120** (2000), No. 1, 1–23. MR**1738215 (2001g:14066)**; 2. with D. Edidin, A. Kresch and A. Vistoli, Brauer groups and quotient stacks, Amer. J. Math., **123** (2001), No. 4, 761–777. MR**1844577 (2002f:14002)**; 3. Moduli spaces of weighted pointed stable curves, Adv. Math., **173** (2003), No. 2, 316–352. MR**1957831 (2004b:14040)**; 4. with Y. Tschinkel, Weak approximation over function fields, Invent. Math., **163** (2006), No. 1, 171–190. MR**2208420 (2007b:14109)**; 5. Introduction to Algebraic Geometry, Cambridge University Press, Cambridge, 2007. MR**2324354 (2008d:14001)**.

Statement by Candidate: It is rare for me to pass a day without using MathSciNet, reading an AMS journal or consulting the AMS website for information about our profession. Given the impact of the AMS on my academic life, I would be honored to participate in its Council as a Member at Large.

David Marker



LAS Distinguished Professor, Department of Mathematics, Statistics, and Computer Science, University of Illinois at Chicago.

Born: January 29, 1958, Schenectady, NY.

Ph.D.: Yale University, 1983.

AMS Committees: Committee on Publications, 2012–present.

Selected Addresses: Invited Address, AMS Regional Meeting, Stillwater, Oklahoma, 1994; Invited Address, Annual Meeting, Mathematical Society of Japan, Nagoya, 1998; Invited Address, European Summer Meeting, Association of Symbolic Logic, Paris, 2000; Invited Address, Canadian Math. Society, Summer Meeting, Calgary, June, 2006; Invited Address, Annual Meeting, Association for Symbolic Logic, UC Irvine, March, 2008.

Additional Information: NSF Postdoctoral Research Fellowship, 1983–1985; AMS Centennial Research Fellowship, 1994–1996; UIC Award for Excellence in Teaching, 2004; Association for Symbolic Logic Shoenfield Prize, 2008; UIC Graduate Mentoring Award, 2010; Department Head UIC, 2007–2011. Editorial Boards: Journal of Symbolic Logic, 1994–2000; Notre Dame Journal of Formal Logic, 1996–present; Annals of Pure and Applied Logic, 1998–2009; Archive for Mathematical Logic, 2004–2009; Association for Symbolic Logic Lecture Notes in Logic, Managing Editor, 2005–2008.

Selected Publications: 1. Semialgebraic expansions of **C**, Trans. Amer. Math. Soc., **320** (1990), No. 2, 581–592. MR**0964900 (90k:03034)**; 2. with L. van den Dries and A. Macintyre, The elementary theory of restricted analytic fields with exponentiation, Ann. of Math. (2), **140** (1994), No. 1, 183–205. MR**1289495 (95k:12015)**; 3. with L. van den Dries and A. Macintyre, Logarithmic-exponential power series, J. London Math. Soc. (2), 56 (1997), No. 3, 417–434. MR**1610431 (99d:03063)**; 4. with D. Macpherson and C. Steinhorn, Weakly o-minimal structures and real closed fields, Trans. Amer. Math. Soc., **352** (2000), No. 12, 5435–5483. MR**1781273 (2001i:03079)**; 5. Model Theory. An Introduction, Graduate Texts in Mathematics, volume 217, Springer-Verlag, New York (2002). MR**1924282 (2003e:03060)**.

Statement by Candidate: As a member of the AMS Council I would work to improve training and opportunities for graduate students and early career mathematicians, keeping in mind the current employment climate. I also feel that it is vital to communicate better with the public and the government the importance and centrality of mathematics. As a former department head, I also understand the importance of spreading our message throughout the higher education community. It would be a great honor to serve the association as a Council member.

Nataša Pavlović

Associate Professor of Mathematics, University of Texas at Austin.

Born: April 2, 1974, Sarajevo, Bosnia and Herzegovina.

Ph.D.: University of Illinois, Chicago, 2002.

AMS Committees: Committee on Committees, 2011–2013.

Selected Addresses: Invited Speaker, 8th Rivière-Fabes Symposium on Analysis and PDE, University of Minnesota, April, 2005; Invited Speaker, AWM and MSRI workshop, Women in Mathematics: The Legacy of Ladyzhenskaya and Oleinik, MSRI, Berkeley, CA, May 18–20, 2006; Invited Hour Address, AMS Sectional Meeting, Hoboken, NJ, April 15–16, 2007; Invited Speaker, RIMS Workshop, Well-posedness and Scattering for Nonlinear Dispersive and Wave Equations, Hokkaido University, Japan, November 23–25, 2009; Invited Speaker, RIMS Workshop, Nonlinear Dispersive Equations, Kyoto University, Japan, November 27, 2009.

Additional Information: Clay Mathematics Institute Summer Fellowship, Special Research Project, summer 2002; Member, Institute for Advanced Study, 2003–2004; Co-director, Graduate Studies, Department of Mathematics, Princeton University, 2005–2007; Alfred P. Sloan Research Fellowship, 2008–2010; John R. Durbin Teaching Excellence in Mathematics Award, Department of Mathematics, University of Texas at Austin, 2009; College of Natural Sciences Teaching Excellence Award, University of Texas at Austin, 2010.

Selected Publications: 1. with N. H. Katz, A cheap Caffarelli-Kohn-Nirenberg inequality for the Navier-Stokes equation with hyper-dissipation, Geom. Funct. Anal., 12 (2002), No. 2, 355–379. MR**1911664 (2003e:35243)**; 2. with S. Friedlander, Blowup in a three dimensional vector model for the Euler equations, Comm. Pure Appl. Math.,

57 (2004), No. 6, 705–725. MR**2038114 (2005c:35241)**; 3. with D. De Silva, G. Staffilani and N. Tzirakis, Global well-posedness for a periodic nonlinear Schrödinger equation in 1D and 2D, Discrete Contin. Dyn. Syst., **19** (2007), No. 1, 37–65. MR**2318273 (2008g:35191)**; 4. with J. Bourgain, Ill-posedness of the Navier-Stokes equations in a critical space in 3D, J. Funct. Anal., **255** (2008), No. 9, 2233–2247. MR**2473255 (2010g:35222)**; 5. with T. Chen and N. Tzirakis, Energy conservation and blowup of solutions for focusing Gross-Pitaevskii hierarchies, Ann. Inst. H. Poincaré Anal. Non linéaire, **27** (2010), No. 5, 1271–1290. MR**2683760 (2011i:82034)**.

Statement by Candidate: If elected, I will be delighted to serve as a Member at Large of the AMS Council. I will try to bring to the attention of the Council concerns of our colleagues at various stages of their careers, including e.g. promotion of early-career mathematicians, retention of members of less represented groups in our profession and addressing issues related to funding of mathematical research. I will listen to fellow mathematicians and will work hard with the Council to represent interests of the mathematical community.

Amber L. Puha

Professor of Mathematics, California State University, San Marcos.

Ph.D.: University of California, Los Angeles, 1998.

AMS Committees: IMS Representative, Joint Committee on Women in the Mathematical Sciences, 2011–present.

Selected Addresses: 10th Anniversary Program for Women in Mathematics Reunion Celebration, Institute for Advanced Study, Princeton, 2003; Southern California Probability Symposium, UCI, 2007; Workshop in Honor of Thomas M. Liggett's 65th Birthday, Peking University, Beijing, 2009; Recent Trends in Probability and Related Fields Session, AMS Sectional Meeting, UCLA, 2010.

Additional Information: University of California Office of the President Postdoctoral Fellowship, UCSD, 1998–1999; National Science Foundation Mathematical Sciences Postdoctoral Fellow, UCSD, 2000–2001, spring 2002; Associate Director, Institute for Pure and Applied Mathematics (IPAM), UCLA, 2009–2011. Awards: National Project NExT (New Experiences in Teaching) Fellow, 2001; National Science Foundation Research at Undergraduate Institutions Grant, 2005; National Security Agency Young Investigators Grant, 2005–2007; The Applied Probability Society of INFORMS Best Publication Award, 2007; Greater San Diego Area Mathematics Council Outstanding Post Secondary Mathematics Teacher, 2009. Member: Institute of Mathematical Statistics, 1997–2012, Bernoulli Society for Mathematical Statistics and Probability, 2001–2012, Applied Probability Society of INFORMS, 2005–2012, INFORMS, Institute for Operations Research and the Management Science, 2008–2012.

Publications: 1. with H. C. Gromoll and R. Williams, The fluid limit of a heavily loaded processor sharing queue, Ann. Appl. Probab., **12** (2003), 797–859. MR**1925442 (2003h:60135)**; 2. with R. Williams, Invariant states and rates of convergence for a critical fluid model of a processor sharing queue, Ann. Appl. Probab., **14** (2004), 517–554. MR**2052894 (2004m:60211)**; 3. with A. Stolyar and R. Williams, The fluid limit of an overloaded processor sharing queue, Math. Oper. Res., **31** (2006), 316–350. MR**2234000 (2007d:60057)**; 4. with D. Down and H. C. Gromoll, Fluid limits for shortest remaining processing time queues, Math. Oper. Res., **34** (2009), 880–911. MR**2573501 (2010m:60316)**; 5. with H. C. Gromoll and L. Kruk, The diffusion limit of an SRPT queue, Stochastic Systems, **1** (2011), 1–16.

Statement by Candidate: I am honored to be nominated for election as a Member at Large on the AMS Council. It would be my pleasure to serve in this capacity. I do not bring a specific agenda to this position. However, I am aware of the need to provide opportunities for young researchers to advance their careers, to promote diversity within the mathematical sciences, to broadly advocate for the importance of mathematics, to support mathematics research and education at all levels, and to continue to advance the profession. The AMS has been a leader on these issues, and I welcome the opportunity to contribute.

Kenneth A. Ribet

Professor of Mathematics, University of California, Berkeley.

Born: June 28, 1948, New York, N.Y.

Ph.D.: Harvard University, 1973.

AMS Committees: Committee on Progress in Mathematics, 1994–1997 (chair, 1996–1997); Committee to Select the Winner of the Cole Prize, 2007–2008 (chair); Committee to Select the Winner of the E.H. Moore Research Article Prize, 2009–2015 (chair, 2012–2013).

Selected Addresses: Congruence relations between modular forms, International Congress of Mathematicians, Warsaw, 1983; Update on Fermat's Last Theorem, AMS-MAA Invited Address, Joint Mathematics Meetings, 1994; Galois representations and modular forms, AMS Progress in Mathematics Lecture, Minneapolis, MN, August, 1994; Modular curves and their twisted analogues, AMS Invited Address, regional meeting, Portland, OR, June, 2002; Non-optimal levels of reducible two-dimensional mod l representations of the Galois group of Q, Special Session on Arithmetic Geometry, Joint Mathematics Meetings, 2010.

Additional Information: Fermat Prize, 1989; Election to American Academy of Arts and Sciences, 1997; Ph.D. honoris causa, Brown University, 1998; Election to US National Academy of Sciences, 2000. Editorial boards: Graduate Texts in Mathematics, Undergraduate Texts in Mathematics, Universitext, Springer Monographs in Mathematics, Proceedings of the National Academy of Sciences,

Journal of Number Theory, Mathematics Research Letters, International Journal of Number Theory.
Selected Publications: 1. A modular construction of unramified p-extensions of $Q(\mu_p)$, Invent. Math., **34**, no. 3 (1976), 151–162. MR**0419403 (54#7424)**; 2. On modular representations of $\mathrm{Gal}(\overline{Q}/Q)$ arising from modular forms, Invent. Math., 100, No. 2 (1990), 431–476. MR**1047143 (91g:11066)**; 3. Report on mod l representations of $\mathrm{Gal}(\overline{Q}/Q)$, Motives (Seattle, WA, 1991), Proc. Sympos. Pure Math., **55**, Part 2, Amer. Math. Soc., Providence, RI, 1994, 639–676. MR**1265566 (95d:11056)**; 4. Galois representations and modular forms, Bull. Amer. Math. Soc., **32** (1995), No. 4, 375–402. MR**1322785 (96b:11073)**; 5. with A. Agashe and W. Stein, The modular degree, congruence primes and multiplicity one, (2005).
Statement by Candidate: I usually shy away from applying the word "senior" to myself, but it seems like a relevant word in this context. Over the years, I've learned quite a bit about mathematics and the mathematics community. I've served on the editorial boards of book series and journals; I'm a former member of the US National Committee for Mathematics; I'm a vice chair of my department; I just completed a three-year term as chair of the mathematics section of the US National Academy of Sciences. I hope that whatever information and perspective I've acquired will enable me to give useful advice to the AMS. It would be an honor for me to serve on the Council.

Benjamin Sudakov

Professor of Mathematics, University of California at Los Angeles.
Born: October 1969, Tbilisi, Georgia.
Ph.D.: Tel Aviv University, Israel, 1999.
AMS Committees: Editor of Mathematical Surveys and Monographs series, 2008–2012; University Lecture Series, 2010–2012.
Selected Addresses: Plenary Speaker, AMS Eastern Section Meeting, Annandale-on-Hudson, NY, 2005; Invited Speaker, International Congress of Mathematicians, Hyderabad, India, 2010.
Additional information: Sloan Fellowship, 2004–2006; NSF CAREER Award, 2006–2011. Editorial boards: SIAM Journal on Discrete Mathematics, 2003–present, Journal of Graph Theory, 2004–present, Combinatorica, 2010–present, Journal of Combinatorics, 2010–present, Moscow Journal of Combinatorics and Number Theory, 2010–present, Advances in Mathematics, 2011–present.
Selected publications: 1. with E. Szemeredi and V. Vu, On a question of Erdös and Moser, Duke Math. J., **129** (2005), 129–155. MR**2155059 (2006c:11118)**; 2. with N. Alon and A. Shapira, Additive approximation for edge-deletion problems, Ann. of Math., **170** (2009), 371–411. MR**2521119 (2010h:05284)**; 3. with D. Conlon and J. Fox, An approximate version of Sidorenko's conjecture, Geom. Funct. Anal., **20** (2010), 1354–1366. MR**2738996**; 4. with D. Conlon and J. Fox, Hypergraph Ramsey numbers, J. Amer. Math. Soc., **23** (2010), 247–266. MR**2552253 (2010m:05192)**; 5. A conjecture of Erdös on graph Ramsey numbers, Adv. Math., **227** (2011), 601–609. MR**2782204 (2012b:05176)**.
Statement by Candidate: The AMS plays a key role inpromoting mathematical research, supporting mathematical education and outreach. It would be an honor to contribute to the mission of AMS as a Member at Large of the Council.

Yuri Tschinkel

Professor of Mathematics, Courant Institute, New York University.
Born: May 31, 1964, Moscow, Russia.
Ph.D.: Massachusetts Institute of Technology, 1992.
AMS Committees: Editorial Committee, Bulletin of the AMS, 2006–present; Committee on Committees, 2007–2008.
Selected Addresses: Wolfe Lecture, Rice University, 2005; Kempf Memorial Lectures, Johns Hopkins University, 2005; International Congress of Mathematicians, Madrid, 2006.
Additional Information: Junior Fellow, Harvard Society of Fellows, 1992–1995; Leibniz Fellow of the EC, 1995–1996; Clay Institute Fellow, 2001–2002; Chair, Department of Mathematics, Courant Institute, 2007–2011; Editor-in-Chief, Experimental Mathematics, 2007–present; Scientific Council of the Foundation Sciences Mathématiques de Paris, 2010–present; Editor, Progress in Mathematics, Birkhäuser, 2011–present.
Selected Publications: 1. with J. Franke and Y. Manin, Rational points of bounded height on Fano varieties, Invent. Math., **95** (1989), 421–435. MR**0974910 (89m:11060)**; 2. with B. Hassett, Weak approximation over function fields, Invent. Math., **163** (2006), 171–190. MR**2208420 (2007b:14109)**; 3. with B. Hassett, Log Fano varieties over function fields of curves, Invent. Math., **171** (2008), 7–21. MR**2403393 (2009c:14080)**; 4. with F. Bogomolov, Reconstruction of function fields, Geom. Funct. Anal., **18** (2008), 400–462. MR**2421544 (2009g:11155)**; 5. with B. Hassett, Moving and ample cones of holomorphic symplectic fourfolds, Geom. Funct. Anal., **19** (2009), 1065–1080. MR**2570315 (2011c:14119)**.
Statement by Candidate: It is an honor and privilege to serve the AMS. I will be happy to contribute to its mission by promoting scientific and educational excellence, fairness, diversity, outreach and public awareness.

Nominating Committee

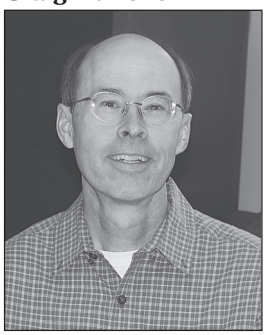
Jeffrey F. Brock
Professor of Mathematics, Brown University; Deputy Director, ICERM.
Born: June 14, 1970, Bronxville, NY.
Ph.D.: University of California, Berkeley.
Selected Addresses: AMS Invited Address, Pittsburgh, PA, 2004; William Thurston's 60th Birthday Conference, Princeton, NJ, 2007; Geometry and Analysis of

Riemann Surfaces and Their Moduli, Scott Wolpert's birthday conference, University of Maryland, College Park, MD, 2010; The 7th William Rowan Hamilton Geometry and Topology Workshop, Dublin, Ireland, 2011; One-hour Invited Speaker, Current Events Bulletin, Joint Mathematics Meetings, Boston, MA, 2012. Additional Information: Alfred P. Sloan Doctoral Dissertation Fellow, U.C. Berkeley, 1996–1997; NSF Postdoctoral Fellow, Stanford University, 1997–2000; Organizer, Kleinian Groups and Teichmüller Theory, MSRI program, 2007; Organizer, Geometry and Dynamics in Surfaces and 3-Manifolds, FRG conference, 2007; John Simon Guggenheim Fellow, 2008.
Selected Publications: 1. Iteration of mapping classes and limits of hyperbolic 3-manifolds, Invent. Math., **143** (2001), No. 3, 523–570. MR**1817644 (2002d:30052)**; 2. The Weil-Petersson metric and volumes of 3-dimensional hyperbolic convex cores, J. Amer. Math. Soc., **16** (2003), No. 3, 495–535. MR**1969203 (2004c:32027)**; 3. with K. Bromberg, On the density of geometrically finite Kleinian groups, Acta Math., **192** (2004), No. 1, 33–93. MR2**079598 (2005e:57046)**; 4. with K. Bromberg, Geometric inflexibility and 3-manifolds that fiber over the circle, J. Topol., **4** (2011), No. 1, 1–38. MR**2783376**; 5. with R. Canary and Y. Minsky, The classification of Kleinian surface groups, II: The Ending Lamination Conjecture, Ann. Math., to appear.
Statement by Candidate: It would be an honor and a privilege for me to serve on the Nominating Committee for the American Mathematical Society. If elected, I will take a broad view of the role of mathematics in society and make every effort to apply this view to nominations for critical elected positions at the AMS. I look forward to the opportunity to play a role in the future emphasis and focus of its efforts in promoting the importance of mathematics nationally and internationally.

John B. Etnyre

Professor of Mathematics, Georgia Institute of Technology.
Born: April 10, 1968, Calgary, Alberta, Canada.
Ph.D.: University of Texas, 1996.
AMS Committees: Southeastern Section Program Committee, 2009–2011 (chair, 2010–2011).
Selected Addresses: Georgia International Topology Conference, University of Georgia, Athens, 2001; Invited Address, AMS Regional Meeting, Courant Institute, New York, 2003; Cornell Topology Festival, Cornell University, Ithaca, 2004; Lecture Series, Park City Math Institute, Park City, 2006; Lecture Series, Seville University, Seville, 2011.
Additional Information: Co-organizer, half-year program in Low Dimensional Contact Geometry, Stanford University and the American Mathematical Institute, 2000; Co-managing editor, Algebraic and Geometric Topology, 2007–present; Co-organizer, MSRI Summer Graduate Workshop, Mathematical Sciences Research Institute, Berkeley, CA, 2009; Co-organizer, MSRI year-long program in Contact and Symplectic Geometry and Topology, Mathematical Sciences Research Institute, Berkeley, CA, 2009–2010; National Science Foundation's Committee of Visitors for the DMS, 2010; Graduate Coordinator at the Georgia Institute of Technology, Summer 2012–present.
Selected Publications: 1. with K. Honda, On the nonexistence of tight contact structures, Ann. of Math., **153** (2001), No. 3, 749–766. MR**1836287 (2002d:53119)**; 2. with K. Honda, Tight contact structures with no symplectic fillings, Invent. Math., **148** (2002), No. 3, 609–626. MR**1908061 (2003c:57025)**; 3. with K. Honda, Cabling and transverse simplicity, Ann. of Math., **162** (2005), 1305–1333. MR**2179731 (2006j:57051)**; 4. with T. Ekholm and J. Sabloff, A duality exact sequence for Legendrian contact homology, Duke Math. J., **150** (2009), 1–75. MR**2560107 (2011b:53214)**; 5. with R. Komendarczyk and P. Massot, Tightness in contact metric 3-manifolds, Invent. Math., to appear.
Statement by Candidate: It is an honor to be nominated for this committee. If elected I will do my best to help strengthen the AMS by bringing a large, diverse slate of candidates to the AMS members for their consideration.

Craig Huneke



Professor of Mathematics, University of Virginia.
Ph.D.: Yale University, 1978.
AMS Committees: AMS/NSA Grant Committee, 1992–1994, 1996–1998; AMS Committee on Meetings and Conferences, 2002–2005; AMS Committee to Select the Winner of the Steele Prize, 2003–2006; Committee to Select the Winner of the Cole Prize, 2005–2006; Council of the AMS, 2006–2009; AMS Committee on the Profession, 2006–2009 (chair, 2008–2009); Executive Committee of the AMS, 2008–2012; AMS Secretary Search Committee, 2011.
Selected Addresses: Invited Hour Talk, AMS regional meeting, Knoxville, 1988; Invited Address, International Congress of Mathematics, Kyoto, Japan, 1990; Principal Speaker, NSF-CBMS Conference on Tight Closure, North Dakota St. Univ., 1995; Mid-Atlantic Algebra Speaker, 2000; GATA Lectureship, University of Sheffield, 2007.

Selected Publications: 1. with B. Ulrich, The structure of linkage, Ann. of Math., (2) **126** (1987), No. 2, 277–334. MR**0908149 (88k:13020)**; 2. with M. Hochster, Tight closure, invariant theory, and the Briancon-Skoda theorem, J. Amer. Math. Soc. 3 (1990), No. 1, 31–116. MR**1017784 (91g:13010)**; 3. Uniform bounds in Noetherian rings, Invent. Math., **107** (1992), No. 1, 203–223. MR**1135470 (93b:13027)**; 4. with M. Hochster, Comparison of symbolic and ordinary powers of ideals, Invent. Math., **147** (2002), No. 2, 349–369. MR**1881923 (2002m:13002)**; 5. with I. Swanson, Integral Closure of Ideals, Rings, and Modules, London Mathematical Society Lecture Note

Series, 336, Cambridge University Press, Cambridge, 2006. MR**2266432 (2008m:13013)**.

Statement: I am honored to be considered for election to the Nominating Committee. This committee has the important function of finding good people to stand for election to several of the offices and committees vital to the mission of the AMS. I believe I can contribute to this purpose.

Ken Ono

Asa Griggs Candler Professor of Mathematics and Computer Science, Emory University.

Born: March 20, 1968, Philadelphia, Pennsylvania.

Ph.D.: UCLA, 1993.

AMS Offices: Member at Large of the Council, 2006–2009.

AMS Committees: Editorial Board, Proceedings of the American Mathematical Society, 2005–present; Associate Editor of Book Reviews, Bulletin of the American Mathematical Society, 2005–present; Committee on Publications, 2006–2009 (chair, 2008); Managing Editor, Proceedings of the American Mathematical Society, 2010–present; AMS Working Group on Graduate Education, 2011–present.

Selected Addresses: AMS Invited Address, Lawrence, Kansas, 2001; NSF-CBMS Lectures, Urbana-Champaign, Illinois, 2003; Harvard-MIT Current Developments in Mathematics, 2008; AMS Invited Address, Joint Mathematics Meetings, Washington, DC, 2009; AMS Memorial Erdös Address, Tucson, Arizona, 2012.

Additional Information: Organized NSF REU annually since 2003; Member: Institute for Mathematics and Education Advisory Board, 2006–present, Banff International Research Station Advisory Board, 2009–present, US National Committee for Mathematics, US National Academy of Science, 2010–present. Facilitator/Sponsor of the AMS Who Wants to be a Mathematician outreach program.

Selected Publications: 1. with C. Skinner, Fourier coefficients of half-integral weight modular forms modulo l, Ann. of Math., **147** (1998), 453–470. MR**1626761 (99f:11059a)**; 2. with W. Kohnen, Indivisibility of class numbers of imaginary quadratic fields and orders of Tate-Shafarevich groups of elliptic curves with complex multiplication, Invent. Math., **135** (1999), 387–398. MR**1666783 (2000c:11087)**; 3. Distribution of the partition function modulo m, Ann. of Math., **151** (2000), 293–307. MR**1745012 (2000k:11115**); 4. with K. Bringmann, Dyson's ranks and Maass forms, Ann. of Math., **171** (2010), 419–449. MR**2630043 (2011e:11165)**; 5. with J. H. Bruinier, Heegner divisors, *L*-functions and harmonic weak Maass forms, Ann. of Math., **172** (2010), 2135–2181. MR**2726107 (2012c:11101)**.

Statement by Candidate: After nearly twenty years as a professional mathematician, I can genuinely say that I still love mathematics. Actually, I love mathematics much more than I did as a student (certainly one who was worried about passing qualifying exams). I enjoy the research, the training, and the fact that mathematicians continue to prove mindblowing theorems. I have had a wonderful time serving the AMS and the wider mathematical community through my various roles as an educator, mentor, policy maker, and spokesperson. I am delighted that President Friedlander has nominated me as a candidate for election to the AMS Nominating Committee. This committee is charged with the important task of selecting members to serve the Society in its various professional missions. I think that I possess the skills (experience, enthusiasm, and sound judgement) that this position requires. It would be a great honor to serve the AMS in this capacity.

Amie Wilkinson

Professor of Mathematics, University of Chicago.

Born: April 4, 1968, Boston, MA.

Ph.D.: University of California, Berkeley, 1995.

AMS Committees: Transactions of the AMS, 2006–2007; Program Committee for National Meetings, 2011–2014.

Selected Addresses: AMS Invited Address, Western Sectional Meeting, Salt Lake City, UT, 2002; Invited Address, SIAM Conference on Applications of Dynamical Systems, Snowbird, UT, 2005; AMS Invited Address, AMS-SBM Joint Meeting, Rio de Janeiro, 2008; AMS Invited Address, Joint Mathematics Meetings, San Francisco, CA, 2010; Invited Address on Dynamical systems and ordinary differential equations, International Congress of Mathematicians, Hyderabad, 2010.

Additional Information: Ruth Lyttle Satter Prize, 2011.

Selected Publications: 1. with M. Shub, Pathological foliations and removable zero exponents, Invent. Math. **139** (2000), 495–508. MR**1738057 (2001c:37030)**; 2. with L. Burslem, Global rigidity of solvable group actions on S1, Geom. Topol., **8** (2004), 877–924. MR**2087072 (2005g:37052)**; 3. with C. Bonatti and S. Crovisier, The C1 generic diffeomorphism has trivial centralizer, Publ. Math. Inst. Hautes Etudes Sci., **109** (2009), 185–244. MR**2511588 (2010g:37035**); 4. with K. Burns, On the ergodicity of partially hyperbolic systems, Ann. of Math. **171** (2010), 451–489. MR**2630044 (2011g:37075)**; 5. with K. Burns and H. Masur, The Weil-Petersson geodesic flow is ergodic, Ann. of Math., **175** (2012), 835–908.

Statement by Candidate: In serving the AMS, I am committed to representing the broad base of mathematicians in the society, across mathematical disciplines, geographic areas, gender and orientation, and ethnic and socioeconomic backgrounds.

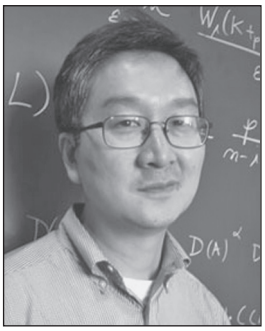
Deane Yang

Professor of Mathematics, Polytechnic Institute of New York University.

Born: September 24, 1957, Philadelphia, PA.

Ph.D.: Harvard University, 1983.

Selected Addresses: First Annual Geometry Festival, University of Pennsylvania, 1984; Invited Hour Address, AMS Meeting, South Bend, Indiana, 1991.

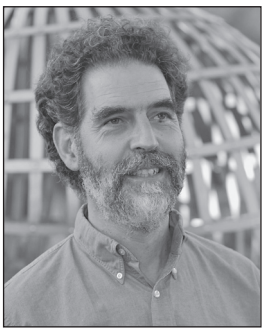


Selected Publications: 1. with E. Lutwak and G. Zhang, Lp affine isoperimetric inequalities, J. Differential Geom., **56** (2000), 111–132. MR**1863023 (2002h:52011)**; 2. with E. Lutwak and G. Zhang, Cramér-Rao and moment-entropy inequalities for Renyi entropy and generalized Fisher information, IEEE Trans. Inform. Theory, **51** (2005), 473–478. MR**2236062 (2008a:94056)**; 3. with E. Lutwak and G. Zhang, Optimal Sobolev norms and the Lp Minkowski problem, Int. Math. Res. Not. (2006), 1–21. MR**2211138 (2007d:52007)**; 4. with E. Lutwak and G. Zhang, Volume inequalities for isotropic measures, Amer. J. Math., **129** (2007), 1711–1723. MR**2369894 (2008k:52010)**.

Statement by Candidate: I am honored to have been asked to be a candidate for the AMS Nominations Committee. If elected, I will work together with the other members of the committee to find the best possible candidates for the Society. Today, with the growing widespread use of mathematics in industry and society, there is an unprecedented opportunity for the AMS to lead and mobilize the mathematical community in many important directions. We will succeed in this, only if we are able to identify and convince people with ideas, energy, and dedication to serve as officers of the AMS.

Editorial Boards Committee

Walter Craig



Professor and Canada Research Chair, McMaster University.

Born: November 28, 1953, State College, Pennsylvania.

Ph.D.: Courant Institute, New York University, 1981.

AMS Committees: Member at Large of the Council, 2000–2003; Committee on the Profession, 2001–2004 (chair, 2003–2004); Committee on Committees, 2003–2005; Executive Committee, 2003–2006.

Selected Addresses: Symposium, Tsunamis and Their Human Impact, AAAS annual meeting, St. Louis, Feb. 19, 2006; FRSC Lectures, Fields Institute, March 25, 2008; Conference, Wave Turbulence, Institut Henri Poincaré, November 19, 2009; Joint Zürich-Bonn-Paris-Berkeley Colloquium, Partial differential equations, Universität Zürich, April 14, 2010; Dynamics and partial differential equations, Convocazione della Accademia Lincei, Rome, Italy, October 14, 2011.

Additional Information: Honors: Alfred P. Sloan Fellowship, 1988; NSF Presidential Young Investigator, 1988–1993. Fellow: Fields Institute, 2005; Royal Society of Canada, 2007; American Association for the Advancement of Science, 2008; Killam Research Fellowship, 2009–2011. Fields Institute, Toronto: Scientific Advisory Panel, 2000–2005, Nominations Committee, 2001–2005, Board of Directors, 2009–2012. Centre de Recherches Mathématiques, Montreal: Comite Consultatif, 2001–2005. Pacific Institute for the Mathematical Sciences, Vancouver: Scientific Review Panel, 2007–2013. Member: Canadian Mathematical Society, London Mathematical Society, Canadian Society of Applied and Industrial Mathematics, American Association for the Advancement of Science.

Selected Publications: 1. with C. E. Wayne, Newton's method and periodic solutions of nonlinear wave equations, Comm. Pure Appl. Math., **46** (1993), 1409–1501. MR**1239318 (94m:35023)**; 2. with T. Kappeler and W. Strauss, Microlocal dispersive smoothing for the Schrödinger equation, Comm. Pure Appl. Math., **48** (1995), 769–860. MR**1361016 (96m:35057)**; 3. Problèmes de petits diviseurs dans les équations aux dérivées partielles, Panaromas et Syntheses, **9**, Société Mathématique de France, Paris (2000). MR**1804420 (2002e:37121)**; 4. with M. Arnold, On the size of the Navier-Stokes singular set, Discrete Contin. Dyn. Syst., **28** (2010), No. 3, 1165–1178. MR**2644785 (2011d:35360)**; 5. with A. Biryuk, Bounds on Kolmogorov spectrum for the Navier-Stokes equations, ArXiv-0807.4505, math-physics, Physica D (2011), 10.1016/j.physd.2011.10.013.

Statement by Candidate: I am a candidate for the AMS Editorial Boards Committee. This committee plays a role in the mathematics publishing enterprise of the Society and has an influence on the quality and standards of what we publish. This is one of my professional concerns and this committee is a venue in which I feel that I could help. The scientific publishing world is undergoing a slow but inexorable change with the advent of the ArXiv, electronic journals, the economic pressures from large commercial publishers on universities, electronic rather than paper distribution of monographs, the advent of open access publishing agreements, and the increasing numbers of globally located low-overhead publishing companies. Some of these changes are definite improvements in the way we disseminate our work, and should be encouraged. Other trends are less clearly so, and it would be a benefit to the mathematics community to understand the difference. The AMS can play a leading role in these changes, shepherding them towards the good. And the AMS Editorial Boards Committee can play a small part in this effort.

Jonathan I. Hall

Professor of Mathematics, Michigan State University, East Lansing, Michigan.

Born: October 20, 1949, Columbus, Ohio.

Ph.D.: University of Oxford, 1974.

AMS Committees: Council, 2006–2010; Archives Committee, 2011–2014; Editorial Boards Committee, 2012–2013; Committee for Publications, 2012–2013.

Selected Addresses: Invited Address, AMS Meeting, Dayton, 1992; Class of 1960 Lecturer, Williams College, 2001; Invited Lecturer, Sociedad Matemática Mexicana, XXXIV Congreso Nacional, Toluca,

2001; Main Speaker, Finite Groups and Algebraic Combinatorics, RIMS, Kyoto, 2007; Main Speaker, Workshop Loops '11, Czech Republic, 2011.
Additional Information: Editor, Journal of Combinatorial Theory (Series A), 1991–present; Chairman, Department of Mathematics, Michigan State University, 1994–1997; J. S. Frame Teaching Award, Michigan State University, 2000, 2012; Mathematical Reviews Editorial Committee, 2001–2010, (chair, 2006–2010); Proceedings of the American Mathematical Society Editorial Committee, 2003–2011. Member: Institute of Electrical and Electronics Engineers, London Mathematical Society.
Selected Publications: 1. Classifying copolar spaces and graphs, Quart. J. Math. Oxford Ser., **33** (1982), 421–449. MR**0679813 (84b:51021)**; 2. with P. J. Cameron, Some groups generated by transvection subgroups, J. Algebra, **140** (1991), 184–209. MR**1114913 (92g:20078)**; 3. with H. Cuypers, The 3-transposition groups with trivial center, J. Algebra, **178** (1995), 149–193. MR**1358261 (96k:20056)**; 4. with S. M. Gagola III, Lagrange's theorem for Moufang loops, Acta Sci. Math. (Szeged), **71** (2005), 45–64. MR**2160355 (2006f:20079)**; 5. Periodic simple groups of finitary linear transformations, Ann. of Math., **163** (2006), 445–498. MR**2199223 (2006k:20080)**.
Statement by Candidate: The main contact the Society has with present and future mathematicians is through its publications. It is vital that publication quality and value remain high, and good editorial committees are essential for this. If elected, I will look for editors who are responsible, ethical, knowledgeable, and energetic. The goal would be broad, diverse, and highly capable editorial committees that are committed to the quality and success of each publication. In pursuing this goal, I will be greatly aided by my experience as a current member of the Editorial Boards Committee and the Committee for Publications, as well as my recent service on two other AMS editorial committees.

Walter D. Neumann

Professor of Mathematics, Barnard College, Columbia University.
Born: January 1, 1946, Caerphilly, Wales, UK.
Ph.D.: Rheinische Friedrich-Wilhelms-Universitaet, Bonn, 1969.
AMS Committees: Transactions and Memoirs of the AMS (topology editor), 1982–1985; Council, 1982–1985; Nominating Committee, 1991–1993.
Selected Addresses: Coble Lectures, UIUC, 2003; Arbeitstagung 50 year Jubiläum, MPIM Bonn, 2007; AMS Invited Address, Worcester, MA, 2011; Plenary Lecture, Resolution of singularities and related topics, in honor of the 80th birthday of Heisuke Hironaka, Tordesillas, Spain, 2011; Plenary Lecture, Topology Down Under (conference in honor of Hyam Rubinstein), Melbourne, Australia, 2011.
Additional Information: Member, European Academy of Sciences, 2002–present; Managing Editor, Geometry & Topology; Editorial board member: Experimental Mathematics, Illinois J. Math, Proceedings Edinburgh Maths. Soc., Electronic Research Announcements in the Mathematical Sciences, Ohio State Univ. Math. Research Institute Publications (de Gruyter), de Gruyter Expositions in Mathematics; Board of Directors, Mathematical Sciences Publishers, Berkeley.
Selected Publications: 1. with D. Eisenbud, Three-dimensional Link Theory and Invariants of Plane Curve Singularities, Annals of Mathematics Studies, **110**, Princeton University Press, Princeton, NJ (1985). MR**0817982 (87g:57007)**; 2. with L. Reeves, Central extensions of word hyperbolic groups, Ann. of Math., (2) **145** (1997), 183–192. MR**1432040 (98b:20059)**; 3. Extended Bloch group and the Cheeger-Chern-Simons class, Geom. Topol., **8** (2004), 413–474. MR**2033484 (2005e:57042)**; 4. with J. Wahl, The end curve theorem for normal complex surface singularities, J. Eur. Math. Soc. (JEMS), **12** (2010), No. 2, 471–503. MR**2608949**; 5. with J. Behrstock, Quasi-isometric classification of nongeometric 3-manifold groups, J. Reine Angew. Math. (Crelle's journal), DOI 10.1515/CRELLE.2011.143.
Statement by Candidate: I am a member of seven editorial boards, including Geometry & Topology, Illinois J. Math., Experimental Mathematics, and former member of several others, including Transactions of the AMS and of Memoirs of the AMS. The AMS aims to publish journals of the highest quality in mathematical research at reasonable prices. I am a founding member of the Board of Directors of the Berkeley based nonprofit corporation, "Mathematical Sciences Publishers," which provides support for many journals, including AMS journals, PJM, Annals of Math. and its own journals such as G&T, AGT, ANT. Its mission "to transform scientific publishing into an industry that helps rather than hinders scholarly activity" strongly overlaps the publishing mission of the AMS.

Edward Scheinerman

Professor of Applied Mathematics & Statistics, Johns Hopkins University.
Born: May 24, 1957, Rochester, NY.
Ph.D.: Princeton University, 1984.
Selected Addresses: AMS/MAA Invited Speaker, Joint Mathematics Meetings, Baltimore, January, 2003; Invited Speaker, Sixth "Hereditarnia" Workshop on Hereditary Properties of Graphs, Kosice, Slovakia, June, 2003; IPAM Workshop on Extraction of Intelligence from Graphs and High Dimensional Data, Los Angeles, July, 2005; Invited Speaker, SIAM Minisymposium, SIAM National Meeting, Denver, July, 2009; MAA Invited Speaker and Session Organizer, Joint Mathematics Meetings, New Orleans, January, 2011.
Additional Information: Lester R. Ford Award (for mathematical exposition), 1991, 2001. Journal of Graph Theory: Managing Editor, 1993–1999, Editorial Board Member, 1999–present. American Mathematical Monthly: Editorial Board Member, 1993–present, Notes Editor, 2006–2011.

Electronic Journal of Combinatorics, Guest Editor for special issue, 1999–2001. Author of five mathematics books including two text books and one research monograph.

Selected Publications: 1. When close enough is close enough, Amer. Math. Monthly, **107** (2000), 489–499. MR**1766736 (2001j:11067)**; 2. Determining planar location via complement-free de Bruijn sequences using discrete optical sensors, IEEE Transactions on Robotics and Automation, **17** (2001), No. 6, 883–889; 3. with E. Reilly, Random threshold graphs, Electron. J. Combin., **16** (2009). MR**2558267 (2011a:05319)**; 4. with K. Tucker, Modeling graphs using dot product representations, Comput. Statist., **25** (2010), 1–6. MR**2586721**; 5. with R. Kang, L. Lovász, and T. Müller, Dot product representations of planar graphs, Electron. J. Combin., **18** (2011), [P216]. MR**2853073**.

Statement by Candidate: Professional societies must play a leading role in all forms of publication as commercial publishers are too expensive and their profits do not support the community.

THE CHINESE UNIVERSITY OF HONG KONG

Applications are invited for:-

Department of Mathematics

Assistant Professor

(Ref. 1213/003(576)/2) (Closing date: March 15, 2013)

The Department invites applications for an Assistant Professorship in all areas of mathematics. Applicants should have a relevant PhD degree and an outstanding profile in research and teaching. Appointment will normally be made on contract basis for up to three years initially commencing August 2013, which, subject to mutual agreement, may lead to longer-term appointment or substantiation later.

Salary and Fringe Benefits

Salary will be highly competitive, commensurate with qualifications and experience. The University offers a comprehensive fringe benefit package, including medical care, a contract-end gratuity for an appointment of two years or longer, and housing benefits for eligible appointee. Further information about the University and the general terms of service for appointments is available at *http://www.per.cuhk.edu.hk*. The terms mentioned herein are for reference only and are subject to revision by the University.

Application Procedure

Please send full resume, copies of academic credentials, a publication list and/or abstracts of selected published papers, together with names, addresses and fax numbers/e-mail addresses of three referees to whom the applicants' consent has been given for their providing references (unless otherwise specified), to the Personnel Office, The Chinese University of Hong Kong, Shatin, N.T., Hong Kong (Fax: (852) 3943 1462) by the closing date. The Personal Information Collection Statement will be provided upon request. Please quote the reference number and mark 'Application - Confidential' on cover.

CALL FOR Suggestions

Your suggestions are wanted by:

The Nominating Committee, for the following contested seats in the 2013 AMS elections:
vice president, trustee,
and five members at large of the Council

Deadline for suggestions: November 4, 2012

The President, for the following contested seats in the 2013 AMS elections:
three members of the Nominating Committee
two members of the Editorial Boards Committee

Deadline for suggestions: January 31, 2013

The Editorial Boards Committee, for appointments to various editorial boards of AMS publications

Deadline for suggestions: Can be submitted any time
Send your suggestions for any of the above to:

Robert J. Daverman, Secretary
American Mathematical Society
Department of Mathematics
237 Ayres Hall
University of Tennessee
1403 Circle Drive
Knoxville, TN 37996-1320 USA
email: secretary@ams.org

AMS
American Mathematical Society
www.ams.org

2013 AMS Election

Nominations by Petition

Vice President or Member at Large

One position of vice president and member of the Council *ex officio* for a term of three years is to be filled in the election of 2013. The Council intends to nominate at least two candidates, among whom may be candidates nominated by petition as described in the rules and procedures.

Five positions of member at large of the Council for a term of three years are to be filled in the same election. The Council intends to nominate at least ten candidates, among whom may be candidates nominated by petition in the manner described in the rules and procedures.

Petitions are presented to the Council, which, according to Section 2 of Article VII of the bylaws, makes the nominations. The Council of 23 January 1979 stated the intent of the Council of nominating all persons on whose behalf there were valid petitions.

Prior to presentation to the Council, petitions in support of a candidate for the position of vice president or of member at large of the Council must have at least fifty valid signatures and must conform to several rules and procedures, which are described below.

Editorial Boards Committee

Two places on the Editorial Boards Committee will be filled by election. There will be four continuing members of the Editorial Boards Committee.

The President will name at least four candidates for these two places, among whom may be candidates nominated by petition in the manner described in the rules and procedures.

The candidate's assent and petitions bearing at least 100 valid signatures are required for a name to be placed on the ballot. In addition, several other rules and procedures, described below, should be followed.

Nominating Committee

Three places on the Nominating Committee will be filled by election. There will be six continuing members of the Nominating Committee.

The President will name at least six candidates for these three places, among whom may be candidates nominated by petition in the manner described in the rules and procedures.

The candidate's assent and petitions bearing at least 100 valid signatures are required for a name to be placed on the ballot. In addition, several other rules and procedures, described below, should be followed.

Rules and Procedures

Use separate copies of the form for each candidate for vice president, member at large, member of the Nominating or Editorial Boards Committees.

1. To be considered, petitions must be addressed to Carla D. Savage, Secretary, American Mathematical Society, 201 Charles Street, Providence, RI 02904-2294 USA, and must arrive by 23 February 2013.
2. The name of the candidate must be given as it appears in the *Combined Membership List* (`www.ams.org/cml`). If the name does not appear in the list, as in the case of a new member or by error, it must be as it appears in the mailing lists, for example on the mailing label of the *Notices*. If the name does not identify the candidate uniquely, append the member code, which may be obtained from the candidate's mailing label or by the candidate contacting the AMS headquarters in Providence (amsmem@ams.org).
3. The petition for a single candidate may consist of several sheets each bearing the statement of the petition, including the name of the position, and signatures. The name of the candidate must be exactly the same on all sheets.
4. On the next page is a sample form for petitions. Petitioners may make and use photocopies or reasonable facsimiles.
5. A signature is valid when it is clearly that of the member whose name and address is given in the left-hand column.
6. The signature may be in the style chosen by the signer. However, the printed name and address will be checked against the *Combined Membership List* and the mailing lists. No attempt will be made to match variants of names with the form of name in the *CML*. A name neither in the *CML* nor on the mailing lists is not that of a member. (Example: The name Carla D. Savage is that of a member. The name C. Savage appears not to be.)
7. When a petition meeting these various requirements appears, the secretary will ask the candidate to indicate willingness to be included on the ballot. Petitioners can facilitate the procedure by accompanying the petitions with a signed statement from the candidate giving consent.

Nomination Petition

for 2013 Election

The undersigned members of the American Mathematical Society propose the name of

_____

as a candidate for the position of (check one):

- ☐ **Vice President**
- ☐ **Member at Large of the Council**
- ☐ **Member of the Nominating Committee**
- ☐ **Member of the Editorial Boards Committee**

of the American Mathematical Society for a term beginning 1 February, 2014

Return petitions by 23 February 2013 to:
Secretary, AMS, 201 Charles Street, Providence, RI 02904-2294 USA

Name and address (printed or typed)	Signature

From the AMS Secretary

Report of the Treasurer (2011)

Introduction

When reviewing the annual financial results of the American Mathematical Society (AMS), it is important to note that the financial support for its membership and professional programs is derived from several sources: the margin from the publication programs, dues income and contributions, and a board-designated endowment fund named the Operations Support Fund (OSF), which in 2011 provided $1,645,100 to operations. The OSF is a fund that has grown over the years through net income from the operations of the AMS as well as investment gains. Together these sources support the Society's widely used membership and professional programs and services, such as MathJobs, *Notices of the American Mathematical Society*, student programs, and fellowships.

In 2011, the American Mathematical Society experienced a net operating margin of approximately $2.7 million. This positive net margin was offset by losses on investments and an actuarial change to the calculation of the postretirement benefit obligation, creating a loss of $612,000 in the total net assets of the AMS for 2011. As explained below, the large net operating margin was due primarily to a reduction in expenses while revenue remained fairly flat.

The Statement of Activities

The AMS Statement of Activities identifies the direct revenues and expenses for the major AMS programs and services, including Mathematical Reviews, Journals, Books, Meetings, Grants, Prizes and Awards, Governance, and Member and Professional Services. The other expense categories on the statement show the overhead costs, and they include Publications Indirect, Customer Services, Warehousing and Distribution, Other Publications-Related Expense, Member and Professional Services Indirect, and General and Administrative. The overhead expense activities are part of the true cost of each of the major programs.

The reason for the large net operating margin of $2.7 million in 2013 was a 3% decrease in expenses. Tables 1 and 2 show key operating figures, and major expense categories for 2010 and 2011, including increases and decreases in major categories. The net operating margin for the AMS was expected to be much smaller for 2011, because expenses were expected to grow by approximately 3% while revenue growth remained relatively flat. However, expenses overall decreased. The reasons for this decline are associated with internal and external influences, which we explain briefly.

Two key factors affecting the reduction in expenses from 2010 to 2011 were accounting changes related to deferrals of prepaid expenses and a book inventory adjustment. The deferral of prepaid expenses to future years was largely due to external market influences in the AMS book program. During 2011, publications staff worked on future year publications to a greater extent than in prior years, because the publications departments were staffed to publish 108 books as compared to the 95 actually published. The reduction in number of books published meant that staff worked on other projects, such as future journal issues, so departmental expenses incurred for these projects were deferred to future years. These deferrals

Key Operating Figures

	2010 Actual	2011 Actual	Variance Pos (Neg) 10A VS 11A	% chg	2011 Budget	Variance Pos (Neg) 11A VS 11B
Total operating revenue	27,092,251	27,284,068	191,817	0.7%	26,673,610	610,458
Total operating expenses	25,283,224	24,581,779	701,445	2.8%	26,055,160	1,473,381
Operating income	**1,809,027**	**2,702,289**	**893,262**	**49.4%**	**618,450**	**2,083,839**
Income (loss) from unrestricted long-term investments	7,493,555	(1,874,771)	(9,368,326)		3,818,513	(5,693,284)
Post-retirement benefit changes	(119,765)	(1,102,350)	(982,585)		(150,000)	(952,350)
Change in unrestr. net assets	**9,182,817**	**(274,832)**	**(9,457,649)**		**4,286,963**	**(4,561,795)**

Table 1

Major Expense Categories (in 000's)

	2010 Actual		2011 Actual		Variance 10 v. 11 inc(dec)	% chg
Personnel Costs	$17,200	68%	$17,345	70.6%	$145	1%
Building and Equipment Related	1,654	7%	1,682	6.8%	28	2%
Postage	814	3%	777	3.2%	(37)	-5%
Outside Print'g, Bind'g and Mail'g	610	2%	587	2.4%	(23)	-4%
Printing paper	433	2%	378	1.5%	(55)	-13%
Travel - Staff, Volunteers and Grants	670	3%	681	2.8%	11	2%
All Other Expenses	3,902	15%	3,132	12.7%	(770)	-20%
	$25,283	100%	$24,582	100%	$ (701)	-3%

Table 2

combined with a book inventory adjustment are the major reason for large decrease in "All Other Expenses" expenses shown in Table 2. Also affecting the "All Other Expenses" category was the decrease in space charges and conference fees for the 2011 Joint Meeting, because it was held in a less expensive venue in New Orleans than in the prior year.

Internally, there was only a slight increase in personnel costs (less than 1%), because management has controlled wage and benefit costs. During the year, approximately 10.25 full-time equivalent positions were held open by management. Also, benefit plans experienced smaller increases than expected due to careful management of the plans over the past few years.

Both internal and external influences affected postage and printing paper expenses. Postage costs were lower than they have been in more than 10 years, because of the trend to use email rather than mail for conducting business, the industry-wide increase in electronic subscriptions, and planned changes in shipping vendors. The amount spent on printing paper is the lowest it has been since 2006, due to a lower-than-average number of books published, lower journal page counts, and the gradual change from paper to electronic journal subscriptions.

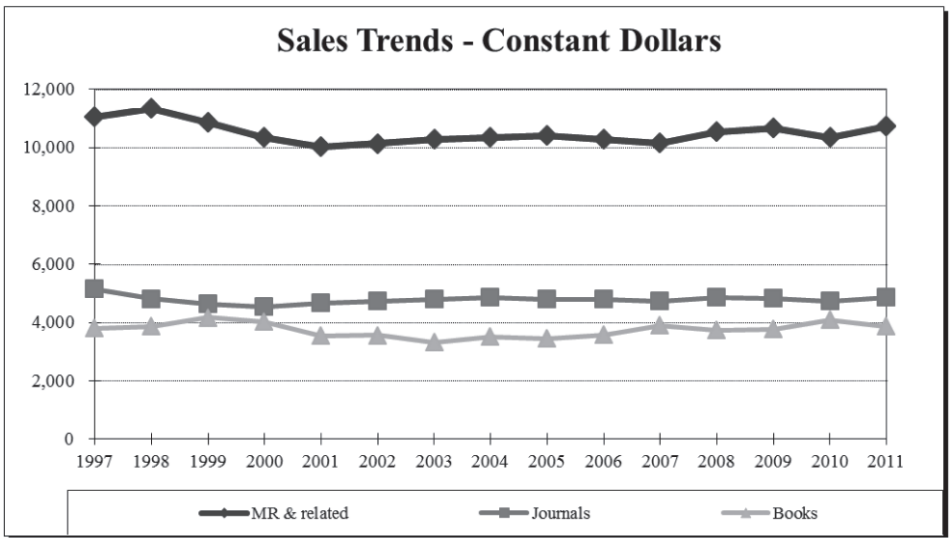


Table 3

As a result of market pressures, publishing revenues continue to be flat as shown in Table 3 (adjusted for inflation). Publications revenues exceeded budget by $434,000, but they increased by only 2% over 2010. Even though the AMS did not publish 108 books as budgeted, book revenues exceeded expectations due to strong backlist sales primarily from monographs. MathSciNet revenues exceeded budget as well, because of an increase in the number of consortium subscribers. Another notable revenue variance is a $199,755 positive variance for new grant revenues, such as those from the Simons Foundation, that were not budgeted. These revenues were offset by related travel expenses for grant participants. Offsetting positive growth in other revenues, the investment income from the operating portfolio was $130,000 below budget due to the poor performance of the mutual funds in the portfolio.

The Balance Sheets

The AMS had a healthy balance sheet as of December 31, 2011, with a ratio of assets to liabilities of nearly 5 to 1. Cash and cash equivalents increased from 2010 to 2011 because of the positive operating margin. Short-term investments decreased during the year, primarily because $2,000,000 was transferred to the long-term portfolio. The long-term investments increased by approximately $1,800,000 because of the transfer from the short-term investments, partially offset by losses on the investments. When there is surplus cash available, funds are transferred from short-term to long-term investments in order to continue to build the OSF, which is an important source of funding for the AMS operations and programs. The largest increase on the liability portion of the balance sheet was a $1.2 million increase in the postretirement benefit obligation associated

Continued on page 1154

Balance Sheets

	December 31, 2011	December 31, 2010
Assets		
Cash and cash equivalents	$ 1,753,474	$ 1,084,237
Certificates of deposit	2,064,000	2,090,000
Short-term investments	11,675,319	13,807,241
Accounts receivable, net of allowances of $344,066 and $347,279 in 2011 and 2010, respectively	470,880	853,254
Deferred prepublication costs	765,162	632,570
Completed books	1,453,931	1,328,076
Prepaid expenses and deposits	1,677,164	1,256,912
Land, buildings and equipment, net	4,828,711	5,031,887
Long-term investments	81,186,072	79,406,346
Total assets	**$ 105,874,713**	**$ 105,490,523**
Liabilities and Net Assets		
Liabilities:		
Accounts payable and accrued expenses	$ 3,128,241	$ 2,960,535
Accrued study leave pay	741,400	829,582
Deferred revenue	12,515,534	12,822,888
Postretirement benefit obligation	5,994,557	4,770,464
Total liabilities	**22,379,732**	**21,383,469**
Net assets:		
Unrestricted:		
Undesignated	1,739,111	4,146,972
Designated	71,018,071	68,885,038
	72,757,182	73,032,010
Temporarily restricted	5,753,285	6,207,920
Permanently restricted	4,984,514	4,867,124
Total net assets	**83,494,981**	**84,107,054**
Total liabilities and net assets	**$ 105,874,713**	**$ 105,490,523**

Statements of Activities

	Years Ended December 31,	
	2011	***2010***
Changes in unrestricted net assets:		
Operating revenue, including net assets released from restrictions:		
Mathematical Reviews	$ 10,735,499	$ 10,307,693
Journals	4,822,189	4,716,428
Books	3,982,668	4,093,467
Dues, services, and outreach	3,688,175	3,885,074
Investments appropriated for spending	1,674,100	1,480,151
Other publications-related revenue	450,928	372,322
Grants, prizes and awards	1,083,719	1,101,874
Meetings	1,034,109	1,143,373
Short-term investment income	270,132	626,227
Other	47,853	60,299
Total operating revenue	**27,789,372**	**27,786,908**
Operating expenses:		
Mathematical Reviews	6,807,854	6,855,152
Journals	1,421,642	1,523,701
Books	3,395,094	3,791,325
Publications indirect	1,062,353	904,832
Customer services, warehousing and distribution	1,313,110	1,363,163
Other publications-related expense	192,610	216,322
Membership, services and outreach	3,842,817	4,116,641
Grants, prizes and awards	1,300,955	1,198,463
Meetings	950,212	1,181,320
Governance	432,498	428,949
Member and professional services indirect	714,527	569,596
General and administrative	3,593,104	3,752,580
Other	60,302	75,839
Total operating expenses	**25,087,078**	**25,977,883**
Excess of operating revenue over operating expenses	**2,702,294**	**1,809,025**
Investment returns less investment returns available for spending	(1,874,771)	7,493,555
Postretirement benefit-related changes other than net periodic cost	(1,102,350)	(119,765)
Change in unrestricted net assets	(274,827)	9,182,815
Changes in temporarily restricted net assets:		
Contributions	172,731	271,547
Investment returns less investment returns appropriated for spending	(19,603)	1,322,495
Net assets released from restrictions	(607,763)	(732,496)
Change in temporarily restricted net assets	(454,635)	861,546
Change in permanently restricted net assets:		
Contributions	117,390	114,475
Change in permanently restricted net assets	117,390	114,475
Change in net assets	**(612,072)**	**10,158,836**
Net assets, beginning of year	84,107,054	73,948,218
Net assets, end of year	**$ 83,494,982**	**$ 84,107,054**

Statements of Invested Funds
As of December 31, 2011 and 2010

Income Restricted:		**12/31/2011**	**12/31/2010**
Research Prize Funds	**Original Gift**	**Total Value**	**Total Value**
Steele	145,009	552,719	579,538
Birkhoff	50,112	69,424	72,792
Veblen	29,773	36,824	38,611
Wiener	29,773	36,824	38,611
Bocher	32,557	37,409	39,224
Conant	9,477	36,862	38,650
Cole Number Theory	33,063	38,136	39,462
Cole Algera	33,063	38,136	39,462
Satter	43,212	55,091	57,764
Doob Prize	45,000	45,572	47,783
Robbins Prize	41,250	42,408	44,466
Eisenbud Prize	40,000	40,000	41,611
Other Prize and Award Funds			
Morgan	25,000	40,114	42,061
Albert Whiteman	93,618	95,893	100,546
Arnold Ross Lectures	70,000	71,401	74,865
Trjitzinsky	196,030	444,400	465,962
C.V. Newsom	100,000	206,799	216,834
Centennial	56,100	106,033	111,178
Menger	97,250	100,473	105,348
Ky Fan (China)	366,757	366,757	371,133
2011 Addition	10,000	10,000	
Epsilon	1,652,259	1,698,148	1,669,024
Einstein Lecture	100,000	102,836	107,826
Exemplary Program	100,000	102,207	107,166
Mathematical Art	20,000	20,441	21,433
Total (Income Restricted)	**3,419,303**	**4,394,907**	**4,471,351**
Income Unrestricted:			
Endowment	100,310	681,420	715,176
Morita	100,000	122,449	128,521
Henderson	548,223	3,651,371	3,832,423
Schoenfeld/Mitchell	573,447	692,284	726,610
Laha	189,309	232,581	244,114
Ritt	51,347	217,543	228,330
Moore	2,575	20,506	21,523
Total (Income Unrestricted)	**1,565,211**	**5,618,155**	**5,896,697**
Total Endowment Funds	**4,984,514**	**10,013,061**	**10,368,047**
Board-Designated Funds:			
Journal Archive Fund		920,784	873,003
Young Scholars		614,004	642,864
Economic Stabilization Fund		24,430,891	23,732,898
Operations Support Fund		45,052,391	43,636,272
Total Board-Designated Funds		**71,018,071**	**68,885,038**
Total All Funds		**81,031,132**	**79,253,085**

Continued from page 1150

with actuarial changes made to the postretirement plan. The AMS sets aside funding for the benefit obligation within its long-term investment portfolio as part of its Economic Stabilization Fund (ESF), and this amount was increased to insure that the retirement funds will be available for AMS retirees in the future.

Market and Economic Conditions Affecting the Society

The investment markets fluctuated wildly in 2011, and the AMS long-term portfolio sustained a small loss for the year. The fluctuations in the market affect the AMS financial health, as a poor return on operating investments affects the operating bottom line, and a negative return on the long-term portfolio affects the funds available for spending from the endowment and the Operations Support Fund. The historically low certificate of deposit and money market interest rates of less than 1% translated to very low returns on the short-term portion of the operating portfolio. The intermediate-term portion of the portfolio fared better with a 4% return. Despite the lower-than-normal combined return of 2% on the operating portfolio investments, the organization had a healthy net income.

The majority of the American Mathematical Society's publishing revenues come from international sources. For example, 67% of MathSciNet customers and sales revenues are international. The European Union debt crisis has affected our customers in Europe, where 20% of the Society's overall publishing sales occur. Consortium customers in some European countries struggled to maintain their MathSciNet and journal subscriptions, but AMS staff worked with university libraries to find ways to save on their subscriptions. The majority of AMS European customers have continued with their subscriptions, and the European recession has not yet had a significant effect on the bottom line. While the AMS has lost subscriptions in some developed countries, business has increased in emerging markets. In the United States, the downward pressure on subscription prices for academic publishers is increasing as university libraries reduce their budgets. The AMS continues to experience subscription attrition, but this is counteracted by subscription price increases and additions of international and consortium subscribers.

The publishing industry continues to change at a fast pace, affecting the AMS in many ways. For example, AMS book sales distribution channels have changed dramatically in recent years, and although the number of units sold has increased by a modest 9% over the past five years, margins through newer channels, such as electronic bookstore retailers, have decreased. In addition, the AMS continues to experience movement from printed to electronic journal subscriptions at an increasing rate. Also, the AMS is investing in digitization of its backfile to take advantage of electronic book sales.

Summary Financial Information

The Statements of Activities and Balance Sheets are from the audited annual financial statements of the AMS, and the Statement of Invested Funds is from the internal financial records of the AMS. A copy of the audited financial statements will be sent from the Providence Office to any member who requests it from the Treasurer. As Treasurer I will be happy to answer any questions members may have regarding the financial affairs of the AMS.

Respectfully Submitted,
Jane Hawkins
Treasurer

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/.

September 2012

1–3 **13th International Pure Mathematics Conference**, Quaid-i-Azam University, Islamabad, Pakistan. (Apr. 2012, p. 592)
Description: The 13th international conference in the series of Pure Mathematics Conferences that take place in Islamabad every year in August/September. It is a thematic conference on Algebra, Geometry, and Analysis held under the auspices of the Pakistan Mathematical Society (http://www.pakms.org.pk) and Algebra Forum (http://www.algebraforum.org.pk).
Support: There will be free housing for foreign participants. Some travel grants are available for foreign speakers. Several free recreational trips will be organized in and around Islamabad introducing the unique local and multi-ethnic culture.
Registration: Please fill in the on-line registration form at http://www.pmc.org.pk and find more information therein. The conference is convened by Professor Dr Qaiser Mushtaq (Department of Mathematics, Quaid-i-Azam University, Islamabad, Pakistan, president@pakms.org.pk).
Information: http://www.pakms.org.pk, www.pmc.org.pk.

* 3–5 **Summer School on Quantum Ergodicity and Harmonic Analysis (Part One)**, Philipps University Marburg, Germany.
Description: The school intends to give an introduction to quantum ergodicity. It will consist of three lecture series: Ingo Witt, Göttingen: Introduction to semiclassical analysis; Frédéric Faure, Grenoble: Ergodicity of quantum maps; Roman Schubert, Bristol: Quantum ergodicity on negatively curved manifolds and single talks by participants.
Support: Financial support can be provided. The school will have a second part to be held in Goettingen in Fall 2012 that revolves around applications of quantum ergodicity to harmonic analysis.
Information: http://www.mathematik.uni-marburg.de/~ramacher/QE.

3–5 **Workshop on Combinatorics**, University of Lisbon, Lisbon, Portugal.
Description: The "Workshop on Combinatorics" will be held at IIIIUL, http://www.ciul.ul.pt/index_en.htm, in Lisbon, Portugal, from September 3 to 5, 2012. This meeting consists of two mini-courses, supplemented by contributed talks and posters and it is mostly addressed to graduate students and researchers interested in exploring and extending their knowledge on topics related to Matroid Theory and Triangulations of Polytopes.
Invited Speakers: Henry Crapo: Topics on Matroid Theory, Francisco Santos: Triangulations of Polytopes.
Registration fees: Registration until June 30, 2012: 50 euro (students: 40 euro). Registration after June 30, 2012: 70 euro (students: 60 euro).
Deadline: For submission of contributed talks: July 15, 2012.
Information: If you have any further questions, please contact us at http://worklis2012.fc.ul.pt.

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/.

3–6 **Symmetries in Differential Geometry and Mathematical Physics**, University of Luxembourg, Luxembourg City, Luxembourg.
Description: The purpose of the conference is to bring together mathematicians and mathematical physicists working in related areas of Differential Geometry and Mathematical Physics. It is intended to present new results about the geometry of symmetric and homogeneous spaces, theory of Lie algebras and superalgebras, Lorentzian and pseudo-Riemannian geometry, spin geometry, mathematical aspects of supersymmetry. The conference is in honor of Dmitri Alekseevsky.
Information: http://math.uni.lu/symm2012/index.html.

3–7 **Geometry, Structure and Randomness in Combinatorics**, Centro di Ricerca Matematica Ennio De Giorgi, Scuola Normale Superiore, Collegio Puteano, Piazza dei Cavalieri, 3, I-56100 Pisa, Italy.
Description: This workshop is organized by the Centro di Ricerca Matematica Ennio De Giorgi of the Scuola Normale Superiore, jointly with the Center for Discrete Mathematics, Theoretical Computer Science and Applications (DIMATIA) of Charles University and with the National Research Council of Italy (CNR). It aims to reflect some key recent advances in combinatorics, and to demonstrate the broad spectrum of techniques and its relationship to other fields of mathematics, particularly to geometry, logic and number theory.
Invited speakers: Imre Barany, Bela Bollobas, Maria Chudnovsky, Zeev Dvir, Zoltan Furedi, Patrice Ossona de Mendez, Alex Scott, Micha Sharir, Jozsef Solymosi, Endre Szemeredi, Luca Trevisan.
Support: For young researchers/students available at http://crm.sns.it/event/241/financial.html.
Deadline for applications: July 15, 2012. Registration (no fees) is required at http://crm.sns.it/event/241/. Partially supported by INdAM, DIMATIA and CNR Inst. for Informatics & Telematics.
Organizing Committee: Jaroslav Nesetril (Charles University, Prague), Marco Pellegrini (CNR, Pisa), Jiri Matousek (Charles University, Prague).
Information: email: crm@crm.sns.it; fax: 050/509177; http://crm.sns.it/event/241/.

3–7 **Dynamical Systems: 100 years after Poincaré**, University of Oviedo, Gijn, Spain. (May 2012, p. 716)
Description: The conference is organized by the Dynamical Systems Group at the University of Oviedo. The aim is to bring together a broad group of scientists working in the field of dynamical systems on the occasion of the 100th anniversary of the death of Henri Poincaré. All topics related to dynamical systems are considered but focusing on local and global bifurcations in discrete and continuous dynamical systems, planar vector fields and celestial mechanics. Applications to real-world problems will be highlighted. The conference will promote the diffusion of recent developments and future perspectives. There will be ten keynote speakers, sixty-four 30-minute contributed talks in two parallel sessions and also two poster sessions. Plenary speakers are experts chosen from different areas of Dynamical Systems.
Information: http://www.unioviedo.es/ds100Poincare/.

3–7 **International Conference on Differential-Difference Equations and Special Functions**, University of Patras, Patras, Greece. (Aug. 2011, p. 1014)
Description: The conference is dedicated to the memory of Professor Panayiotis D. Siafarikas, who left so early in 2010 and its main aim is to bring together experts working in all areas (including numerical investigations and applications) of differential equations, difference equations and special functions and to promote the research in these areas.
Information: http://www.icddesf.upatras.gr.

3–7 **1st International Conference on Mathematical Sciences and Applications (IECMSA)**, Prishtine University, Prishtine, Kosovo. (Mar. 2012, p. 455)
Description: The goal of the conference is to contribute to the development of mathematical sciences and its applications and to bring the mathematics community, interdisciplinary researchers, educators, mathematicians, statisticians and engineers from all over the world. The conference will present new results and future challenges, in series invited and short talks, poster presentations. The presentations can be done in the language of Albanian, Turkish and English. Also, original, unpublished papers are invited for presentation in the conference IECMSA. All presented paper's abstracts will be published in the conference proceeding. Moreover, selected and peer review articles will be published in the following journals: *Applied and Computational Mathematics* (SCI), *TWMS Journal of Pure and Applied Mathematics*, *TWMS Journal of Applied and Engineering Mathematics*, *International Electronic Journal of Geometry*, *Mathematical Sciences and Applications*, *e-Notes*. Looking forward to see you in IECMSA.
Information: http://www.iecmsa.org.

3–7 **Third Iberoamerican Meeting on Geometry, Mechanics and Control**, University of Salamanca, Salamanca, Spain.
Description: The Iberoamerican Meetings on Geometry, Mechanics and Control are held every two years and are intended for young and senior researchers with interest in differential geometry, mechanics and control theory. These subject matters are highly topical, interacting in a common area of Mathematics, Physics, Mechanics, and Engineering.
Plenary speakers: Henrique Bursztyn (IMPA, Brazil), Marco Castrillón (UCM and ICMAT, Spain), Gonzalo Contreras (CIMAT, Mexico), Rui L. Fernandes (IST, Portugal), Mark J. Gotay (PIMS, Canada), Janusz Grabowski (IMPAN, Poland), Darryl Holm (Imperial College, United Kingdom), Sonia Martínez (UCSD, USA)–to be confirmed, Juan-Pablo Ortega (CNRS, France), Edith Padrón (ULL, Spain), Narcisco Roman-Roy (UPC, Spain) and Carlos Tomei (PUC-Rio, Brazil). There are also 15 invited talks and a poster session.
Information: http://fundacion.usal.es/3imgmc.

3–8 **XVII Geometrical Seminar**, Zlatibor, Serbia Hotel "Ratko Mitrović" (Apr. 2012, p. 592)
Conference Topics: Differential geometry, topology, lie groups, mathematical physics, discrete geometry, integrable systems, visualization, as well as other subjects related to the main themes are welcome.
Organizers: Faculty of Mathematics, University of Belgrade, Belgrade, Serbia; Mathematical Institute of the Serbian Academy of Sciences and Arts Belgrade, Serbia.
Co-organizer: Bogolubov Laboratory of Geometrical Methods Mathematical Physics, Moscow.
Deadlines: Registrations: June 1, 2012. Abstracts: July 1, 2012.
Hotel reservation: By June 1, 2012. Contact person: Miroslava Antic; email: geometricalseminar@matf.bg.ac.rs.
Information: http://poincare.matf.bg.ac.rs/~geometricalseminar/.

4–9 **MADEA 2012 International Conference on Mathematical Analysis, Differential Equations and Their Applications**, Mersin University, Mersin, Turkey. (Apr. 2012, p. 592)
Description: This is the sixth Turkish-Ukrainian Mathematical conference which will be held in Mersin-Turkey. The first conference was held August 26–30, 2003, in National Juriy Fedkovich University of Chernivtsi (Chernivtsi, Ukraine), The second was held September 7–11, 2004, in Mersin University (Mersin, Turkey). The third was held September 18–23, 2006, in Uzhgorod National University (Uzhgorod, Ukraine). The fourth was held September 12–15, 2008, at Eastern Mediterranean University (Famagusta, North Cyprus). The fifth was held September 15–20, 2010, at Sunny Beach, Bulgaria. The conference format includes the plenary lectures and the section sessions.
Languages: English, Russian and Turkish.

Information: email: mkucukaslan@mersin.edu.tr or mkkaslan@gmail.com; http://madea2012.mersin.edu.tr/.

5–7 **Complex patterns in wave functions: Drums, graphs, and disorder**, Kavli Royal Society International Centre, Chicheley Hall, Chicheley, Newport Pagnell, Buckinghamshire MK16 9JJ, UK. (May 2012, p. 716)
Description: Wave functions display complex patterns which are intensively studied in many branches of Mathematics and Physics. Their value distributions, nodal sets, extreme values, and localization properties – to cite a few examples – are investigated using diverse methods developed within a network of fields whose connectivity leaves a lot to be desired. This conference gives a unique opportunity to discuss these common questions, and present different points of view and methods, yet in a single high-level forum. A set of world-leading researchers has been invited to lecture on their recent contributions to the field. The participants will have the opportunity to present contributions in a poster session and discuss future directions across discipline borders.
Information: http://royalsociety.org/events/Complex-patterns-in-wave-functions/

5–7 **ICERM Semester Program: Computational Challenges in Probability**, ICERM, Providence, Rhode Island. (Jan. 2012, p. 106)
Description: Modern explorations in science, technology and medicine increasingly demand complex stochastic models. Computational and theoretical advances are needed in order to formulate, analyze, apply, and interpret these models. Recent years have witnessed a remarkable interplay between computation and probability. On the one hand, probabilistic techniques have led to powerful computational methods such as Markov chain Monte Carlo algorithms, while on the other hand, the calculation of probabilistic quantities such as modes and marginals of high-dimensional distributions and the analysis of data from random samples has posed several computational challenges. The fall 2012 semester on "Computational Challenges in Probability" aims to bring together leading experts and young researchers who are advancing the use of probabilistic and computational methods to study complex models in a variety of fields. The goal is to identify common challenges, exchange existing tools, reveal new application areas.
Information: http://icerm.brown.edu/sp-f12.

5–9 **Lie Algebras and Applications**, Uppsala University, Uppsala, Sweden. (Mar. 2012, p. 455)
Invited speakers: Peter Fiebig (Universität Erlangen-Nürnberg), Maria Gorelik (Weizmann Institute), Jonas Hartwig (Stanford University), Daniel Nakano (University of Georgia), Maxim Nazarov (University of York), Ivan Penkov (Jacobs University Bremen), Alistair Savage (University of Ottawa), Vera Serganova (University of California at Berkeley), Eric Vasserot (Université Paris VII), Weiqiang Wang (University of Virginia), Geordie Williamson (MPIM Bonn), Kaiming Zhao (Wilfrid Laurier University).
Organizer: Volodymyr Mazorchuk.
Registration: Deadline: June 15, 2012.
Information: email: lie2012@math.uu.se. http://www.math.uu.se/Lie2012/.

7–12 **Workshop on Stochastic and PDE Methods in Financial Mathematics**, Yerevan State University, Yerevan, Armenia. (May 2012, p. 716)
Description: Institute of Mathematics of the National Academy of Sciences in association with Yerevan State University and American University of Armenia is organizing an international workshop in Stochastic and PDE Methods in Financial Mathematics, September 7–12, 2012.
Objective: The objective of this workshop is to bring together experts in the area of partial differential equations and stochastic analysis, working within financial mathematics to encourage and give an opportunity to young mathematicians in the region, to initiate contacts with experts in this area, and to stimulate contacts between theoretical and applied science and financial companies of the region having interests in development of mathematical modelling and research. The program of the workshop will consist of invited 50-minute plenary lectures and contributed 20-minute talks, poster sessions as well as short presentations.
Information: http://math.sci.am/conference/sept2012/index.html.

9–12 **2012 Federated Conference on Computer Science and Information Systems (FedCSIS)**, Wroclaw, Poland.
Description: We would like to cordially invite you to consider contributing a paper to the FedCSIS 2012.
Information: For all matters relating to this conference please visit: http://www.fedcsis.org.

9–14 **26th Large Installation System Administration Conference (LISA '12)**, Sheraton San Diego Hotel and Marina, 1380 Harbor Island Drive, San Diego, California.
Description: Join us for the most in-depth, practical system administration training available. The annual LISA conference is the meeting place of choice for system and network administrators and engineers; it is the crossroads of Web operations, DevOps, enterprise computing, educational computing, and research computing. The conference serves as a venue for a lively, diverse, and rich mix of technologists of all specialties and levels of expertise. LISA is the place to teach and learn new skills, debate current issues, and meet industry gurus, colleagues, and friends. The 6-day event offers training by industry leaders; invited talks; the latest research through refereed papers, practice and experience reports, posters, and workshops; answers to your toughest questions; and that all-important face-to-face time with experts in the community.
Information: http://static.usenix.org/events/lisa12/index.html.

9–16 **Fourth Russian-Armenian workshop on mathematical physics, complex analysis and related topics**, Institute of Mathematics, Siberian Federal University, Krasnoyarsk, Russian Federation.
Description: We plan to publish the abstracts of the accepted talks. The abstract should be prepared (in Russian or English) in LaTeX according to the template and using the conference LaTeX class file rus-am.cls. Both can be downloaded here. The abstracts (both tex and pdf files) should be sent by e-mail, using the address above.
Information: http://conf.sfu-kras.ru/conf/math2012/info.

10–12 **3rd IMA Conference on Numerical Linear Algebra and Optimisation**, University of Birmingham, United Kingdom. (Feb. 2012, p. 340)
Scope: The success of modern codes for large-scale optimisation is heavily dependent on the use of effective tools of numerical linear algebra. On the other hand, many problems in numerical linear algebra lead to linear, nonlinear or semidefinite optimisation problems. The purpose of the conference is to bring together researchers from both communities and to find and communicate points and topics of common interest.
Topics: Include any subject that could be of interest to both communities, such as: Direct and iterative methods for large sparse linear systems, eigenvalue computation and optimisation, large-scale nonlinear and semidefinite programming, effect of round-off errors, stopping criteria, embedded iterative procedures, optimisation issues for matrix polynomials, fast matrix computations, compressed/sparse sensing, PDE-constrained optimisation, applications and real time optimisation.
Information: http://www.ima.org.uk/conferences/conferences_calendar/numerical_linear_algebra_and_optition.cfm.

10–13 **3rd International Conference of the Moroccan Society of Applied Mathematics (SM2A)**, Cadi Ayyad University, Marrakesh, Morocco.
Description: The Moroccan Society of Applied Mathematics (SM2A) organizes its Third International Conference in Marrakech from 10 to 13 September 2012. This conference follows the first two sessions held in Rabat in 2008 and 2010 respectively and having been attended by over 250 researchers from, Europe, the United States, Africa and Morocco. This third conference aims to consolidate all the developed efforts, enabling Moroccan mathematicians to review research in the field of applied mathematics, explore opportunities for cooperation and exchanges with their mates in the region and worldwide and enable young researchers in the region of North Africa to get in or regain contact with researchers of international renown.
Information: http://sm2a-2012.ucam.ac.ma/en/index.html.

10–14 **6th International Conference on Stochastic Analysis and its Applications**, The Mathematical Research and Conference Center of the Institute of Mathematics of the Polish Academy of Sciences, Bedlewo, Poland. (May 2012, p. 716)
Description: The conference will be the 6th in a series of international conferences on Stochastic Analysis and Its Applications. The previous ones were held at Seattle (2006), Seoul (2008), Beijing (2009), Osaka (2010) and Bonn (2011). The main topics of the conference are 1. Dirichlet forms and stochastic analysis; 2. Jump processes; 3. Stochastic partial differential equations; 4. Stochastic analysis and geometry; 5. Optimal transport and allocation problems; 6. Potential theory; 7. Random media, percolation clusters and fractals; 8. Stochastic models in physics and biology
Information: http://bcc.impan.pl/6ICSA/.

* 10–14 **Indo-Spanish Conference on Geometry and Analysis**, ICMAT, Madrid, Spain.
Description: This conference is dedicated to M. S. Narasimhan for his 80th birthday.
Speakers: V. Balaji (CMI, Chennai), D. Faraco (ICMAT & UAM, Madrid), M. Garcia-Fernandez (QGM, Aarhus), L. Goettsche (ICTP, Trieste), T. Gomez (ICMAT, Madrid), G. Harder (MPI, Bonn), N. Hitchin (Oxford), Y. Holla (TIFR, Mumbai), J. N. Iyer (IMSc, Chennai), V. Mehta (TIFR, Mumbai), I. Mundet i Riera (UB, Barcelona), E. K. Narayanan (IISc, Bangalore), P. Newstead (Liverpool), N. Nitsure (TIFR, Mumbai), J. Parcet (ICMAT, Madrid), C. Pauly (ICMAT Madrid & Nice), M. S. Raghunathan (TIFR, Mumbai), S. Ramanan (CMI, Chennai), K. Rogers (ICMAT, Madrid), R. Rubio (Oxford), R. Sarkar (ISI, Kolkata), J. Sengupta (TIFR, Mumbai), S. Thangavelu (IISc, Bangalore), X. Tolsa (ICREA, UAB, Barcelona), V. Trivedi (TIFR, Mumbai).
Information: http://www.icmat.es/congresos/isc2012/; http://www.icmat.es/facilities/howtoarrive.

10–15 **International Conference on Nonlinear PDE & Free Surface and Interface Problems Workshop**, Oxford, United Kingdom.
Description: The main objective of the conference is to bring together scientists with interests in the analysis of nonlinear partial differential equations (PDE) and their applications to present recent developments and explore new connections between nonlinear PDE and other areas in mathematics and related fields in the sciences. Held at the Maths Institute, Oxford, there will be 12 lectures and 8 mini-symposium sessions over 4 days (Monday to Thursday). The workshop will be held at St. Anne's College, Oxford, and consist of three sessions, each three hours in duration (Friday and Saturday).
Theme: The theoretical and numerical aspects of nonlinear hyperbolic and dispersive free boundary and interface problems.
Speakers: Luigi Ambrosio, Constantine Dafermos, Isabelle Gallagher, Martin Hairer, Fanghua Lin, Pierre-Louis Lions, Felix Otto, Frank Pacard, Richard Schoen, Gigliola Staffilani, Andrew Majda, Eitan Tadmor.
Information: http://www.maths.ox.ac.uk/groups/oxpde/events.

10–December 14 **Materials Defects: Mathematics, Computation and Engineering**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California. (Oct. 2011, p. 1325)
Description: Material defects prsent a huge challenge for mathematical modeling and simulation, as anything that breaks up the regular, homogenous structure of a calculation requires special consideration. In recent years, there has been particular focus on the multiscale nature of materials research—how computational methods and mathematical models for describing materials vary from the atomistic to the continuum scale. This program aims to promote collaboration among scientists to assess the current status of defect modeling, promote the development of new computational techniques, and stimulate new applications. An application is available online. Encouraging the careers of women and minority mathematicians and scientists is an important component of IPAM's mission and we welcome their applications.
Information: http://www.ipam.ucla.edu/programs/md2012/.

11–14 **Workshop on Operator Theory and Operator Algebras 2012–WOAT 2012**, Instituto Superior Técnico, Universidade Técnica de Lisboa, Portugal. (May 2012, p. 717)
Description: The main scientific goal of WOAT 2012 is to present developments in operator theory, operator algebras and their applications, and to promote research exchanges in the operator theory and operator algebras areas. This workshop is dedicated to Professor António Ferreira dos Santos.
Information: http://www.math.ist.utl.pt/~woat2012.

12–14 **Algebra Geometry and Mathematical Physics – 8th workshop – Brno 2012**, Faculty of Mechanical Engineering, Brno University of Technology, Czech Republic. (Mar. 2012, p. 455)
Description: AGMP is the traditional scientific meeting on contemporary topics in Algebra, Geometry and Mathematical Physics, with an emphasis on the interface between them. The aim of the conference is to bring together researchers in these disciplines. The meeting is organized in Brno, the city in the geographical center of Europe. All participants are encouraged to present a contributed talk. The proceedings of the conference is planned to be published as a special number of an established journal.
Information: http://agmp.eu/brno12/general.php.

* 12–14 **Conference on Geometric Measure Theory**, University Paris Diderot (Paris 7), Paris, France.
Description: This conference in geometric measure theory will focus on the latest fundamental developments in the field as well as recent applications to and interactions with differential geometry, probability theory, real analysis and partial differential equations. It will be held on the new campus Paris Rive Gauche of University Paris Diderot (Paris 7).
List of Speakers: Raphael Cerf, Camillo De Lellis, Nicola Fusco, Jan Maly, Andre Neves, Herve Pajot, David Preiss, Severine Rigot, Tristan Riviere, Antonio Ros, Neshan Wickramasekera.
Organizers: Thierry De Pauw, Antoine Lemenant, Vincent Millot.
Information: http://www.ljll.math.upmc.fr/~lemenant/GMT/index.html.

17–19 **IMA Conference on Mathematics of Medical Devices and Surgical Procedures**, University of London, United Kingdom. (Apr. 2012, p. 592)
Description: The conference programme will include keynote speakers drawn from both clinical and mathematical communities, along with contributed presentations and poster sessions. The programme will also include breakout sessions in certain topics as well as refreshment breaks for informal discussions. Social events include a drinks reception and a conference dinner.

Topics: The topics that will be discussed will broadly include cardiovascular devices, medical imaging, ophthalmology, cell biology, disease transmission, orthopaedic, advanced simulations, as well as health in ageing.
Information: http://www.ima.org.uk/conferences/conferences_calendar/maths_of_medical_devices_&_surgical_procedures.cfm.

17–21 **ICERM Workshop: Bayesian Nonparametrics**, ICERM, Providence, Rhode Island. (Jan. 2012, p. 106)
Description: Data-rich investigations need advanced tools for allowing data to inform and interact with models. Bayesian Nonparametrics is a rapidly growing subfield of statistics and machine learning that provides a framework for creating complex statistical models that are both expressive and tractable. Recent successful applications of nonparametric Bayesian models across a variety of domains suggests that these models have the potential for wide use. The challenge of constructing and using models on very high-dimensional or even infinite-dimensional spaces creates many opportunities for fruitful interactions between mathematicians, statisticians, and computer scientists. Areas of interest include prior construction, posterior inference, posterior asymptotics, algorithmic development, and practical applications.
Information: http://icerm.brown.edu/sp-f12-w1.

17–21 **Summer School on New Trends in Harmonic Analysis, Fractional Operator Theory, and Image Analysis**, Inzell, Germany. (Apr. 2012, p. 592)
Description: Recently, focus has been placed on the detection and classification of singularities in images possessing fractional or fractal characteristics. Therefore, investigations center on fractional operator-like bases acting as multiscale versions of derivatives. This new methodology needs to firmly embed into the existing classical concepts of harmonic analysis, and the relations to image analysis have to be established and unified. To achieve the greatest possible synergy between the areas of harmonic analysis, fractional operator theory and image analysis, we have invited seven highly renowned researchers from these fields. The goal of the summer school is to bring together young researchers and a distinguished group of scientists whose lectures are intended to establish new and exciting directions for future investigations.
Information: http://www-m6.ma.tum.de/Lehrstuhl/Inzell2012.

18–21 **Dynamical systems on random graphs**, Cantabria, Spain.
Description: This conference aims to bring together mathematical physicists, experts in dynamical systems and neuroscientists, all with research interests in graph theory, networks, complex systems, continuous dynamical systems on random graphs and heterogeneous media, and their applications. The conference will comprise 4 sessions, each devoted to a different topic: random graphs and spectral theory, point models (e.g., neural networks or coupled ODEs), spatial models (e.g., quantum graphs or detailed neuron models) and complex networks. We plan to allow a significant amount of time for interdisciplinary discussion.
Speakers: Gustavo Deco (Universitat PompeuFabra, Barcelona, Spain), Krešimir Josić (University of Houston, USA), Bojan Mohar (Simon Fraser University, Canada), Uzy Smilansky (Weizmann Institute, Israel, and Cardiff University, UK).
Information: http://www.uni-ulm.de/dsrg2012.

19–21 **School on Singular Analysis**, University of Hanover, Germany.
Description: The school is aimed at doctoral students and offers introductory and advanced courses on the analysis of singular spaces. What the courses have in common is the use of pseudodifferential techniques to approach problems ranging from spectral theory to global analysis and nonlinear PDEs. Partial support for doctoral students is available.
Information: http://www.math-conf.uni-hannover.de/ana12/.

19–25 **ICNAAM2012: 3rd Symposium on Semigroups of Linear Operators and Applications**, Kypriotis Hotels and Conference Center, Kos, Greece. (Mar. 2012, p. 455)
Description: The 3rd Symposium on Semigroups of Linear Operators and Applications brings together researchers from all over the world to present new results in the theory of semigroups of linear operators and its applications. Besides scheduling talks from established mathematicians, we will give opportunity to junior researchers to present their works.
Information: http://www.fih.upt.ro/personal/dan.lemle/conferinte/Lemle_Simpozion_2012.pdf.

20–22 **Lie and Klein; the Erlangen program and its impact on mathematics and physics**, Institut de Recherche Mathématiqué Avancé, University of Strasbourg, France. (Nov. 2011, p. 1495)
Description: The theme is "Lie and Klein; the Erlangen program and its impact on mathematics and physics".
Organizers: Lizhen Ji and Athanase Papadopoulos.
The invited speakers are: Norbert A.'Campo (Basel), Gérard Besson (Grenoble), Pierre Cartier (IHES), Hubert Goenner (Göttingen), Misha Gromov (IHES), to be confirmed, Frances Kirwan (Oxford), to be confirmed, Vladimir Matveev (Jena), Catherine Meusburger (Erlangen), Pierre Py (Strasbourg), Jean-Marc Schlenker (Toulouse), Alexei Sossinsky (Moscow), Anna Wienhard (Princeton).
Language: English. Graduate students and young mathematicians are welcome.
Reservations: Hotel booking can be asked for through the registration link. Contact: email: lji@umich.edu and athanase.papadopoulos@math.unistra.fr.
Information: http://www-irma.u-strasbg.fr/article1173.html.

20–October 20 **ERC research period on Diophantine geometry**, Centro di Ricerca Matematica "Ennio De Giorgi", Scuola Normale Superiore, Piazza dei Cavalieri 3, 56100 Pisa, Italy. (May 2012, p. 717)
Description: This event is part of the European Research Council programme. Beyond the natural scientific exchange among participants, the activities should consist of seminars. The event should focus on integral points, algebraic dynamics, unlikely intersections.
Scientific committee: Enrico Bombieri (Institute for Advanced Study), David Masser (University of Basel), Lucien Szpiro (Graduate Center, CUNY), Gisbert Wuestholz (ETH, Zürich) and Shou-Wu Zhang (Columbia University and Princeton University).
Local committee: Pietro Corvaja (University of Udine), Roberto Dvornicich (University of Pisa), Umberto Zannier (Scuola Normale Superiore, ERC coordinator).
Attendance/Registration/Financial Support: Is free, but registration is required. To register please link to http://www.crm.sns.it/event/242/registration.html. Financial support is available for invited participants only.
Information: http://www.crm.sns.it, crm@sns.it; http://www.crm.sns.it/event/242/.

22–23 **AMS Eastern Section Meeting**, Rochester Institute of Technology, Rochester, New York. (Sept. 2011, p. 1187)
Information: http://www.ams.org/meetings/sectional/sectional.html.

24–27 **Eighth National Congress on Finite Element Method**, School of Mathematical Sciences, Nankai University, 94 Weijin Road, Nankai District, Tianjin 300071, China. (May 2012, p. 717)
Description: The Eighth National Congress on Finite Element Method will be held in Nankai University in Tianjin on September 24-27, 2012. This congress aims at providing a forum for computational mathematicians, scientists and engineers to meet and exchange ideas, research results and state-of-the-art themes and topics in

various scientific and engineering disciplines related to finite element methods.
Information: http://www.math.nankai.edu.cn/conference/fem8/8thfem_Eg/Home.

24–27 **56th Annual Meeting of the Australian Mathematical Society**, University of Ballarat, Mt. Helen Campus, Victoria, Australia. (Apr. 2012, p. 592)
Plenary Speakers: Henning Haahr Andersen (Aarhus University), Michel Brion (Université Joseph Fourier, Grenoble), Sidney A. Morris (University of Ballarat), Mary Myerscough (University of Sydney), Assaf Naor (Courant Institute of Mathematical Sciences, New York University), Narutaka Ozawa (Research Institute for Mathematical Sciences, Kyoto University), Aidan Sims (University of Wollongong), Kate Smith-Miles (Monash University), Fedor Sukochev (University of New South Wales), Benar F. Svaiter (Institute of Pure and Applied Mathematics, Rio de Janeiro), Neil Trudinger (Australian National University).
Information: http://www.ballarat.edu.au/austms2012.

24–28 **Mathematics and Physics of Moduli Spaces**, Heidelberg University, Germany. (May 2012, p. 717)
Description: The main thematic focus is higher Teichmueller spaces and the various contexts in which they arise in theoretical physics. The goal of this activity is to make recent developments accessible to both mathematicians and physicists. The program will consist of lecture series given by Vladimir Fock, Edward Frenkel, Sergei Gukov, Francois Labourie, Greg Moore (tbc) and Joerg Teschner and a few additional talks. There will be plenty of time for informal discussions. Young researchers can apply for financial support to attend the workshop at the webpage.
Information: http://www.match.uni-heidelberg.de/MPMS/.

26–29 **Tensors and Their Geometry in High Dimensions**, University of California, Berkeley, Berkeley, California.
Description: Berkeley RTG on Representation Theory, Geometry, and Combinatorics will host a workshop on "Tensors and Their Geometry in High Dimensions", featuring Andrew Snowden, Jan Draisma, and Giorgio Ottaviani giving mini-courses. There will also be opportunities for some of the other participants to give related talks.
Information: For details visit: http://math.berkeley.edu/~oeding/RTG/index.html. There are no registration fees; however participants are kindly asked to register online. There may be some funding for young researchers.

October 2012

1–5 **New trends in Dynamical Systems**, Salou, Catalonia, Spain. (Feb. 2012, p. 340)
Goal: To show the recent developments in Dynamical Systems. Precisely, we will focus on Qualitative theory of differential equations, discrete dynamical systems (real and complex) and applications to Celestial mechanics.
Sessions: The conference will have about 30 plenary sessions (no parallel sessions) and a poster session. We plan about 150 participants.
Information: http://www.gsd.uab.cat/ntds2012/index.php.

1–April 30 **Semester on Curves, Codes, Cryptography**, Sabanci University, Istanbul, Turkey. (Feb. 2012, p. 340)
Description: A series of events (workshops, conferences, visits, talks) are organized at Sabanci University with the purpose of providing a platform to present state-of-the-art results as well as to discuss open problems on various topics including: Algebraic curves over finite fields (towers of function fields, modular towers, maximal curves), coding theory (list decoding, polar codes, algebraic coding), sequences over finite fields, pseudorandom sequences (measures of randomness, generation of pseudorandom numbers, complexity), functions over finite fields (polynomials. permutations, polynomial systems, rational functions), exponential sums, cryptographically significant functions.
Supporter: This semester is supported by Sabanci University and TUBITAK.
Information: http://sccc.sabanciuniv.edu.

2–4 **SIAM Conference on Mathematics for Industry: Challenges and Frontiers (MI12)**, The Curtis, A Doubletree by Hilton, Denver, Colorado. (Aug. 2011, p. 1014)
Description: The SIAM conferences on Mathematics for Industry focus attention on the many and varied opportunities to promote applications of mathematics to industrial problems. From the start of planning for these conferences, the major objective has been the development and encouragement of industrial, government and academic collaboration. The format of this conference provides a forum for industrial and government engineers and scientists to communicate their needs, objectives and visions, to the broad mathematical community.
Information: http://www.siam.org/meetings/mi12/.

* 3–4 **National Seminar on Current Research and Developments in Mathematics and Computing (CRDMC-2012)**, Aliah University, Kolkata, India.
Description: The main objective of the seminar is to promote mathematical research and to focus on the recent developments in different areas of mathematics and its computational aspects. The conference will provide ideal platform for the young researchers throughout the country to interact with senior scientists, to exchange their views and ideas, also to make possible scientific collaboration with them. Another objective of the seminar is to highlight the works of S. Ramanujan in the context of present day research and developments in mathematics, especially in the field of number theory. The programme will consist of invited lectures by eminent mathematicians and scientists, contributed papers in various technical sessions.
Deadlines: Last date of receipt of abstract: July 31, 2012. Communication to selected candidates: August 15, 2012. Last date of receipt of full paper: August 20, 2012. A peer reviewed proceedings of the seminar will be published by a reputed publisher.
Information: http://www.aliah.ac.in/Math_Brochure.pdf.

3–6 **International Conference on Applied and Computational Mathematics (ICACM)**, Middle East Technical University (METU), Ankara, Turkey. (Oct. 2011, p. 1325)
Description: ICACM marks the 10th anniversary of the IAM at METU and aims to highlight the recent advances in applied and computational mathematics as well as to demonstrate their applicability in science, engineering and industry. In addition to the traditional and strong focus on applied and computational mathematics, the special emphasis will be given to information security and cryptology, financial mathematics, actuarial sciences, scientific computing and their applications. Furthermore, the proceedings of the conference will be published by the Journal of Computational and Applied Mathematics (JCAM) as a special issue.
Keynote talks: Will be given by Dr. Peter Deuflhard and Dr. Avner Friedman. The conference will welcome also the invited speakers, Dr. Marc Goovaerts, Dr. Gary McGuire, Dr. Florian Hess, Dr. Monique Jeanblanc, Dr. Jurgen Jost, Dr. Ralf Korn, Dr. Karl Kunisch, Dr. Bernt Oksendal, Dr. Krzysztof M. Ostaszewski, Dr. Monique Pontier, Dr. Bart Preneel, Dr. Halil Mete Soner, Dr. M. Grazia Speranza.
Information: http://www.iam.metu.edu.tr/icacm/.

5–7 **Yamabe Memorial Symposium (50th anniversary)**, University of Minnesota, Minneapolis, Minnesota.
Theme: "Geometry and Analysis".
Speakers: The 8 confirmed speakers are: Huai-Dong Cao, Jean-Pierre Demailly, Benson Farb, Robert Hardt, Misha Kapovich, Conan Leung, Natasa Sesum, and Ben Weinkove.

Financial support: Has been provided by NSF to defray expenses for a number of participants. Highest preference will be given to younger scientists (grad students, postdocs, young faculty), but some funds will be reserved for more senior mathematicians. Applications from women and underrepresented minorities are especially encouraged. For more details and an application form, please consult our website.
Information: http://www.math.umn.edu/yamabe/2012/.

6–8 **The Legacy of Daniel Quillen: K-theory and Homotopical Algebra**, Massachusetts Institute of Technology, Cambridge, Massachusetts.
Description: This conference celebrates the many fundamental contributions of Daniel Quillen.
Speakers: Luchezar Avramov, Jaochim Cuntz, Eric Friedlander, Tom Goodwillie, Lars Hesselholt, Michael Hopkins, Jean-Louis Loday, Christophe Soule, Dennis Sullivan, Douglas Ravenel, Ulrike Tillmann, Mathai Varghese.
Information: http://math.mit.edu/quillen/.

8–12 **ICERM Workshop: Uncertainty Quantification**, ICERM, Providence, Rhode Island. (Jan. 2012, p. 106)
Description: Rapid growth in computational resources has heightened the expectation that scientific knowledge can indeed be a driver for societal well-being and betterment. At the same time, our ability to measure the natural and social world around has significantly increased, aided by technological development in sensors, the Internet, and other modalities of communication. Science is thus faced, simultaneously, with a complex description of reality at an unprecedented resolution, and the possibility to describe this reality with mathematical models of increasing complexity. Probabilistic formulations of physical problems can be viewed as attempts to adapt rational procedures to this complexity, while tackling the conceptual challenges they inevitably present. As a testament to the significance of this confluence of mathematics, science, and technology, Uncertainty Quantification is arguably one of the fastest growing sub-disciplines in mechanics.
Information: http://icerm.brown.edu/sp-f12-w2.

8–12 **Workshop on geometry and statistics in bioimaging: Manifolds and stratified spaces**, Sandbjerg Estate, Sonderborg, Denmark.
Description: This workshop is dedicated to geometric and statistical modeling in biomedical image analysis. The workshop is a result of our desire to bring together researchers from biomedical image analysis, who have an interest in the underlying mathematical constructions, along with mathematicians who have an interest in the underlying practical problems.
Invited Speakers: Alfred Bruckstein, Technion, Israel Institute of Technology; James Damon, University of North Carolina, Chapel Hill; Herbet Edelsbrunner, Duke University and Institute of Science and Technology, Austria; Stephan Huckemann, Universität Göttingen; Sarang Joshi, University of Utah; Steve Marron, University of North Carolina; Peter W. Michor, Universität Wien; Ezra Miller, Duke University; David Mumford, Brown University; Megan Owen, University of Waterloo; Xavier Pennec, INRIA Sophia Antipolis; Steven W. Zucker, Yale University.
Information: http://csgb.dk/activities/2012/geostat/.

9–11 **Algerian-Turkish International Days on Mathematics 2012, "ATIM'2012"**, Badji Mokhtar Annaba University, Annaba, Algeria. (Apr. 2012, p. 593)
Aim: Of this conference is to provide a platform for scientific experts in mathematics to present their recent works, exchange ideas and new methods in this important area and to bring together mathematicians to improve collaboration between local and international participants. We are looking forward to meeting you in Annaba at ATIM'2012.
Organizers: Jointly organized by the Laboratory of Advanced Materials, Badji Mokhtar Annaba University and Fatih University, Istanbul, Turkey.
Information: http://www.univ-annaba.org/ATIM2012/.

11–13 **4th Berlin Workshop on Mathematical Finance for Young Researchers**, Humboldt Universitaet zu Berlin, Berlin, Germany.
Description: The 4th Berlin Workshop on Mathematical Finance for Young Researchers provides a forum for Ph.D. students, postdoctoral researchers and young faculty members from all over the world to discuss their research in an informal atmosphere.
Lectures: Keynote lectures will be given by Freddy Delbaen (Zurich) Rüdiger Frey (Vienna), Steven Shreve (Pittsburgh). We also invite up to 15 contributed papers from young researchers.
Accommodation and Support: Expenses for speakers will be covered. Very limited support for travel expenses may also be available upon request. The closing date for submissions to http://finance@math.hu-berlin.de is June 15th, 2012. Notification of acceptance will be sent by July 15, 2012.
Information: http://www.qfl-berlin.com/workshop2012.

12–14 **The International Workshop on Functional Analysis**, West University of Timisoara, Timisoara, Romania.
Description: This workshop is organized as part of the project "Cross-Border Research of Functional Analysis and Differential Equations" which is held under the framework of the Hungary-Romania Cross-Border Co-operation Programme 2007-2013 (http://www.huro-cbc.eu).
Topics: Include (but are not limited to): Operator theory, representation theory, differential equations, invariant subspaces, function theory, systems theory, optimization theory, differential geometry, spectral theory, wavelet analysis, Fourier analysis, mathematical physics, topological methods.
Deadline: For online registration is September 15, 2012. There will be no registration fee.
Information: http://wfa.info.uvt.ro.

13–14 **AMS Southeastern Section Meeting**, Tulane University, New Orleans, Louisiana. (Aug. 2011, p. 1014)
Information: http://www.ams.org/meetings/sectional/sectional.html.

15–19 **Higher Teichmüller-Thurston Theory**, Centre de recherches mathématiques, Montreal, Canada.
Overview: Higher Teichmüller-Thurston theory, among other things, deals with deformation spaces of locally homogeneous geometric structures on manifolds, representations of fundamental grohps of surfaces, and flat connections. This workshop will focus on the side of the subject dealing with conformally flat Lorentzian metrics, geometric structures arising from Anosov representations, and the geometry of the hitchin components which extends the Weil-Petersson geometry of Teichmüller sdpace. In particular recent work on realizing Anosov representations as geometric structures on closed manifolds, the pressure metric on Hitchin representations, as well as tameness results for flat Lorentzian manifolds, will be among the topics discussed at the workshop.
Information: http://www.crm.umontreal.ca/2012/Thurston12.

15–19 **School on Conformal Blocks in ICMAT-Madrid**, Madrid, Spain.
Aim: The aim of the school is to report on recent progress made in the mathematical theory of Conformal Blocks and to give an introduction to the different areas where Conformal Blocks have emerged: Unitarity of the KZ/Hitchin connection, divisors over the moduli space of n-pointed rational curves, identification between the conformal field theory construction of: Topological Quantum Field Theory (tqft) and the tqft based on knot theory, toric algebras and combinatorics of the Verlinde formula.

Speakers: J. Andersen (Aarhus), P. Belkale (Chapel Hill), N. Fakhruddin (Mumbai), N. Giansiracusa (ZE. Looijenga (Utrecht), C. Manon (Berkeley), T. R. Ramadas (Trieste).
Organizing committee: L. Alvarez-Consul (ICMAT), M. Bolognesi (Rennes), T. L. Gomez (ICMAT), C. Pauly (ICMAT and Nice).
Accommodation/Funding: We can offer accommodation and travel reimbursement to a limited number of participants, depending on funding.
Contact: email: michele.bolognesi@univ-rennes1.fr.
Information: A detailed programme with the contents of the lectures will be available online shortly: http://confblocks.sciencesconf.org.

18 **2nd Annual Symposium on Large-Scale Inference**, AFI Silver Theatre and Cultural Center, Silver Spring, Maryland.
Description: Social & Scientific Systems, Inc. hosts its 2nd Annual Symposium on Large-Scale Inference.
Keynote Speaker: Dr. Carl N. Morris, Professor of Statistics, Harvard University.
Information: Please RSVP to: http://LargeData@s-3.com.

18–21 **First International Conference on Analysis and Applied Mathematics**, Gumushane University, Gumushane, Turkey.
Description: We are proud to announce the First International Conference on Analysis and Applied Mathematics. The aim of this conference is to bring together mathematicians working in the area of analysis and applied mathematics to share new trends of applications of math. In mathematics, the developments in the field of applied mathematics open new research areas in analysis and vice versa. That is why we plan to found a journal to provide a forum for researchers and scientists to communicate their recent developments and to present their original results in various fields of analysis and applied mathematics.
Information: http://icaam2012.gumushane.edu.tr.

20–21 **AMS Central Section Meeting**, University of Akron, Akron, Ohio. (Aug. 2011, p. 1014)
Information: http://www.ams.org/meetings/sectional/sectional.html.

22–26 **AIM Workshop: Lipschitz metric on Teichmüller space**, American Institute of Mathematics, Palo Alto, California. (May 2012, p. 717)
Description: This workshop, sponsored by AIM and the NSF, will be devoted to recent developments and new directions in Teichmüller theory from the point of view of Thurston's Lipschitz metric.
Information: http://aimath.org/ARCC/workshops/lipschitzteich.html.

* 22–28 **Conference on Cycles, Calibrations and Nonlinear PDE**, Stony Brook University, Stony Brook, New York.
Description: This conference is being held in honor of Blaine Lawson's 70th birthday. The meeting will cover a wide range of topics centered around developments over the past decade or so in the geometry of cycles, calibrations and relations with nonlinear PDE and applications to physics. There will be an embedded workshop for younger participants. Funding is available to cover at least a portion of expenses, especially for junior participants. For further details, please consult the website of the conference.
Information: http://www.math.sunysb.edu/~cycles2012.

24–26 **DIMACS Workshop on Recent Work on Differential Privacy across Computer**, DIMACS Center, CoRE Building, Rutgers University, Piscataway, New Jersey.
Description: Presented under the auspices of the DIMACS Special Focus on Information Sharing and Dynamic Data Analysis and the DIMACS Special Focus on Cybersecurity. The last few years have seen an explosion of results concerning differential privacy across many distinct but overlapping communities: Theoretical Computer Science, Databases, Programming Languages, Machine Learning, Data Mining, Security, and Cryptography. Each of these different areas has different priorities and techniques, and despite very similar interests, motivations, and choice of problems, it has become difficult to keep track of this large literature across so many different venues. The purpose of this workshop is to bring researchers in differential privacy across all of these communities together under one roof to discuss recent results and synchronize our understanding of the field. The first day of the workshop will include tutorials, representing a broad cross-section of research across fields. The remaining days will be devoted to talks on the exciting recent results in differential privacy across communities, discussion and formation of interesting open problems, and directions for potential inter-community collaborations.
Organizers: Aaron Roth, University of Pennsylvania; email: aaroth@cis.upenn.edu; Adam Smith, Pennsylvania State University, email: asmith@cse.psu.edu.
Information: email: workshop@dimacs.rutgers.edu; http://dimacs.rutgers.edu/Workshops/Differential-Privacy/.

24–26 **International Conference in Modeling Health Advances 2012**, San Francisco, California. (Mar. 2012, p. 456)
Description: The conference ICMHA'12 is held under the World Congress on Engineering and Computer Science WCECS 2012. The WCECS 2012 is organized by the International Association of Engineers (IAENG), a non-profit international association for the engineers and the computer scientists. The congress has the focus on the frontier topics in the theoretical and applied engineering and computer science subjects. The last IAENG conference attracted more than five hundred participants from over 30 countries. All submitted papers will be under peer review and accepted papers will be published in the conference proceeding (ISBN: 978-988-19251-6-9). The abstracts will be indexed and available at major academic databases.
Deadline: Draft Paper Submission Deadline: July 2, 2012.
Information: http://www.iaeng.org/WCECS2012/ICMHA2012.html.

24–26 **International Conference in Number Theory and Applications 2012 (ICNA 2012)**, Department of Mathematics, Faculty of Science, Kasetsart University, Bangkok, Thailand. (Apr. 2012, p. 593)
Aim: Providing a forum for researchers, teachers, students and people interested in Number Theory and Applications to present, exchange and get in touch with one another in a relaxed atmosphere. The academic program of the conference consists of invited lectures by leading mathematicians in the field of Number Theory and Applications and sessions for contributed talks, which will be included in a special issue of the *East-West Journal of Mathematics* after a peer review process. There will also be a social banquet (included in the registration fee) and a sight-seeing tour (not included in the registration fee).
Information: http://maths.sci.ku.ac.th/icna2012.

* 26–28 **History and Pedagogy of Mathematics (HPM) Americas Section 2012 West Coast Meeting**, University of California, Berkeley, California.
Description: Special features of this meeting include a rare book exhibit and a visit to the Lawrence Hall of Science. This is a first call for papers to be presented at the meeting. HPM seeks a variety of talks on relations between the history and pedagogy of mathematics. Talks will be about 30 minutes long. Because of time constraints, we cannot guarantee that all submissions for talks will be accepted. Priority will be given to speakers who have not spoken at recent HPM meetings. Prospective speakers should send a title and abstract, as well as their own contact information, to Kathy Clark at drkclark@gmail.com by September 26, 2012. Contact Amy Ackerberg-Hastings, aackerbe@verizon.net, for information on registration or visit the website.
Information: http://www.hpm-americas.org.

27–28 **AMS Western Section Meeting**, University of Arizona, Tucson, Arizona. (Aug. 2011, p. 1014)
Information: http://www.ams.org/meetings/sectional/sectional.html.

29–31 **The 17th edition of the Symposium on Solid and Physical Modeling**, University of Burgundy, Dijon, France. (May 2012, p. 717)
Description: The Symposium on Solid and Physical Modeling 2012 (SPM'2012) is organized in cooperation with SIAM and in cooperation with ACM SIGGRAPH (pending).
Focus: The focus of the conference is on the mathematical and computational issues that arise in generating, analyzing, and processing geometric information in applications such as: mechanical design, process planning, manufacturing, bio-medical, games, animation, geology, and virtual reality. The proceedings of SPM2012, including full papers and short papers, will be published as a special issue of the *Journal of Computer Aided Design* (Elsevier). Technical papers should present previously unpublished, original results that are not simultaneously submitted elsewhere. All papers will be rigorously peer-reviewed by members of the international program committee.
Important Dates: Abstracts Due: March 25, 2012. Paper Submissions Due: April 2, 2012.
Information: http://spm12.u-bourgogne.fr; http://spm12.u-bourgogne.fr.

29–November 2 **Cluster Algebras in Combinatorics, Algebra, and Geometry**, Mathematical Sciences Research Institute, Berkeley, California. (May 2012, p. 717)
Description: Cluster algebras provide a unifying algebraic/combinatorial framework for a wide variety of phenomena in settings as diverse as quiver representations, Teichmuller theory, Poisson geometry, Lie theory, discrete integrable systems, and polyhedral combinatorics. The workshop aims at presenting a broad view of the state-of-the-art understanding of the role of cluster algebras in all these areas, and their interactions with each other.
Information: http://www.msri.org/web/msri/scientific/workshops/all-workshops/show/-/event/Wm570

29–November 2 **ICERM Workshop: Monte Carlo Methods in the Physical and Biological Sciences**, ICERM, Providence, Rhode Island. (Jan. 2012, p. 106)
Description: Monte Carlo methods are one of the main tools used to study the properties of complex physical, chemical, and biological systems. Since their introduction in the late 1940s, these methods have undergone a remarkable expansion and are now used in many other fields, including statistical inference, engineering, and computer science. However, the design and theoretical understanding of Monte Carlo methods is still a challenging topic, especially for those problems where rare events play the key role in determining algorithm performance. The aim of the workshop is to bring together specialists in the application areas who understand the specific challenges posed by realistic problems and have developed sophisticated tools to tackle these problems, and mathematicians developing methods for algorithm analysis, abstraction, and optimization.
Information: http://icerm.brown.edu/sp-f12-w3.

November 2012

1–2 **Central and Eastern European Software Engineering Conference in Russia 2012**, Digital October Center, Moscow, Russia. (Apr. 2012, p. 593)
Description: Organized since 2005, CEE-SECR is the key annual software event in Central and Eastern Europe that is regularly attended by about 800 participants from local industry. The conference was initially positioned as a Russian event; however, it attracted speakers from 20 countries and regular attendees from even more places, so in 2009 the conference was repositioned as a CEE event. The conference employs a double-blind review process producing a high quality program with acceptance rate about 35%.
Keynote speakers: From previous conferences includes Jeff Sutherland, Bertrand Meyer, Bjarne Stroustrup, Thomas Erl, Grady Booch, Ivar Jacobson, Erich Gamma, Michael Cusumano, Larry Constantine, Lars Bak, Michael Fagan, Bill Hefley, Rick Kazman, Yuri Gurevich, Steve Masters, Mark Paulk and other software thought leaders as well as VP-s and Technical Fellows of major high-tech corporations.
Information: http://www.cee-secr.org.

1–3 **The 13th International Conference of Mathematics and its Applications ICMA2012**, Department of Mathematics, "Politehnica" University of Timisoara, City of Timisoara, Romania. (May 2012, p. 717)
Description: The aim of the conference is to bring together mathematicians, engineers, economists, physicians from all over the world, with research interests in mathematics or in its applications and to attract original papers.
Topics: Mathematical Analysis and Applications, Algebra and Geometry, Computer Algebra Systems in Research, Applied Mathematics in Engineering, and Economics Probability and Statistics, Applications in Health and Clinical Research.
Information: http://www.mat.upt.ro/ICMA2012/index.htm.

5–7 **Ramanujan 125**, University of Florida, Gainesville, Florida.
Description: A conference to commemorate the 125th anniversary of Ramanujan's birth. Topics of the conference include all areas of mathematics influenced by Ramanujan.
Confirmed plenary speakers: Include George Andrews, Bruce Berndt, Christian Krattenthaler, Gérald Tenenbaum and Doron Zeilberger. Please let us know as soon as possible if you intend to participate in or would like to speak at our conference. We have some funding available for speakers and junior participants. Requests will be considered and decisions made by June 1, 2012.
Information: http://www.math.ufl.edu/~fgarvan/ramanujan125.html.

7–9 **International Conference on Advancement of Science and Technology (iCAST 2012)**, Kuantan, Pahang, Malaysia.
Description: iCAST2012 aims to provide an international forum for researchers to present and discuss recent advances and new findings in mathematics and its applications. Moreover, it should accelerate the growth of mathematics and its applications and their benefits to the community at large. The theme of the conference is Contemporary Mathematics, Mathematical Physics and Their Applications.
Information: http://iium.edu.my/icast/2012/.

9–10 **Blackwell Tapia Conference 2012**, Institute for Computational and Experimental Research in Mathematics (ICERM), 121 South Main Street, Providence, Rhode Island. (Feb. 2012, p. 340)
Description: This is the seventh in a series of biannual conferences honoring David Blackwell and Richard Tapia, two seminal figures who inspired a generation of African-American, Native American, and Latino/Latina students to pursue careers in mathematics. Carrying forward their work, this one-and-a-half-day conference will: Recognize and showcase mathematical excellence by minority researchers, recognize and disseminate successful efforts to address under-representation, inform students and mathematicians about career opportunities in mathematics, especially outside academia, provide networking opportunities for mathematical researchers at all points in the higher education/career trajectory. The conference will include a mix of activities including scientific talks; poster presentations; panel discussions; and ample opportunities for discussion and interaction.
Information: http://icerm.brown.edu/blackwell-tapia-2012.

12–14 **DIMACS Workshop on Information-Theoretic Network Security Program**, DIMACS Center, CoRE Building, Rutgers University, Piscataway, New Jersey.
Description: Presented under the auspices of the DIMACS Special Focus on Algorithmic Foundations of the Internet

and the DIMACS Special Focus on Cybersecurity. Information theoretic security has emerged as a promising new approach for achieving secure network communications at various protocol layers. In particular, it holds promise for wireless networks that have little or no infrastructure, possess limited computational resources, and are subject to dynamically changing environments. In recent years, this topic has been studied extensively for wireless networks with a view to providing guidelines for implementing associated techniques in current and future systems. Information theoretic security has intriguing connections to important areas of research including cryptography, signal processing, networking, and quantum computation. Thus, advancement of information theoretic security will benefit substantially from interaction with researchers from these diverse communities. The Workshop will be a collective forum for researchers and practitioners in network security, from academia as well as industry, which seeks to motivate and explore interdisciplinary collaborations. The Workshop will consist of invited talks by leading researchers and practitioners, and invited poster presentations by postdoctoral researchers and graduate students, punctuated by adequate time for discussion. Topics will include information theoretic security, secure coding, cryptography, wireless network security, quantum approach to security, and security in practical networks. General participation in the Workshop is open subject to seating limitations.
Organizers: Yingbin Liang, Syracuse University; email: yliang06@syr.edu; Prakash Narayan, University of Maryland; email: prakash@umd.edu.
Information: email: workshop@dimacs.rutgers.edu; http://dimacs.rutgers.edu/Workshops/NetworkSecurity/.

12–16 **Mal'tsev Meeting**, Sobolev Institute of Mathematics SB RAS, Novosibirsk, Russia.
Organizers: Sobolev Institute of Mathematics and Novosibirsk State University. In 2012, the event is dedicated to Vladimir P. Shunkov (1932-2011). The programme committee is headed by Academician Yurii L. Ershov and Corresponding Member of RAS Sergei S. Goncharov. The topics of the conference include group theory, ring theory, model theory, universal algebra, mathematical logic, computability theory, theoretical computer science, and related areas of mathematics. The scientific programme of the conference will consist of invited talks and contributions in sections. Abstracts will be published electronically.
Information: http://www.math.nsc.ru/conference/malmeet/12/index.html.

12–March 3, 2013 **A fixed point theorem for Meir-Keeler contractions and its applications to integral equations in ordered modular function spaces**, Semnan University, Semnan, Iran.
Description: The Banach contraction mapping principle is one of the pivotal results of analysis. Generalization of the above principle has been a heavily investigated branch of research. In particular, Meir and Keeler present the following fixed point theorem: Theorem: Let (X, d) be a complete metric space and $T : X \to X$ an operator. Suppose that for every $\epsilon > 0$ there exists $\delta > 0$ such that for $x, y \in X$, $\epsilon < d(x, y) < \epsilon + \delta$, then $d(Tx, Ty) < \epsilon$. Then, T admits a unique fixed point z and for any $x \in X$, the sequence $T^n x$ converges to z. On the other hand, it is well known that one of the standard proofs of Banach's fixed point theorem is based on Cantor's theorem in complete metric spaces. In this paper we present a fixed point theorem of Meir-Keeler type in ordered modular space. As an application we study the existence and uniqueness of a solution for an integral equation of Lipschitz type in a Musielak-Orlicz space.
Information: http://Semnan.ac.ir.

15–17 **Fourth International Conference for Young mathematicians on Differential Equations and Its Applications dedicated to Ya. B. Lopatinskii**, Donetsk National University, Universitetskaya str., 24, Donetsk, 83155, Ukraine.
Description: Conference sections: general theory of boundary value problems; nonlinear boundary value problems; operator methods; mathematical physics; ordinary differential equations and dynamic systems; applications of differential equations. The word "young" in the title means a general direction of the conference and its mathematical school form but doesn't mean any age limitations for the participants.
Official languages: English, Ukrainian, Russian.
Programm committee: B. V. Bazaliy, Yu. M. Berezanskii, V. P. Burskii, Ya. M. Dymarskii, G. Eskin, M. L. Gorbachuk, E . Ya. Khruslov, V. A. Ilyin, M. I. Ivanchov, N. D. Kopachevsky, A. M. Kovalev, A. A. Kovalevskii , A. I. Kozhanov, E. I. Moiseev, L. Nirenberg, B. Yo. Ptashnyk, V. V. Puhnachev, F. S. Rofe-Beketov, A. M. Samoilenko, A. P. Soldatov, V. I. Storozhev, N. N. Uraltseva, M. Yo. Vishik, A. E. Shishkov, V. V. Zharinov.
Information: http://www.math.donnu.edu.ua/conference/?lang=en.

16–18 **Special Functions, Partial Differential Equations and Harmonic Analysis, a conference in honor of Calixto P. Calderón**, Roosevelt University, 425 Wabash Ave, Chicago, Illinois. (May 2012, p. 717)
Description: A group of friends of Calixto P. Calderón have decided to organize a conference to celebrate his research and academic archivements in his long academic career.
Confirmed main speakers: Carlos Kenig, University of Chicago; Mario Milman, Florida Atlantic University; Yoram Sagher, Florida Atlantic University; Ahmed Zayed, DePaul University; Marshall Ash, DePaul University; Alberto Torchinsky, Indiana University; Richard Wheeden, Rutgers University; Robert Fefferman, University of Chicago; Jeff Lewis, University of Illinois at Chicago; Richard Askey, University of Wisconsin; Rodolfo Torres, University of Kansas; James Moller, University of Illinois at Chicago; Alexandra Bellow, Northwestern University.
Information: http://www.roosevelt.edu/calderon.

17 **Info-Metrics and Nonparametric Inference**, University of California Riverside, Riverside, California. (Mar. 2012, p. 456)
Description: The one-day conference is organized jointly by the Info-Metrics Institute, American University, and the Department of Economics of University of California, Riverside. Interest in nonparametric estimation and inference goes back half a century but has rapidly increased recently (especially with recent advances in computing power) with many new directions of research that cover a vast range of applications in different disciplines. Ongoing research on information-theoretic estimation and inference methods is similarly inter-disciplinary, involving information theory, engineering, mathematical statistics, econometrics and the natural sciences. This one-day conference will explore recent advances in the area of nonparametric estimation and inference and in info-metrics, which may help current and future research combining nonparametric procedures with information-theoretic methods. For more information, please visit our Info-Metrics Institute web page.
Information: http://www.american.edu/cas/economics/info-metrics/workshop/workshop-2012-november.cfm.

19–20 **International Seminar on History of Mathematics and Celebration of National Mathematics Year 2012 to Commemorate 125th Birth Year of Srinivasa Ramanujan**, Department of Mathematics & Statistics, Ramjas College, Delhi University, North Campus, Delhi 110007, India.
Focus: The Seminar will cover all aspects of the history of mathematics and, in particular, the following areas: Life and Achievements of Srinivasa Ramanujan; History of Mathematics in Educational Curricula; Mathematics and Indigenous Cultures of the World; Historical Aspects of Modern Mathematics. The academic sessions will consist

of invited talks, panel discussions and paper presentations. The Ramjas Seminar shall be followed by an International Conference on History of Mathematics at MD University, Rohtak, on November 21–24, 2012, along with the Annual Meeting of ISHM. Details are available at http://www.indianshm.com.
Organizers: Indian Society for History of Mathematics and Ramjas College, Delhi.
Deadline/Registration: Abstracts pertaining to the above are invited by October 1, 2012. Registered participants will be provided with free Conference Kit and meals at the Seminar venue. Shared accommodations for the outstation participants will be arranged in the University guest-houses. Those interested in accommodations in city hotels on payment may request them. Cultural programs and sightseeing tours for the participants could be arranged to nearby tourist places and historical monuments.
Contacts: Dr. Man Mohan, Convenor ISHM 2012, Ramjas College, Delhi, India; email: manmohan@indianshm.com; http://www.indianshm.com.

19–21 **Adventures in Mathematical Physics/Aventures en Physique Mathematique (25 èmes Entretiens Jacques Cartier)**, Université Lyon 1, Villeurbanne, Rhône, France.
Description: Among the selected themes, integrability stands in a privileged position, due to its importance as well as in different branches of physics, particularly in statistical physics and in elementary particle physics, as in several domains of algebra and geometry. Let us mention, as examples, the importance of random matrix theory in integrable systems and also in inflationary cosmology; the relationship between matrix models and topological string amplitudes; the role of integrability for scattering amplitudes in super-symmetric gauge theories. These are some of the subjects which will be discussed in this colloquium, in addition to other fields such as, in condensed matter physics, the algebraic field theoretical treatment of quantum wires, a subject directly related to nano-sciences; combinatory problems in connection with integrable models; the relevance of solitons in fluid dynamics (tsunamis) and, last but not least, the mathematical approach of tiling in biology.
Information: http://math.univ-lyon1.fr/~roger/.

28–30 **ICERM Workshop: Performance Analysis of Monte Carlo Methods**, ICERM, Providence, Rhode Island.
Description: Monte Carlo methods have become increasingly important in Engineering and the Sciences. These application areas have posed challenges and opportunities in the analysis of modern Monte Carlo algorithms. The workshop's main focus is on: a) the mathematical techniques and aspects that have been key in the analysis of these algorithms, and b) the identification of techniques that are likely to play a role in future analysis.
Information: http://icerm.brown.edu/sp-f12-w4.

29–December 1 **2012 Third International Conference on Emerging Applications of Information Technology (EAIT 2012)**, Indian Statistical Institute, Kolkata, India. (May 2012, p. 717)
Description: The Computer Society of India (CSI) has been instrumental in guiding the Indian IT industry since its formative years. The mission of CSI is to facilitate research, knowledge sharing, learning and career enhancement for all categories of IT professionals, while simultaneously inspiring and nurturing new entrants into the industry and helping them to integrate into the IT community. Encouraged by the earlier events, EAIT 2006 (proceedings published by Elsevier) and EAIT 2011 (proceedings published by IEEE CS and Xplore), CSI Kolkata Chapter is organizing the Third International Conference on Emerging Applications of Information Technology (EAIT 2012). The event will be comprised of Pre-Conference Tutorials, plenary sessions, invited lectures by eminent speakers of international repute, session papers and panel discussions. Detailed call for papers can be found at: https://sites.google.com/site/csieait2012/cfp.
Information: http://sites.google.com/site/csieait2012.

December 2012

* 2–5 **Inaugural meeting of the Australian and New Zealand Association of Mathematical Physics (ANZAMP)**, Cumberland resort, Lorne, Victoria, Australia.
Description: ANZAMP is a special interest group of the Australian Mathematical Society. It was founded in 2011 for the promotion and extension of mathematical physics in Australia and New Zealand wherever appropriate; and in particular, encourage the interaction between mathematical physicists and workers in fields where mathematical physics is relevant. This is ANZAMP's inaugural annual meeting.
Confirmed speakers: Debra Bernhardt (University of Queensland, Brisbane), Paul Fendley (University of Virginia, Charlottesville), Jarmo Hietarinta (University of Turku), Andrei Okounkov (Columbia University, New York), Todd Oliynyk (Monash University, Melbourne), Arkady Tseytlin (Imperial College, London).
Information: http://www.anzamp.austms.org.au/meetings/2012/.

3–7 **Combinatorial Commutative Algebra and Applications**, Mathematical Sciences Research Institute, Berkeley, California. (May 2012, p. 718)
Description: This workshop on Combinatorial Commutative Algebra aims to bring together researchers studying toric algebra and degenerations, simplicial objects such as monomial ideals and Stanley-Reisner rings, and their connections to tropical geometry, algebraic statistics, Hilbert schemes, D-modules, and hypergeometric functions.
Information: http://www.msri.org/web/msri/scientific/workshops/programmatic-workshops/show/-/event/Wm571.

3–16 **ICTS Program: Groups, Geometry and Dynamics**, CEMS, Kumaun University, Almora, Uttarakhand, India.
Description: This program will be organized around the areas of Geometry and Dynamics, which encompasses a large portion of Group Theory (finite or otherwise) in its proximity. The program will have two components: (i) Advanced School, Dec. 3–12, 2012; (ii) Discussion Meeting, Dec. 13–16, 2012.
Topics: The list of topics in the advanced school includes Lorentzian geometry, Real and complex Kleinian groups, Geometry of negatively curved spaces, Arithmetic of hyperbolic manifolds, Flows on homogeneous spaces, Discrete subgroups of Lie groups. The discussion meeting will lead to the frontier of current research and trends in the fields mentioned above. The lectures on the final day of the program will be centered around the areas which are influenced by Ravi Kulkarni's ideas, and are still very much active and important in the context of modern mathematics.
Deadline: The deadline for filling up application form for the program is July 31, 2012.
Information: http://www.icts.res.in/program/GGD2012.

3–20 **ICTS Program: Winter School on Stochastic Analysis and Control of Fluid Flow**, School of Mathematics, Indian Institute of Science Education and Research, Thiruvananthapuram, Kerala, India.
Description: The aim of the school is to make students and researchers across various organizations working in fluid flow problems well acquainted with the basic and advanced topics in control of partial differential equations (PDEs) arising from fluid dynamics with special emphasis on Navier-Stokes equations in both deterministic and stochastic settings. In the first week, introductory topics from Navier-Stokes equations, stochastic analysis and control of PDEs will be introduced. This would help in building the background for the advanced topics to be covered later on. In the following two weeks, solvability, control and large deviations of Navier-Stokes equations in

both deterministic and stochastic settings will be covered. Topics on stochastic Navier-Stokes equations and stochastic Landau-Lifschitz-Gilbert equation on manifolds will also be covered using tools from differential geometry and stochastic analysis.
Information: http://www.icts.res.in/program/control2012.

* 4–6 **New Zealand Mathematical Society Colloquium**, Massey University, Palmerston North, New Zealand.
Description: The annual Colloquium brings together the mathematical community of New Zealand while welcoming overseas visitors to join us. Time will be dedicated to the discussion of all aspects of pure and applied mathematics and statistics. Talks will be given by internationally recognized leaders in the field and also by emerging researchers and postgraduate students.
Plenary Speakers: Astrid an Huef, Functional Analysis, Otago; Bill Barton, Mathematics Education, Auckland; John Sader, Continuum Mechanics & Nanoscience, Melbourne & Caltech; Kate Smith-Miles, Neural networks, combinatorial optimization, and data mining, Monash; Ilze Ziedins, Stochastic networks, Auckland.
Information: http://nzmathsoc.org.nz/colloquium.

7–9 **International Conference on Frontiers of Mathematical Sciences with Applications (ICFMSA-2012)**, Calcutta Mathematical Society, Kolkata, India.
Theme: Theme of ICFMSA-2012; algebra and applications, analysis and applications, geometry and applications, logic and applications, continuum mechanics, mathematical physics, mathematical modelling, optimization techniques, nonlinear systems and dynamics, time series analysis and applications, image processing and pattern recognition, applicable mathematics in engineering sciences and technology, probability, statistics and stochastic processes and applications, numerical methods and applications, soft computing and applications.
Registration: Fees: Rs.1000 (for Indian), USD 200 (for non-Indians). Send the Title of presentation and abstract to cmsconf@gmail.com. Last date for submission: September 30, 2012. Notification of Acceptance: October 15, 2012. Contact persons: Prof. U. C. De, Secretary; Dr. Sanjay Sen, Jt Convenor; Dr. Ranajit Dhar, Jt Convenor; Dr. Koushik Ghosh, Jt Convenor. For any query please send email to: cmsconf@gmail.com.
Information: http://www.calmathsoc.org/downloads/ICFMSA-2012.pdf.

10–14 **AIM Workshop: Log minimal model program for moduli spaces**, American Institute of Mathematics, Palo Alto, California. (May 2012, p. 718)
Description: This workshop, sponsored by AIM and the NSF, will be devoted to applications of the minimal model program (MMP) to the study of geometry of moduli spaces of algebraic varieties.
Information: http://www.aimath.org/ARCC/workshops/logminmoduli.html.

10–14 **36ACCMCC—The 36th Australasian Conference on Combinatorial Mathematics and Combinatorial Computing**, University of New South Wales, Sydney, Australia. (Feb. 2012, p. 340)
Description: Annual conference of the Combinatorial Mathematics Society of Australia.
Information: http://conferences.science.unsw.edu.au/36accmcc/.

10–14 **Reproducibility in Computational and Experimental Mathematics**, Institute for Computational and Experimental Research in Mathematics (ICERM), Providence, Rhode Island.
Description: The purpose of this workshop is to discuss aspects of reproducibility most relevant to the mathematical sciences among researchers from pure and applied mathematics from academics and other settings, together with interested parties from funding agencies, national laboratories, professional societies, and publishers. This will be a working workshop, with relatively few talks and dedicated time for breakout group discussions on the current state of the art and the tools, policies, and infrastructure that are needed to improve the situation. The groups will be charged with developing guides to current best practices and/or white papers on desirable advances.
Information: http://icerm.brown.edu/tw12-5-rcem.

10–21 **VI-MSS Event: Winter School and Conference on Computational Aspects of Neural Engineering**, Bangalore, India.
Description: We are pleased to announce the first joint IMI-ICERM Winter School on Computational Aspects of Neural Engineering. The course is directed at graduate students, postdoctoral fellows, and other researchers from the physical sciences (e.g., physics, mathematics, computer science, engineering) and the life sciences (e.g., neuroscience, biology, physiology). The course will offer participants the opportunity to learn about the foundations of neural engineering and brain-computer interfacing, and develop their skills in computational analysis of neural data for the control of external devices.
Topics: Will range from primers on neuroscience, signal processing, and machine learning to brain-computer interfacing based on multi neuronal activity, electrocorticography (ECoG), and electroencephalography (EEG). The course will consist of 3 hours of lectures each morning, followed by a 3-hour MATLAB-based computer laboratory in the afternoon. Participants will pair up for these laboratories, and an effort will be made to pair someone from the life sciences with someone from the physical sciences. All classes and laboratories will be held on the campus of the Indian Institute of Science (IISc). This program is part of the IISc Mathematics Initiative (IMI) at the Indian Institute of Science and the VIMSS program at ICERM.
Information: http://icerm.brown.edu/vi-mss.

15–16 **2nd International Conference on Mathematical Sciences and Applications**, India International Centre, 40, Max Mueller Marg, Lodhi Estate, New Delhi-110 003, India.
Description: A premier forum for the presentation of new advances and research results in all areas of Mathematical Sciences and Applications. ICMSA-2012 will bring together leading researchers, engineers and scientists in the domain of interest from around the world. Leading mathematicians around the world shall deliver keynote addresses and chair sessions.
Topics: Of interest for submission include, but are not limited to: Algebra, algebraic topology, advanced calculus, advanced numerical methods, artificial neural networks, calculus and trigonometry, complex analysis, computational fluid dynamics, etc.
Directions: Nearest Metro Stations: "Khan Market" & "Jor Bagh" Map: IIC at Google Maps.
Information: http://www.journalshub.com.

16–22 **Commutative Rings, Integer-Valued Polynomials and Polynomial Functions**, Graz University of Technology, Graz, Austria. (Nov. 2011, p. 1495)
Confirmed speakers: Jean-Luc Chabert, Sarah Glaz, Byung Gyun Kang, Alan Loper, Irena Swanson.
Description: The conference will be preceded by different minicourses, December 16–18, 2012, taught by the main speakers of the conference.
Information: Contact: email: commring@tugraz.at; http://integer-valued.org/conf2012/.

17–20 **9th IMA International Conference on Mathematics in Signal Processing**, Austin Court, Birmingham, United Kingdom. (Nov. 2011, p. 1495)
Description: Signal processing constitutes an important area for the application of mathematical concepts and techniques fuelled, for example, by developments in mobile communications, multimedia systems and digital TV. The subject is still advancing rapidly in areas such as non-linear/non-Gaussian/non-stationary signal processing, compressive sampling, digital communication systems, iterative estimation (e.g., turbo codes), blind deconvolution/signal separation and

broadband systems. The last IMA conference on this subject was held in December 2008 and in response to popular demand, the next one will be held in December 2012. The aim of the conference is to bring together mathematicians, statisticians, and engineers with a view to exploring recent developments and identifying fruitful avenues for further research. It is hoped that the meeting will help to attract more mathematicians into this important and challenging field.
Information: http://www.ima.org.uk/conferences/conferences_calendar/mathematics_in_signal_processing.cfm.

17–21 **AIM Workshop: Rational Catalan Combinatorics**, American Institute of Mathematics, Palo Alto, California. (May 2012, p. 718)
Description: This workshop, sponsored by AIM and the NSF, will be devoted to understanding the interaction between new developments in algebra and combinatorics. In particular, it will focus on combinatorial objects counted by generalizations of Catalan numbers and their interaction with the representation theory of Cherednik algebras.
Information: http://aimath.org/ARCC/workshops/rationalcatalan.html.

17–21 **International Conference on the Theory, Methods and Applications of Nonlinear Equations**, Department of Mathematics, Texas A&M University-Kingsville, Kingsville, Texas. (Feb. 2012, p. 340)
Description: The main aim of the conference is to promote, encourage, and bring together researchers in the fields of ordinary differential equations, partial differential equations, functional equations, fractional differential equations, Delay-differential equations, integral equations, integrodifferential equations, stochastic differential equations, impulsive differential equations, operator equations, difference equations and dynamic equations on time scales. A special emphasis will be on the applications of Nonlinear Equations. It is anticipated that the conference will attract about 400 participants with 9 plenary speakers (50 minutes), 50 main speakers (40 minutes), and 300 lectures (20 minutes). It will be a mathematically enriching and socially exciting event.
Information: http://www.tamuk.edu/artsci/math/conference_2012/about.html.

21–23 **6th International Conference of IMBIC on "Mathematical Sciences for Advancement of Science and Technology" (MSAST 2012)**, Salt Lake City, Kolkata, West Bengal, India.
Description: The main objective of the conference is to bring specialized topics in mathematics, statistics, computer science, information technology, bioinformatics and closely related interdisciplinary areas to the forefront. Original full papers are invited. All papers are to be screened and accepted papers will be published in the proceedings, except for a few full selective papers of high quality which may be published in the highly acclaimed series of monographs of IMBIC in Volume 2 (2013).
Contact: All correspondence in respect to the conference is to be addressed to Dr. Avishek Adhikari, Convenor MSAST 2012 & Secretary, IMBIC; email: msast.paper@gmail.com; http://www.isical.ac.in/~avishek_r/.
Information: http://imbic.org/forthcoming.html.

22–24 **The International Congress on Science and Technology**, Allahabad, U.P., India. (Apr. 2012, p. 593)
Focus: The conference has the focus on the current trends on frontier topics of the science and technology (Applied Engineering) subjects. The ICST conferences serve as good platforms for our members and the entire science and technological community to meet with each other and to exchange ideas.
Organizer: The CWS, a non-profit society for the scientists and the technocrats.
Deadline: Submission of abstracts with full-length paper to complexgeometry18@yahoo.com with a cc: to ss123a@rediffmail.com: July 25, 2012.
Information: http://sites.google.com/site/intcongressonsciandtech/.

26–January 1 **International Conference: Mathematical Science and Applications**, Abu Dhabi University, College of Arts and Science, Department of Applied Sciences and Mathematics, Abu Dhabi, United Arab Emirates.
Aim: The main aim of the conference is to promote, encourage, and bring together researchers in the different fields of Mathematics. We are pleased to invite you to give a lecture in the forthcoming International Conference on Mathematical Science and Applications, December 26-31, 2012, Abu Dhabi University. A special emphasis will be on the applications of Mathematical Sciences and Applied Mathematics. Organizing Committee will make it a mathematically enriching and socially exciting event. The aim of the conference is discussing the latest developments and researches in the field of Mathematical Sciences and its applications. The conference is broad-based that covers all branches of mathematics and interdisciplinary researches. ICMSA 2012 is a peer-reviewed conference.
Information: Please visit: http://www.adu.ac.ae/en/section/international-conference-mathematical-sciences-and-applications.

27–29 **International Conference on Mathematics, Trends and Development (ICMTD12)**, Cairo, Egypt.
Organizer: Egyptian Mathematical Society.
Topics: Topology and Application, ODE Theory and Techniques, Quantum Computation, Quantum Information, Data Security, Data Mining, Functional Analysis, Geometry and Application, Related Topics, Related Topics, Modelling.
Information: http://etms-eg.org/.

27–30 **Eighth International Triennial Calcutta Symposium on Probability and Statistics**, Department of Statistics, Calcutta University, Kolkata, West Bengal, India. (Nov. 2011, p. 1495)
Description: The Eighth International Triennial Calcutta Symposium following the foot steps of the previous seven symposia held in the years 1991, 1994, 1997, 2000, 2003, 2006 and 2009 plans to bring together researchers engaged in theoretical, methodological, and applied aspects of Statistics and Probability on a common platform to exchange ideas and facilitate discussions. A fairly large number of eminent researchers from all over the world are expected to attend. The symposium will feature invited and contributory sessions on theoretical and applied statistics and probability. There will also be poster sessions for students and young researchers. As in the past, a special session on Design of Experiments and Related Combinatorial Aspects will be organized in the memory of Prof. Raj Chandra Bose.
Information: http://triennial.calcuttastatisticalassociation.org/sympBrochure.php.

28–31 **International Conference on Mathematical Sciences (ICMS2012)**, Shri Shivaji Education Society's Science College, Nagpur, Maharashtra, India.
Description: We have the honour to inform you that Science College, Nagpur, affiliated to R.T.M. Nagpur University, Nagpur, is a premier institution of Central India. It is celebrating the 125th Birth Anniversary of great mathematician Srinivasa Ramanujam, declared as a "National Mathematical Year" by the government of India. To commemorate this occasion we are holding an International Conference on Mathematical Sciences, from December 28–31, 2012. The academicians round the globe are being invited to participate. It is our sincere wish that you come and participate in the academic community gathering on this occasion. It shall be our privilege to make your stay at Nagpur comfortable and the expenses towards your stay and local hospitality shall be our responsibility. We shall

feel obliged if you inform us of your consent and the title of your Invited Talk/Paper presentation and your food preferences.
Information: http://www.icms2012.org.

31–January 11 **Recent Advances in Operator Theory and Operator Algebras**, Indian Statistical Institute, Bangalore, India.
Description: Focusing on the general theme of operator theory, operator algebras and function theory. There will be a one-week workshop December 31, 2012–January 5, 2013, followed by a conference January 7, 2013–January 11, 2013. The purpose of the workshop is to bring experts and students as well as researchers together to discuss the most recent developments in certain topics in those areas. The conference will concentrate on recent developments in Operator Theory, Operator Algebras and related fields.
Information: http://www.isibang.ac.in/~jay/rota.html.

January 2013

1–9 **VI-MSS Event: Workshop and Conference on Limit Theorems in Probability**, Bangalore, India.
Description: Ever since Jakob Bernoulli proved the law of large numbers for Bernoulli random variables in 1713, the subject of limit theorems has been a driving force for the development of probability theory as a whole. The elucidation of different flavours of laws of large number, central limit theorems and laws of iterated logarithm, their extensions to Markov chains or sums of weakly dependent or stationary processes, limit theorems for Banach space valued random variables, etc., have given rise to a rich theory as well as the basic tools for tackling any problem involving randomness. Today, 300 years after the landmark result of Bernoulli, it is fruitful to look back at the way in which the search for limit theorems has shaped the subject. It is also fruitful to consider how the emphasis has evolved over time from simple limit theorems to getting bounds on the rates of convergence or obtaining inequalities, which are of more immediate relevance in applications to nite samples. The current workshop and conference will focus on some of these topics, and also more broadly on issues of current interest in probability theory. The workshop will consist of five short courses on a variety of topics, aimed at the level of graduate students but also of potential interest to researchers in probability and related fields. The conference following the workshop will have lectures on recent developments in various relevant fields of probability.
Information: http://icerm.brown.edu/vi-mss.

6–8 **ACM-SIAM Symposium on Discrete Algorithms (SODA13)**, Astor Crowne Plaza Hotel, New Orleans, Louisiana. (Apr. 2012, p. 593)
Description: This symposium focuses on research topics related to efficient algorithms and data structures for discrete problems. In addition to the design of such methods and structures, the scope also includes their use, performance analysis, and the mathematical problems related to their development or limitations. Performance analyses may be analytical or experimental and may address worst-case or expected-case performance. Studies can be theoretical or based on data sets that have arisen in practice and may address methodological issues involved in performance analysis.
Information: http://www.siam.org/meetings/da13/.

7–12 **Iwasawa Theory, Representations, and the p-adic Langlands Program**, University of Münster, Münster, Germany. (Jan. 2012, p. 106)
Description: A conference in honour of Peter Schneider's 60th birthday.
Information: http://wwwmath.uni-muenster.de/sfb878/activities/.

14–18 **AIM Workshop: Modeling problems related to our environment**, American Institute of Mathematics, Palo Alto, California.
Description: This workshop, sponsored by AIM and the NSF, will bring together mathematicians, graduate students, and industry and public agency representatives to work on mathematical modeling problems related to the planet Earth.
Information: http://www.aimath.org/ARCC/workshops/modelenvironment.html.

14–May 24 **Noncommutative Algebraic Geometry and Representation Theory**, Mathematical Sciences Research Institute, Berkeley, California. (Oct. 2011, p. 1325)
Description: Over the last few decades noncommutative algebraic geometry (in its many forms) has become increasingly important, both within noncommutative algebra/representation theory, as well as having significant applications to algebraic geometry and other neighbouring areas. The goal of this program is to explore and expand upon these subjects and their interactions. Topics of particular interest include noncommutative projective algebraic geometry, noncommutative resolutions of (commutative or noncommutative) singularities, Calabi-Yau algebras, deformation theory and Poisson structures, as well as the interplay of these subjects with the algebras appearing in representation theory—like enveloping algebras, symplectic reflection algebras and the many guises of Hecke algebras.
Information: http://www.msri.org/web/msri/scientific/programs/show/-/event/Pm145.

* 17–19 **Mathematics of Planet Earth 2013 - Pan-Canadian Thematic Program - Disease Dynamics 2013: Immunization, a True Multi-Scale Problem**, PIMS, Vancouver, British Columbia, Canada.
Description: Recent debates surrounding the HPV vaccine and the rush to develop and distribute a vaccine during the 2009 influenza pandemic are reminders of the important role immunization plays in our fight against infectious diseases. This workshop will provide a forum for presentation of leading-edge research in applied mathematics focused on infectious disease dynamics, with emphasis on vaccine development and use to halt or mitigate the impact of diseases, in particular HIV/HPV/influenza. By facilitating interactions between scientists from a variety of disciplines (epidemiology/ immunology/ mathematics), we aim to bring a broad perspective to the role of immunization at population and host levels.
Information: http://www.crm.umontreal.ca/act/theme/theme_2013_1_en/disease_dynamics13_e.php.

* 21–25 **AIM Workshop: Online databases - from L-functions to combinatorics**, International Centre for Mathematical Sciences Edinburgh, Scotland, United Kingdom.
Description: This workshop, sponsored by AIM, ICMS, and the NSF, will be devoted to the development of new software tools for handling mathematical databases. These tools will assist mathematicians in the integration, display, distribution, maintenance and investigation of mathematical data.
Information: http://www.aimath.org/ARCC/workshops/onlinedata.html.

24–25 **Connections for Women: Noncommutative Algebraic Geometry and Representation Theory**, Mathematical Sciences Research Institute, Berkeley, California. (Aug. 2011, p. 1014)
Description: The Connections for Women workshop associated with the MSRI program in noncommutative algebraic geometry and representation theory is intended to bring together women who are working in these areas in all stages of their careers. As the first event in the semester, this workshop will feature a "tapas menu" of current research and open questions: light but intriguing tastes, designed to encourage further exploration and interest. Talks will be aimed at a fairly general audience and will cover diverse topics within the theme of the program. In addition, there will be a poster session for graduate students and recent Ph.D. recipients and a panel discussion on career issues, as well as free time for informal discussion.
Information: http://www.msri.org/web/msri/scientific/workshops/all-workshops/show/-/event/Wm9061.

28–February 1 **Introductory Workshop: Noncommutative Algebraic Geometry and Representation Theory**, Mathematical Sciences Research Institute, Berkeley, California. (Aug. 2011, p. 1014)
Description: This workshop will provide several short lecture series consisting of two or three lectures each to introduce postdocs, graduate students and non-experts to some of the major themes of the conference. While the precise topics may change to reflect developments in the area, it is likely that we will run mini-series in the following subjects: noncommutative algebraic geometry; D-module theory; derived categories; noncommutative resolutions of singularities; deformation-quantization; symplectic reflection algebras; growth functions of infinite dimensional algebras.
Information: http://www.msri.org/web/msri/scientific/workshops/all-workshops/show/-/event/Wm9062.

28–May 3 **ICERM Semester Program: Automorphic Forms, Combinatorial Representation Theory and Multiple Dirichlet Series**, ICERM, Providence, Rhode Island. (Jan. 2012, p. 106)
Description: This program will explore this interface between automorphic forms and combinatorial representation theory, and will develop computational tools for facilitating investigations. On the automorphic side, Whittaker functions on p-adic groups and their covers are the fundamental objects. Whittaker functions and their relatives are expressible in terms of combinatorial structures on the associated L-group, its flag variety, or Schubert varieties. In the combinatorial theory crystal graphs, Demazure characters, the Schubert calculus and Kazhdan-Lusztig theory all enter.
Information: http://icerm.brown.edu/sp-s13.

February 2013

4–8 **AIM Workshop: Stochastics in geophysical fluid dynamics**, American Institute of Mathematics, Palo Alto, California.
Description: This workshop, sponsored by AIM and the NSF, will be devoted to the mathematical foundations, physical underpinnings and applications of large scale stochastic models for climate and weather.
Information: http://www.aimath.org/ARCC/workshops/stochasticfluid.html.

4–8 **The Second Biennial International Group Theory Conference**, Dogus University, Istanbul, Turkey.
Description: We would like to announce herewith the second of the Biennial International Group Theory Conferences hosted every other year by the countries Malaysia, Turkey and Iran successively. The conference aims to bring together leading mathematicians and active researchers working on the theory of groups in order to exchange ideas, present new results and identify the key problems in the field. This series of conferences is considered as an important means to bring together young group theorists and graduate students with the leading experts of the world and help them to get acquainted with relevant and actual theories, problems and methods of their research area.
Information: Please contact: 2big@dogus.edu.tr; http://istanbulgroup2013.dogus.edu.tr.

5–7 **International Conference on Mathematical Sciences and Statistics (ICMSS2013)**, Kuala Lumpur, Malaysia.
Description: ICMSS2013 is organized by the Department of Mathematics, Faculty of Science, Universiti Putra Malaysia. All papers will be peer-reviewed and selected for publication in the American Institute of Physics (AIP) Conference Proceedings which will appear in major databases like SCOPUS and ISI and selected papers will be published in a special issue of *Malaysian Journal of Mathematical Sciences* (indexed by SCOPUS) or *Discovering Mathematics* (*Menemui Matematik*) indexed by Zentralblatt Math. ICMSS2013 Secretariat International Conference on Mathematical Sciences and Statistics (ICMSS2013).
Information: http://math.upm.edu.my/icmss2013; Phone: +603 89466812; email: icmss2013@yahoo.com.

* 6–8 **Mathematics of Planet Earth 2013 - Pan-Canadian Thematic Program - Models and Methods in Ecology and Epidemiology**, CRM, Montréal, Canada.
Description: In epidemiology and ecology, models are typically developed along one of two directions: directly from available data, incorporating as much empirical records as possible, or conceptually as dynamical systems, incorporating data via estimation of parameters. The means of investigation for these model classes are quite distinct, and an important methodological problem is the reconciliation of a priori method-independent issues when they are described in different terms.
Information: http://www.crm.umontreal.ca/act/theme/theme_2013_1_en/epidemiology13_e.php.

11–15 **ICERM Workshop: Sage Days: Multiple Dirichlet Series, Combinatorics, and Representation Theory**, ICERM, Providence, Rhode Island.
Description: This workshop will bring together experienced Sage and Sage-Combinat developers and experts of multiple Dirichlet series and computational algebraic combinatorics. Like every workshop in the Sage Days series, it will welcome whoever wants to discover Sage, learn more about it, or contribute to it. This workshop will focus on Sage training and on the design and planning of new computational features of central interest for the semester, around Weyl groups, Hecke algebras and their representations, crystals, posets, combinatorial data visualization, etc. The workshop will consist of mathematical presentations, presentations on Sage and coding sprints. The mathematical presentations will include talks introducing the relevant mathematics for the entire audience and more advanced talks for interested participants. The Sage presentations will begin with introductory tutorials and progress to more advanced topics, including software development in Sage.
Information: http://icerm.brown.edu/sp-s13-w1.

20–22 **DIMACS Workshop on Energy Infrastructure: Designing for Stability and Resilience**, DIMACS Center, CoRE Building, Rutgers University, Piscataway, New Jersey.
Description: Presented under the auspices of the Special Focus on Energy and Algorithms. The operation of modern power grids presents challenges and opportunities that are best met with appropriate technical methodology; it is clear that future grids will rely, to a much greater degree than is common today, on extensive sensorization and algorithmic machinery to guide both strategic planning and real-time operation. Although there is significant sophistication already present today, substantial innovative work remains to fulfill the promise implicit in mathematical methodologies. This workshop will focus on three themes of particular importance: AC power flow analysis and optimization, uncertainty mitigation, and power markets. All presentations will be by faculty and industry experts.
Organizers: Daniel Bienstock, Columbia University; email: dano@columbia.edu, Steven Low, Caltech; email: slow@caltech.edu.
Information: email: workshop@dimacs.rutgers.edu; http://dimacs.rutgers.edu/Workshops/Infrastructure/.

25–March 1 **AIM Workshop - Brauer groups and obstruction problems: Moduli spaces and arithmetic**, American Institute of Mathematics, Palo Alto, California.
Description: This workshop, sponsored by AIM and the NSF, will be devoted to studying elements of the Brauer group from both an arithmetic perspective and a Hodge-theoretic and derived categorical perspective.
Information: http://www.aimath.org/ARCC/workshops/brauermoduli.html.

March 2013

1–3 **2013 Spring Southeastern Section Meeting**, University of Mississippi, Oxford, Mississippi.
Information: http://www.ams.org/meetings/sectional/sectional.html.

4–8 **ICERM Workshop: Whittaker Functions, Schubert Calculus and Crystals**, ICERM, Providence, Rhode Island.
Description: Schubert calculus is the modern approach to classical problems in enumerative algebraic geometry, specifically on flag varieties and their many generalizations. Crystals are combinatorial tools based on quantum groups which arise in the study of representations of Lie algebras. Whittaker functions are special functions on Lie groups or p-adic groups, for example $GL(n, F)$, where F might be the real or complex numbers, or a p-adic field. The area of intersection between these three topics is combinatorial representation theory. Common tools such as Demazure operators, the Bruhat partial order, and Macdonald polynomials appear in all three areas. Some connections between these three areas are quite new. This workshop will explore these connections.
Information: http://icerm.brown.edu/sp-s13-w2.

11–14 **Interactions between Analysis and Geometry**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California. (Oct. 2011, p. 1325)
Description: Within mathematics, as within science in general, there is a need for greater communication between workers from different research specialties. The purpose of this program is to promote the interaction between two core areas of mathematics—analysis and geometry. Geometers can give analysts new perspectives and focus for their research; geometers can benefit from an exchange of ideas with analysts by becoming more familiar with the powerful tools of their field. An application is available online. Encouraging the careers of women and minority mathematicians and scientists is an important component of IPAM's mission and we welcome their applications.
Information: http://www.ipam.ucla.edu/programs/iag2013/.

13–15 **IAENG International Conference on Operations Research 2013 (ICOR'13)**, Royal Garden Hotel, Hong Kong, China.
Description: The conference ICOR'13 is held under the International MultiConference of Engineers and Computer Scientists 2013. The IMECS 2013 is organized by the International Association of Engineers (IAENG). The IMECS conferences serve as good platforms for our members and the entire engineering community to meet with each other and to exchange ideas. All submitted papers will be under peer review and accepted papers will be published in the conference proceeding (ISBN: 978-988-19251-8-3). The abstracts will be indexed and available at major academic databases. The accepted papers will also be considered for publication in the special issues of the journal *Engineering Letters*, in IAENG journals and in edited books.
Deadline: Manuscript Submission: December 8, 2012.
Information: http://www.iaeng.org/IMECS2013/ICOR2013.html.

* 18–22 **84th Annual Meeting of GAMM (The International Association of Applied Mathematics and Mechanics)**, University of Novi Sad, Novi Sad, Serbia.
Description: The GAMM e.V. cordially invites you to its 84th Annual Scientific Conference in Novi Sad, Serbia, March 18-22, 2013. Scientific Program consists of honorary Ludwig Prandtl Memorial lecture, v. Misses lecure(s), 10 plenary lectures, 6 minisymposia, 6 young researchers' minisymposia, 24 parallel contributed sections and a public lecture.
Information: http://www.dmi.uns.ac.rs/gamm2013.

20–22 **17th International Conference on Discrete Geometry for Computer Imagery (DGCI 2013)**, Escuela Tecnica Superior de Ingenieria Informatica, Univ. de Sevilla, Seville, Spain.
Aim: Of the DGCI conference is to gather researchers in discrete models, discrete geometry and topology, with applications in image analysis and image synthesis.
Topics: Of interest include (but are not limited to): Models for discrete geometry, discrete and combinatorial topology, geometric transforms, discrete shape representation, recognition and analysis, discrete tomography, morphological analysis, discrete modelling and visualization, discrete and combinatorial tools for image segmentation and analysis. Publication of the conference proceedings will be in LNCS by Springer-Verlag.
Submissions: Must be in electronic form (PDF or PS) and should be uploaded through the DGCI 2013 website. Submissions will be peer-reviewed by at least 2 qualified reviewers.
Important Dates: Full paper submission: July 2, 2012. Full paper notification: November 5, 2012. Camera-ready submission: December 5, 2012.
Information: http://dgci2013.us.es/.

25–27 **7th IMA Conference on Quantitative Modelling in the Management of Health and Social Care**, Central London College, London, United Kingdom.
Description: The aim of the conference is to bring together health care managers, clinicians, management consultants, and mathematicians, operational researchers, statisticians, health economists, computer scientists, etc. from across the world with a view to bridging the gap between the respective communities and to exploring recent developments and identifying fruitful avenues for further research.
Information: http://www.ima.org.uk.

25–29 **AIM Workshop: Mathematical problems arising from biochemical reaction networks**, American Institute of Mathematics, Palo Alto, California.
Description: This workshop, sponsored by AIM and the NSF, will be devoted to the mathematical analysis of biochemical reaction networks arising in systems biology, in particular, in classes of nonlinear dynamical systems that arise from biologically relevant networks of chemical reactions, parametrized by rate constants that are usually unknown and difficult to measure.
Information: http://www.aimath.org/ARCC/workshops/biochemnet.html.

April 2013

6–7 **2013 Spring Eastern Sectional Meeting**, Boston College, Chestnut Hill, Massachusetts.
Information: http://www.ams.org/meetings/sectional/sectional.html.

* 8–9 **IMA Mathematics in Finance**, Edinburgh Conference Centre, Heriot-Watt University, Edinburgh, United Kingdom
Description: One persistent theme in the history of mathematics is the close relationship between the subject and finance. From the Babylonians, through Fibonacci and then Stevin, Pascal, Fermat, Huygens, Bernoulli and Bachelier the development of mathematics has often been based on solving problems in finance. The series of financial crises following 2007 have highlighted the need for novel mathematics to address the increasingly complex problems of finance. The IMA Conference on Mathematics in Finance has been organised in conjunction with the Bank of England, now responsible for financial stability in the UK, and with reference to the Department for Business Innovation and Skills Foresight project on the Future of Computer Trading in Financial Markets. The aim is to encourage mathematicians, from a wide range of backgrounds, to address important societal issues in relation to the operation of modern markets.
Information: http://www.ima.org.uk/.

8–10 **Fourteenth International Conference on Numerical Combustion (NC13)**, Holiday Inn Riverwalk, San Antonio, Texas.

Description: Advances in computational algorithms, hardware, and software continue to have a revolutionary impact on the combustion sciences and permit the examination of scientific and engineering problems of increasing complexity. Detailed combustion simulations and models are now being considered as part of integrated system applications. The International Conference on Numerical Combustion will focus on the integration of theory, modeling, and numerical implementation in the study of basic combustion physics and technological applications. The distinct questions and challenges found in combustion and phase transitions arise from the multiplicity of length and time scales defined by the chemical, geometric, and flow ingredients. Physically descriptive, efficient, and accurate numerical modeling of complex phenomena and the design and implementation of complex, integrated simulation are the challenges to be addressed at this conference.
Information: http://www.siam.org/meetings/nc13/.

* 8–12 **AIM Workshop: Geometric perspectives in mathematical quantum field theory**, American Institute of Mathematics, Palo Alto, California.
Description: This workshop, sponsored by AIM and the NSF, will be devoted to mathematical challenges in quantum field theory.
Information: http://www.aimath.org/ARCC/workshops/geometricqft.html.

8–12 **Interactions between Noncommutative Algebra, Representation Theory, and Algebraic Geometry**, Mathematical Sciences Research Institute, Berkeley, California. (Aug. 2011, p. 1014)
Description: In recent years there have been increasing interactions between noncommutative algebra/representation theory on the one hand and algebraic geometry on the other. This workshop would aim to examine these interactions and, as importantly, to encourage the interactions between the three areas. The precise topics will become more precise nearer the time, but will certainly include: Noncommutative algebraic geometry; noncommutative resolutions of singularities and Calabi-Yau algebras; symplectic reflection and related algebras; D-module theory; deformation-quantization.
Information: http://www.msri.org/web/msri/scientific/workshops/all-workshops/show/-/event/Wm9063.

13–14 **2013 Spring Western Section Meeting**, University of Colorado Boulder, Boulder, Colorado.
Information: http://www.ams.org/meetings/sectional/sectional.html.

13–14 **3rd IIMA International Conference on Advanced Data Analysis, Business Analytics and Intelligence**, Indian Institute of Management, Ahmedabad, India. (Apr. 2012, p. 593)
Description: Indian Institute of Management Ahmedabad is happy to announce the 3rd international conference dedicated to advanced data analysis, business analytics and business intelligence. The objectives of the conference are to facilitate sharing of: a) Research based knowledge related to advanced data analysis, business analytics and business intelligence among academicians and practitioners, b) Case studies and novel business applications of tools and techniques of advanced data analysis, business analytics and business intelligence among academicians and practitioners. Papers are invited from academicians and practitioners on any topic mentioned in the list of conference topics and related areas. Applications, case studies, review and discussion papers on these topics and related areas are also welcome.
Information: http://www.iimahd.ernet.in/icadabai2013/.

15–19 **ICERM Workshop: Combinatorics, Multiple Dirichlet Series and Analytic Number Theory**, ICERM, Providence, Rhode Island.
Description: Recent years have seen a flurry of activity in the field of Weyl group multiple Dirichlet series. Surprising and unexpected connections between these multiple Dirichlet series and several different fields of mathematics have emerged. This workshop will survey recent results and set the stage for future developments which further interrelate analytic number theory, automorphic forms and combinatorial representation theory. Particular focus will be given to applications of Weyl group multiple Dirichlet series to the following areas: Average value and nonvanishing results for families of L-functions, Periods of automorphic forms, Connections between characters sums over function fields and characters of affine root systems, Metaplectic Casselman-Shalika formulae and deformations of the Weyl character formula.
Information: http://icerm.brown.edu/sp-s13-w3.

27–28 **2013 Spring Central Section Meeting**, Iowa State University, Ames, Iowa.

Visit http://www.ams.org/meetings/sectional/sectional.html.

* 29–May 1 **Mathematics of Planet Earth 2013. Establishing the Scientific Foundation for Quantitative Public Health Decision-Making: Linking surveillance, disease modeling, and simulation** Fields Institute, Toronto, Canada.
Description: Science informed public health policy relies on the interactive interplay among surveillance systems, data analysis, mathematical modeling, and simulation. The effectiveness of modeling epidemiological characteristics and interventions depends on the accuracy of model parameterization, which requires an understanding of the underlying epidemiological processes and statistical analysis of available population and disease data collected through surveillance data. On the other hand, the requirement of model parameters and features of disease specific data combined provide challenges and opportunities to develop statistical techniques which in turn can contribute to the design and improvement of surveillance.
Information: http://www.fields.utoronto.ca/programs/scientific/12-13/public_health/.

May 2013

* 5–9 **Mathematics of Planet Earth 2013 - Pan-Canadian Thematic Program - Major and Neglected Diseases in Africa**, Ottawa, Canada.
Description: Africa counts 54 countries and 15% of the world population, however, the combined GDP of African countries represented in 2003 just over 3% of the world's GDP. From a demographic perspective, Africa is characterized by an over-representation of youths (40% of the population under 15), and a life expectancy below 65 years (e.g., 31.6 years in Botswana) compared to 82.6 years in Japan. Several factors contribute to this low life expectancy (e.g., poverty, inadequate health care systems) but the main reason is the compounding of these factors with the effect of several major infectious diseases and some less known ones that are plaguing the continent.
Information: http://www.crm.umontreal.ca/act/theme/theme_2013_1_en/africa13_e.php.

6–10 **AIM Workshop: Algorithms for lattices and algebraic automorphic forms**, American Institute of Mathematics, Palo Alto, California.
Description: This workshop, sponsored by AIM and the NSF, will be devoted to explicit methods for algebraic modular forms.
Information: http://www.aimath.org/ARCC/workshops/algoautoforms.html.

6–10 **The Commutative Algebra of Singularities in Birational Geometry: Multiplier Ideals, Jets, Valuations, and Positive Characteristic Methods**, Mathematical Sciences Research Institute, Berkeley, California.
Description: The workshop will examine the interplay between measures of singularities coming both from characteristic p methods of commutative algebra, and invariants of singularities coming from birational algebraic geometry. There is a long history of this interaction which arises via the "reduction to characteristic p" procedure. It is only in the last few years, however, that very concrete objects from both areas, namely generalized test ideals from commutative algebra and multiplier ideals from birational geometry, have been

shown to be intimately connected. This workshop will explore this connection, as well as other topics used to study singularities such as jets schemes and valuations.
Information: http://www.msri.org/web/msri/scientific/workshops/all-workshops/show/-/event/Wm9000.

* 12–17 **Mathematics of Planet Earth 2013 - Pan-Canadian Thematic Program- Impact of climate change on biological invasions and population distributions**, BIRS, Banff, Canada.
Description: The issues outlined are broad and important, but initially progress must be made on more specific questions that can be defined in ways amenable to mathematical treatments. The purpose of this BIRS workshop is to generate, develop and apply new tools for the analysis of invasions and population distributions under environmental change.
Information: http://www.birs.ca/events/2013/5-day-workshops/13w5095.

13–17 **AIM Workshop: Nonhomogeneous boundary-value problems for nonlinear waves**, American Institute of Mathematics, Palo Alto, California.
Description: This workshop, sponsored by AIM and the NSF, will be concerned with boundary-value problems for nonlinear dispersive evolution equations and systems.
Information: http://www.aimath.org/ARCC/workshops/nonlinwaves.html.

19–23 **SIAM Conference on Applications of Dynamical Systems (DS13)**, Snowbird Ski and Summer Resort, Snowbird, Utah. (Oct. 2011, p. 1326)
Description: The application of dynamical systems theory to areas outside of mathematics continues to be a vibrant, exciting and fruitful endeavor. These application areas are diverse and multidisciplinary, ranging over all areas of applied science and engineering, including biology, chemistry, physics, finance, and industrial applied mathematics. This conference strives to achieve a blend of application-oriented material and the mathematics that informs and supports it. The goals of the meeting are a cross-fertilization of ideas from different application areas, and increased communication between the mathematicians who develop dynamical systems techniques and applied scientists who use them.
Information: http://www.siam.org/meetings/ds13/.

* 19–25 **15th International Conference on Functional Equations and Inequalities**, Ustron (near the borders with the Czech Republic and Slovakia), Poland.
Description: The International Conference on Functional Equations and Inequalities - ICFEI has been organized by the Department of Mathematics of the Pedagogical University in Cracow since 1984. The conference is devoted to functional equations and inequalities, their applications in various branches of mathematics and other scientific disciplines, as well as related topics.
Information: http://mat.up.krakow.pl/icfei/15ICFEI/.

* 19–27 **Mathematics of Planet Earth 2013 - Pan-Canadian Thematic Program - Summer School on Mathematics of Infectious Disease**, York University, Toronto, Canada.
Description: The summer school school will include lectures on mathematical epidemiology, and one of the most important aspects will be projects for groups of 4–6 students, mixing scientific backgrounds and levels of experience, and focusing on real-world problems around which students develop and analyze models. It will also incorporate several lectures on public-health topics with focus on those relevant to other events of MPE2013 such as global spread, Indigenous populations health, vector-borne diseases and integration of surveillance, statistical data analysis and dynamical modelling and simulations.
Information: http://www.fields.utoronto.ca/programs/scientific/12-13/infectious/.

* 25–27 **10th HSTAM International Congress on Mechanics**, Technical University of Crete, Chania, Crete, Greece.
Description: The Hellenic Society for Theoretical and Applied Mechanics http://hstam.ntua.gr/announcements.html in cooperation with the Technical University of Crete (http://www.tuc.gr) organizes the 10th HSTAM International Congress on Mechanics to be held in Chania from May 25–27, 2013.
Important dates: Submission of abstract (300 words) by December 1, 2012. Preliminary acceptance based on abstract by January 5, 2013. Submission of full paper by February 28, 2013. Final acceptance by March 15, 2013. Submission of abstracts and final papers will be done only electronically via the Congress email: 10hstam@dpem.tuc.gr. The Congress Co-chairmen are Professor Dimitrios E. Beskos, University of Patras, Greece President of HSTAM; Professor Georgios E. Stavroulakis, Technical University of Crete, Chania, Greece.
Information: http://www.10hstam.tuc.gr.

26–30 **The 19th International Conference on Difference Equations and Applications**, Sultan Qaboos University, Muscat, Oman.
Purpose: Of the conference is to bring together experts and novices in the theory and applications of difference equations and discrete dynamical systems.
Theme: The main theme of the conference will be the applications of difference equations to mathematical sciences, and in particular, mathematical biology, ecology and epidemiology.
Plenary speakers: Are experts chosen from areas of difference equations and discrete dynamical systems. Contributed talks in all areas of difference equations and their applications are welcomed.
Organizer: The conference is organized by the Department of Mathematics and Statistics under the auspices of the International Society of Difference Equations (ISDE).
Information: http://www.squ.edu.om/Portals/87/Conference/Conference2013/index.htm.

June 2013

* 3–7 **MEGA 2013: Effective Methods in Algebraic Geometry**, Goethe University, Frankfurt am Main, Germany.
Description: MEGA is a series of biennial international conferences which is devoted to computational and application aspects of Algebraic Geometry and related topics. MEGA 2013 is the twelfth conference in the series. It will comprise invited talks, regular talks (based on a competitive submission process), software presentations, as well as a poster session.
Executive committee: Alin Bostan, Wolfram Decker, Alicia Dickenstein, Jan Draisma, Christian Haase, Bernard Mourrain (chair), Tomas Recio, Thorsten Theobald.
Invited speakers: Lucia Caporaso, Felipe Cucker, Bas Edixhoven, Benjamin Nill, Giorgio Ottaviani, Frank-Olaf Schreyer, Markus Schweighofer, Seth Sullivant, Rekha Thomas.
Information: http://www.math.uni-frankfurt.de/mega2013/.

3–28 **Focus Program on Noncommutative Geometry and Quantum Groups**, Fields Institute for Research in Mathematical Sciences, Toronto, Ontario, Canada.
Description: Weeks 1, 2, and 3 will be devoted to short courses and seminars on the topics of noncommutative geometry and dynamical systems, quantum groups and Hopf cyclic homology, and connections between noncommutative geometry and index theory, geometry, and mathematical physics. The last week will be devoted to a capstone conference in honor of the 75th birthday of Marc Rieffel of the University of California, Berkeley, who has been one of the most influential mathematicians in the world in the area of noncommutative geometry and quantum groups.
Information: http://www.fields.utoronto.ca/programs/scientific/12-13/quantumgroups/.

4–14 **Conference on Nonlinear Mathematical Physics: Twenty Years of JNMP**, The Sophus Lie Conference Center, Nordfjordeid, Norway.
Description: The conference is a celebration of the twentieth anniversary of the *Journal of Nonlinear Mathematical Physics* (JNMP), which is published jointly by World Scientific and Atlantis Press.
Aim: To bring together experts and young scientists in the area of Mathematical Physics that concern Nonlinear Problems in Physics and Mathematics.
Main topic: The main topic is centered around the scope of JNMP: continuous and discrete integrable systems including ultradiscrete systems, nonlinear differential and difference equations, applications of Lie transformation groups and Lie algebras, nonlocal transformations and symmetries, differential-geometric aspects of integrable systems, classical and quantum groups, super geometry and super integrable systems.
Information: http://staff.www.ltu.se/~johfab/jnmp/index.html.

* 5–9 **4th Novi Sad Algebraic Conference–NSAC 2013**, Department of Mathematics and Informatics, Faculty of Science, University of Novi Sad, Novi Sad, Serbia.
Description: The NSAC is a series of conferences organised every four years at the Department of Mathematics and Informatics, Faculty of Science, University of Novi Sad, with particular emphasis to areas of algebra and related fields that have been cultivated by researchers from Novi Sad.
Main topics: Universal algebra, lattice theory, and their applications in computer science (in particular, in CSP's); semigroups, automata, groups, and their interactions; model theory, set theory, connections between algebra, logic, and combinatorics.
Aim: To promote the recent research results and trends in these areas.
Information: http://sites.dmi.rs/events/2013/nsac2013.

10–14 **ApplMath13, 8th Conference on Applied Mathematics and Scientific Computing**, Sibenik, Croatia.
Description: The aim of the Conference is the exchange of ideas, methods and problems between various disciplines of applied mathematics. Nonmathematicians using mathematics as a tool are also encouraged to take part in the Conference. The first seven conferences had a strong international flavor. The first two were held in Dubrovnik in 1999 (ApplMath99), 2001 (AMSC2001), the next three on Brijuni in 2003 (ApplMath03), 2005 (ApplMath05) and 2007 (ApplMath07); then in Zadar (ApplMath09), and the last one in Trogir (ApplMath11). Each one had a special topic, see the related web sites. Proceedings have been published by Dept. of Mathematics, Univ. of Zagreb (ApplMath99), by Kluwer publishers (AMSC2001), by Springer (ApplMath03), Annali dell.Università di Ferrara (ApplMath05, ApplMath07), and accepted papers from the ApplMath09 and ApplMath11 appeared in Mathematical Communications.
Information: http://applmath13.math.hr/.

10–14 **Computational Methods and Function Theory 2013**, Shantou University, Shantou, Guangdong, China.
Description: The general theme of the meeting concerns various aspects of interaction of complex variables and scientific computation, including related topics from function theory, approximation theory and numerical analysis. Another important aspect of the CMFT meetings, previously held in Valparaiso 1989, Penang 1994, Nicosia 1997, Aveiro 2001, Joensuu 2005 and Ankara 2009, is to promote the creation and maintenance of contacts with scientists from diverse cultures.
International Organizing Committee: Ilpo Laine (University of Eastern Finland); Stephan Ruscheweyh (Universität Würzburg, Germany); Edward B. Saff (Vanderbilt University, USA); Yuefei Wang (AMSS, Chinese Academy of Sciences, China); Hasi Wulan (Shantou University, China).
Information: email: ptli@stu.edu.cn; http://math.stu.edu.cn/cmft/index.asp.

17–21 **AIM Workshop: Exponential random network models**, American Institute of Mathematics, Palo Alto, California.
Description: This workshop, sponsored by AIM and the NSF, will bring practicing social scientists and statisticians, who study exponential random graph models, into contact with an emerging group of mathematicians who use a variety of new tools, including graph limit theory and tools from statistical mechanics such as spin glasses.
Information: http://www.aimath.org/ARCC/workshops/exprandnetwork.html.

* 21–24 **"Experimental and Theoretical Methods in Algebra, Geometry and Topology". Held in honor of Alexandru Dimca and Stefan Papadima on the occasion of their 60th birthdays**, Mangalia (near Constanta), Romania.
Description: The international conference having as topic "Experimental and Theoretical Methods in Algebra, Geometry and Topology" will be organized by Ovidius University of Constanta in cooperation with the Institute of Mathematics "Simion Stoilow" of the Romanian Academy and the Romanian Mathematical Society. We would like to mention that in 2013 the Joint International Meeting of the AMS and the Romanian Mathematical Society will take place in Romania as well, between June 27-30, at Alba Iulia.
Information: http://math.univ-ovidius.ro/Conference/ETMAGT60/GeneralInfo.htm.

28–30 **First International Conference on Smarandache Multispace and Multistructure**, Academy of Mathematics and Systems, Chinese Academy of Sciences, Beijing 100190, People's Republic of China.
Description: The notion of multispace was introduced by F. Smarandache in 1969 under his idea of hybrid mathematics: combining different fields into a unifying field, which is closer to our real life, since we don.t have a homogeneous space, but many heterogeneous ones. Today, this idea is widely accepted by the world of sciences. S-Multispace is a qualitative notion and includes both metric and non-metric spaces. It is believed that the smarandache multispace with its multistructure is the best candidate for 21st century Theory of Everything in any domain. It unifies many knowledge fields. In a general definition, a smarandache multi-space is a finite or infinite (countable or uncountable) union of many spaces that have various structures. The spaces may overlap. A such multispace can be used, for example, in physics for the Unified Field Theory that tries to unite the gravitational, electromagnetic, weak and strong interactions. Other applications: multi-groups, multi-rings, geometric multispace.
Information: http://fs.gallup.unm.edu/multispace.htm.

July 2013

1–5 **Erdös Centennial**, Budapest, Hungary.
Description: The Hungarian Academy of Sciences, the Alfréd Rényi Mathematical Institute of the Hungarian Academy of Sciences, the Eötvös Loránd University and the János Bolyai Mathematical Society announce that a conference dedicated to the 100th anniversary of Paul Erdös will be held in Budapest, Hungary.
Topics: Include all basic fields that Paul Erdös contributed to: Number theory, analysis, combinatorics, probability theory and set theory, among others. The emphasis will be on the recent developments in these areas, initiated or inspired by his mathematical legacy.
Information: http://www.renyi.hu/conferences/erdos100/index.html.

1–5 **International conference on Sampling Theory and Applications 2013**, Jacobs University, Bremen, Germany.
Description: SampTA 2013 is the 10th International Conference on Sampling Theory and Applications. SampTA takes place every two years, the previous locations were Riga (Latvia), Aveiro (Portugal), Loen (Norway), Orlando (USA), Strobl (Austria), Samsun (Turkey),

Thessaloniki (Greece), Marseille (France), and, most recently, in Singapore. SampTA conferences bring together mathematicians and engineers interested in sampling theory and its applications to related fields (such as signal and image processing, coding theory, control theory, complex analysis, harmonic analysis, differential equations) to exchange recent advances and to discuss open problems. SampTA 2013 will feature plenary lectures, special sessions on selected topics such as frame theory, compressed sensing, sampling and communications, quantization, super resolution imaging, and general sessions on sampling and its applications. Paper submissions on any aspect of sampling theory and applications are welcome.
Information: http://www.jacobs-university.de/sampta.

8–10 **SIAM Conference on Control and Its Applications (CT13)**, Town and Country Resort and Convention Center, San Diego, California.
Description: The field of control theory is central to a wide range of aerospace, industrial, automotive and advanced technological systems and increasingly recognized as fundamental for emerging fields ranging from nanotechnology to cell regulation. Moreover, in addition to its traditional ubiquity in process regulation for the physical sciences and engineering, control concepts now pervade the biological, computer, and social sciences. This conference will showcase a wide range of topics in control and systems theory. The topics and applications include real-time optimization and data assimilation, cellular and biological regulation, control of hybrid systems, numerical methods for control and optimization, control techniques for financial mathematics, cooperative control for unmanned autonomous vehicles, differential games, biomedical control, risk sensitive control and filtering, control of smart systems, flow control and quantum control.
Information: http://www.siam.org/meetings/ct13/.

8–12 **AIM Workshop: Generalizations of chip-firing and the critical group**, American Institute of Mathematics, Palo Alto, California.
Description: This workshop, sponsored by AIM and the NSF, will center around the abelian sandpile model and related chip-firing games on graphs, including generalizations to higher dimension, abelian networks, and pattern formation.
Information: http://www.aimath.org/ARCC/workshops/chipfiring.html.

* 8–12 **Mathematics of Planet Earth 2013 - Pan-Canadian Thematic Program - Climate Change and the Ecology of Vector-borne Diseases**, Fields Institute, CDM, Toronto, Canada.
Description: Climate change is a significant and emerging threat to public health, and changes the way we must look at protecting vulnerable populations. Infectious diseases, especially vector-borne diseases (VBD) are the ones in which the pathogenic microorganism is transmitted from an infected individual to another by an arthropod or other agent, sometimes with other animals serving as intermediary hosts. According to the WHO, nearly half the world's population is infected by vector-borne diseases, resulting in high morbidity and mortality. Important determinants of VBD transmission include: (i) vector survival and reproduction, (ii) the vector's biting rate, and (iii) the pathogen's incubation rate within the vector organism.
Information: http://www.crm.umontreal.ca/act/theme/theme_2013_1_en/vector_borne13_e.php.

20–25 **European Meeting of Statisticians**, Eotvos Lorand University, Budapest, Hungary.
Description: The European Meeting of Statisticians is uniquely the broadest and most prestigious regular meeting of the profession in Europe, having long history and well established traditions. Two distinguishing features of the current occasion are worth being emphasized, however. Beyond providing a natural forum for exchange of ideas for European statisticians and probabilists, particular organisational effort has been made to represent both traditional and newly emerging ties of the European professionals with the whole World. Hence, we expect colleagues from India, China, South-East Asia, the Middle-East, North- and Latin-America to participate in greater than usual number. It is also the ambition of the organisers to stimulate the inseminating tie between probability and statistics by a balanced representation of intertwined topics of both disciplines. The year 2013 itself provides the framework as it brings a number of celebrating anniversaries of probability theory and statistics.
Information: http://www.ems2013.eu.

* 22–25 **MIP2013: Mixed Integer Programming Workshop**, University of Wisconsin-Madison, Madison, Wisconsin.
Description: The Mixed Integer Programming (MIP) workshop series is designed to bring together the integer programming research community in an annual meeting. MIP 2013 will be the tenth workshop in the series.

* 22–26 **Mathematics of Planet Earth 2013 - Pan-Canadian Thematic Program - Biodiversity in a Changing World**, CRM, Cambam, Montréal, Canada.
Description: Biodiversity describes the manifestations of life through its many forms at the molecular level and across ecosystems. Biodiversity has always been the main topic of study for ecologists and evolutionary biologists since it remains a paradox within a number of theoretical paradigms.
Information: http://www.crm.umontreal.ca/act/theme/theme_2013_1_en/changing_world13_e.php

29–August 2 **36th Conference on Stochastic Processes and their Applications**, Boulder, Colorado.
Information: http://math.colorado.edu/spa2013/; email: brian.rider@colorado.edu.

August 2013

3–11 **Groups St. Andrews 2013**, University of St. Andrews, St. Andrews, Fife, Scotland, UK.
Description: This conference, the ninth in the series of Groups St. Andrews conferences, will be organized along similar lines to previous events in this series. The conference aims to cover all aspects of group theory, and to be accessible to postgraduate students, postdoctoral fellows, and researchers in all areas of group theory.
Speakers: The principal speakers will each deliver a short lecture course: Emmanuel Breuillard (Université Paris-Sud 11), Martin Liebeck (Imperial College, University of London), Alan Reid (University of Texas), Karen Vogtmann (Cornell University). The one-hour speakers are: Inna Capdeboscq (University of Warwick), Radha Kessar (University of Aberdeen), Markus Lohrey (Universität Leipzig), Derek Robinson (University of Illinois at Urbana-Champaign), Christopher Voll (University of Bielefeld). There will be further plenary talks, the opportunity for contributed talks, and an extensive social programme. The webpage for expressions of interest is now open.
Information: http://www.groupsstandrews.org/2013/index.shtml.

5–9 **1st Mathematical Congress of the Americas**, Guanajuato, Mexico.
Description: The goals of the Mathematical Congress of the Americas are to highlight the excellence of mathematical achievements in the Americas within the context of the international arena and to foster the scientific integration of all the mathematical communities in the continents. It is anticipated that the MCA will take place every 4 years starting in 2013.
Information: http://www.mca2013.org.

5–9 **XXII Rolf Nevanlinna Colloquium**, Helsinki, Finland. (Aug. 2011, p. 1014)
Description: For further information, please contact Kirsi Peltonen, Aalto University; email: kirsi.peltonen@tkk.fi.

19–December 20 **Mathematical General Relativity**, Mathematical Sciences Research Institute, Berkeley, California.

Description: The study of Einstein's general relativistic gravitational field equation, which has for many years played a crucial role in the modeling of physical cosmology and astrophysical phenomena, is increasingly a source for interesting and challenging problems in geometric analysis and PDE. This semester-long program aims to bring together researchers working in mathematical relativity, differential geometry, and PDE who wish to explore this rapidly growing area of mathematics.
Information: http://www.msri.org/web/msri/scientific/programs/show/-/event/Pm8946.

19–December 20 **Optimal Transport: Geometry and Dynamics**, Mathematical Sciences Research Institute, Berkeley, California.
Description: In the past two decades, the theory of optimal transportation has emerged as a fertile field of inquiry, and a diverse tool for exploring applications within and beyond mathematics. This transformation occurred partly because long-standing issues could finally be resolved, but also because unexpected connections emerged which linked these questions to classical problems in geometry, partial differential equations, nonlinear dynamics, natural sciences, design problems and economics. The aim of this program will be to gather experts in optimal transport and areas of potential application to catalyze new investigations, disseminate progress, and invigorate ongoing exploration.
Information: http://www.msri.org/web/msri/scientific/programs/show/-/event/Pm8952.

20–May 24 **Commutative Algebra Program**, Mathematical Sciences Research Institute, Berkeley, California.
Description: Commutative algebra was born in the 19th century from algebraic geometry, invariant theory, and number theory. Today it is a mature field with activity on many fronts. The year-long program will highlight exciting recent developments in core areas such as free resolutions, homological and representation theoretic aspects, Rees algebras and integral closure, tight closure and singularities, and birational geometry. In addition, it will feature the important links to other areas such as algebraic topology, combinatorics, mathematical physics, noncommutative geometry, representation theory, singularity theory, and statistics. The program will reflect the wealth of interconnections suggested by these fields, and will introduce young researchers to these diverse areas.
Information: http://www.msri.org/web/msri/scientific/programs/show/-/event/Pm142.

22–23 **Connections for Women on Optimal Transport: Geometry and Dynamics**, Mathematical Sciences Research Institute, Berkeley, California.
Description: This two-day event aims to connect women graduate students and beginning researchers with more established female researchers who use optimal transportation in their work and can serve as professional contacts and potential role-models. As such, it will showcase a selection of lectures featuring female scientists, both established leaders and emerging researchers. These lectures will be interspersed with networking and social events such as lunch or tea-time discussions led by successful researchers about (a) the particular opportunities and challenges facing women in science, including practical topics such as work-life balance and choosing a mentor, and (b) promising new directions in optimal transportation and related topics. Junior participants will be paired with more senior researchers in mentoring groups, and all participants will be encouraged to stay for the Introductory Workshop the following week, where they will have the opportunity to propose a short research communication.
Information: http://www.msri.org/web/msri/scientific/workshops/all-workshops/show/-/event/Wm9225.

* 26–30 **International Conference AMMCS-2013 (Applied Mathematics, Modeling and Computational Science)**, Waterloo, Ontario, Canada.
Description: AMMCS-2013 is an interdisciplinary international conference in a series of AMMCS meetings held in Waterloo, Ontario, Canada. The series aims at promoting interdisciplinary research and collaboration involving mathematical and computational sciences, and highlighting recent advances in Applied Mathematics, Modeling and Computational Science (AMMCS). In 2013 the conference will be held in the last week of August (August 26-30, 2013). The conference provides a unique opportunity for in-depth technical discussions and exchange of ideas in all areas involving mathematical and computational sciences, modeling and simulation, as well as their applications in natural and social sciences, engineering and technology, industry and finance.
Information: http://www.ammcs2013.wlu.ca.

26–30 **Introductory Workshop on Optimal Transport: Geometry and Dynamics**, Mathematical Sciences Research Institute, Berkeley, California.
Description: The workshop is intended to give an overview of the research landscape surrounding optimal transportation, including its connections to geometry, design applications, and fully nonlinear partial differential equations. As such, it will feature some survey lectures or minicourses by distinguished visitors and/or a few of the organizers of the theme semester, amounting to a kind of summer school. These will be complemented by a sampling of research lectures and short presentations from a spectrum of invited guests and other participants, including some who attended the previous week's *Connections for Women* workshop.
Information: http://www.msri.org/web/msri/scientific/workshops/all-workshops/show/-/event/Wm9226.

September 2013

1–August 31, 2014 **Call for Research Programmes 2013-2014**, Centre de Recerca Matemàtica, Bellaterra, Barcelona, Spain.
Description: The Centre de Recerca Matemàtica (CRM) invites proposals for Research Programmes for the academic year 2013–2014. CRM Research Programmes consist of periods ranging between two to five months of intensive research in a given area of mathematics and its applications. Researchers from different institutions are brought together to work on open problems and to analyse the state and perspectives of their area.
Deadline: The deadline for submission of proposals is November 18, 2011.
Information: Guidelines and application instructions can be found at http://www.crm.cat/CALLS/CALLS RESEARCH PROGRAMS/Call Research Program 1314.htm.

3–4 **Connections for Women: Mathematical General Relativity**, Mathematical Sciences Research Institute, Berkeley, California.
Description: Ever since the epic work of Yvonne Choquet-Bruhat on the well-posedness of Einstein's equations initiated the mathematical study of general relativity, women have played an important role in many areas of mathematical relativity. In this workshop, some of the leading women researchers in mathematical relativity present their work.
Information: http://www.msri.org/web/msri/scientific/workshops/programmatic-workshops/show/-/event/Wm9551.

9–13 **Introductory Workshop: Mathematical General Relativity**, Mathematical Sciences Research Institute, Berkeley, California.
Description: Mathematical relativity is a very widely ranging area of mathematical study, spanning differential geometry, elliptic and hyperbolic PDE, and dynamical systems. We introduce in this workshop some of the leading areas of current interest, with a special focus on those areas which are related to the geometry and physics

of the initial data of general relativity, and those which primarily involve Riemannian geometry and elliptic PDE.
Information: http://www.msri.org/web/msri/scientific/workshops/programmatic-workshops/show/-/event/Wm9552.

9–December 6 **ICERM Semester Program on "Low-Dimensional Topology, Geometry, and Dynamics"**, Institute for Computational and Experimental Research in Mathematics (ICERM), Providence, Rhode Island.
Description: The program focuses on the recent impact of computation and experiment on the study of the pure mathematics sides of topology, geometry, and dynamics. Specific areas include 3-dimensional topology, the study of locally symmetric spaces, low-dimensional dynamics, and geometric group theory. Included are areas where computation has not yet had an impact, but might do so in the near future.
Information: http://icerm.brown.edu/sp-f13.

11–13 **14th IMA Conference on Mathematics of Surfaces**, University of Birmingham, United Kingdom.
Description: Computer-based methods for the capture, construction, representation, fitting, interrogation and manipulation of complicated surfaces have led to a wide interest in, and need for, the mathematics of surfaces and related curves. Many applications require the use of surface descriptions, especially in such fields as computer aided design and manufacturing, computer graphics and computer vision. The description of surfaces is also of interest in geographic information systems, multimedia, and many other areas of science and medicine. This diversity and the wide range of applicability of the subject have already enabled the IMA to hold thirteen very successful international conferences in the Mathematics of Surfaces series. Several international authorities are being invited to present papers. The Institute of Mathematics and its Applications is a not-for-profit organisation registered as a charity in the UK.
Information: http://www.ima.org.uk/conferences/conferences_calendar/14th_mathematics_of_surfaces.cfm.

* 28–29 **Mathematics of Planet Earth 2013 - Pan-Canadian Thematic Program - Mathematical Modeling of Indigenous Population Health**, BIRS, Banff, Canada.
Description: In Canada, the 2009 influenza H1N1 pandemic disproportionately affected Indigenous populations with severe disease outcomes often necessitating hospitalization and intensive care unit admission. The maintenance of surge capacity for the healthcare was seriously challenged in many several geographic areas, including northern remote communities and First Nation reserves. The reasons for this disproportionate impact are not well understood, but important factors may include the prevalence of pre-disposing health conditions, limited access to healthcare, and environmental and demographic characteristics including the transportation network. Same factors apply to other diseases and hence the inequity issues arise from many other diseases and settings.
Information: http://www.crm.umontreal.ca/act/theme/theme_2013_1_en/indigenous_population13_e.php.

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.

October 2013

5–6 **2013 Fall Southeastern Section Meeting**, University of Louisville, Louisville, Kentucky.
Information: http://www.ams.org/meetings/sectional/sectional.html.

12–13 **2013 Eastern Sectional Meeting**, Temple University, Philadelphia, Pennsylvania.
Information: http://www.ams.org/meetings/sectional/sectional.html.

14–18 **Fluid Mechanics, Hamiltonian Dynamics, and Numerical Aspects of Optimal Transportation**, Mathematical Sciences Research Institute, Berkeley, California.
Description: The workshop will be devoted to emerging approaches to fluid mechanical, geophysical and kinetic theoretical flows based on optimal transportation. It will also explore numerical approaches to optimal transportation problems.
Information: http://www.msri.org/web/msri/scientific/workshops/all-workshops/show/-/event/Wm9227.

18–20 **2013 Fall Central Section Meeting**, Washington University, St. Louis, Missouri.
Information: http://www.ams.org/meetings/sectional/sectional.html.

* 21–25 **Mathematics of Planet Earth 2013 - Pan-Canadian Thematic Program - Sustainability of Aquatic Ecosystem Networks**, AARMS, Fredericton, New Brunswick, Canada.
Description: The Canadian landscape is dotted with thousands of lakes, mighty rivers and uncountable streams run through it, and three oceans border it. For many decades, Canadians have taken clean and available water for granted: for transport and hydropower, for consumption and recreation. But the impact of human activities is clearly visible: many rivers are polluted and their flow regime altered; algal blooms destroy lake ecosystems; invasive species threaten native species assemblages, oceans are overfished. Many initiatives are under way to understand and manage aquatic ecosystems in a sustainable way.
Information: http://www.crm.umontreal.ca/act/theme/theme_2013_1_en/ecosystem_network13_e.php

November 2013

2–3 **2013 Western Fall Section Meeting**, University of California Riverside, Riverside, California.
Information: http://www.ams.org/meetings/sectional/sectional.html.

* 10–15 **Mathematics of Planet Earth 2013 - Pan-Canadian Thematic Program - Current Challenges for Mathematical Modelling of Cyclic Populations**, BIRS, Banff, Canada.
Description: We propose to bring together ecologists and mathematicians with expertise in cyclic populations to discuss recent advances in our theoretical understanding of the causes and implications of population cycles from both the ecological and mathematical points of view.
Information: http://www.birs.ca/events/2013/5-day-workshops/13w5151.

18–22 **Evolution Problems in General Relativity**, Mathematical Sciences Research Institute, Berkeley, California.
Description: With cosmic censorship, the formation of black holes, and the stability of Kerr black holes as focus problems, the study of the evolution of solutions of Einstein's equations has made dramatic progress in recent years. In this workshop, we highlight some of this recent development, and examine the major areas in which future progress is likely.
Information: http://www.msri.org/web/msri/scientific/workshops/programmatic-workshops/show/-/event/Wm9554.

26–28 **International Conference on Pure and Applied Mathematics, ICPAM-LAE 2013**, Png University of Technology, Lae, Morobe Province, Papua New Guinea.
Description: The objective of the ICPAM-LAE, 2013 is to bring together international team of mathematicians that will contribute to

the development of Pure and Applied Mathematics in Papua New Guinea. The conference aims at bringing together experts, who are already practicing in different fields of pure and applied mathematics, as well as researchers, undergraduates and postgraduate students from around the globe to discuss mathematical questions, exchange high level knowledge of methods and investigate diverse applications of Pure and Applied Mathematics to domains such as astronomy, biology, education, engineering, geosciences, security, health care, medicine etc. Academia and industries are invited to participate. Mathematics Educationists are also welcome.
Information: Please contact: journal@cms.unitech.ac.pg; http://www.unitech.ac.pg/.

January 2014

20–May 23 **Model Theory and Number Theory**, Mathematical Sciences Research Institute, Berkeley, California.
Description: The program aims to further the flourishing interaction between model theory and other parts of mathematics, especially number theory and arithmetic geometry. At present the model theoretical tools in use arise primarily from geometric stability theory and o-minimality. Current areas of lively interaction include motivic integration, valued fields, diophantine geometry, and algebraic dynamics.
Information: http://www.msri.org/web/msri/scientific/programs/show/-/event/Pm146.

23–24 **Connections for Women: Algebraic Topology**, Mathematical Sciences Research Institute, Berkeley, California.
Description: This two-day workshop will consist of short courses given by prominent female mathematicians in the field. These introductory courses will be appropriate for graduate students, post-docs, and researchers in related areas. The workshop will also include a panel discussion featuring successful women at various stages in their mathematical careers.
Information: http://www.msri.org/web/msri/scientific/workshops/programmatic-workshops/show/-/event/Wm9545

27–31 **Introductory Workshop: Algebraic Topology**, Mathematical Sciences Research Institute, Berkeley, California.
Description: Algebraic topology is a rich, vibrant field with close connections to many branches of mathematics. This workshop will describe the state of the field, focusing on major programs, open problems, exciting new tools, and cutting edge techniques.
Information: http://www.msri.org/web/msri/scientific/workshops/programmatic-workshops/show/-/event/Wm9546.

February 2014

10–11 **Connections for Women: Model Theory and its interactions with number theory and algebraic geometry**, Mathematical Sciences Research Institute, Berkeley, California.
Description: The development of model theory has always been influenced by its potential applications. Recent years have seen a remarkable flowering of that development, with many exciting applications of model theory in number theory and algebraic geometry. The introductory workshop will aim to increase these interactions by exposing the techniques of model theory to the number theorists and algebraic geometers, and the problems of number theory and algebraic geometry to the model theorists. The Connections for Women workshop will focus on presenting current research on the borders of these subjects, with particular emphasis on the contributions of women. In addition, there will be some social occasions to allow young women and men to make connections with established researchers, and a panel discussion addressing the challenges faced by all young researchers, but especially by women, in establishing a career in mathematics.
Information: email: chris@msri.org; http://www.msri.org/web/msri/scientific/workshops/all-workshops/show/-/event/Wm9548.

April 2014

7–11 **Reimagining the Foundations of Algebraic Topology**, Mathematical Sciences Research Institute, Berkeley, California.
Description: Recent innovations in higher category theory have unlocked the potential to reimagine the basic tools and constructions in algebraic topology. This workshop will explore the interplay between these higher and ∞-categorical techniques with classical algebraic topology, playing each off of the other and returning the field to conceptual, geometrical intuition.
Information: http://www.msri.org/web/msri/scientific/workshops/programmatic-workshops/show/-/event/Wm9550.

May 2014

12–14 **SIAM Conference on Imaging Science (IS14)**, Hong Kong Baptist University, Hong Kong, China.
Description: The interdisciplinary field of imaging science is experiencing tremendous growth. New devices capable of imaging objects and structures from nanoscale to the astronomical scale are continuously being developed and improved, and as result, the reach of science and medicine has been extended in exciting and unexpected ways. The impact of this technology has been to generate new challenges associated with the problems of formation, acquisition, compression, transmission, and analysis of images. By their very nature, these challenges cut across the disciplines of physics, engineering, mathematics, biology, medicine, and statistics. While the primary purpose of this conference is to focus on mathematical issues, the other facets of imaging, such as biomedical and engineering aspects, for example, will also play an important role.
Information: http://www.siam.org/meetings/is14/.

12–16 **Model Theory in Geometry and Arithmetic**, Mathematical Sciences Research Institute, Berkeley, California.
Description: The workshop will feature talks in a range of topics where model theory interacts with other parts of mathematics, especially number theory and arithmetic geometry, including: motivic integration, algebraic dynamics, diophantine geometry, and valued fields.
Information: http://www.msri.org/web/msri/scientific/workshops/programmatic-workshops/show/-/event/Wm9547.

June 2014

29–July 3 **26th International Conference on Formal Power Series and Algebraic Combinatorics (FPSAC)**, DePaul University, Chicago, Illinois.
Topics: Include all aspects of combinatorics and their relations with other parts of mathematics, physics, computer science, and biology. The conference will include invited lectures, contributed presentations, poster sessions, and software demonstrations. There will be no parallel sessions.
Information: http://sites.google.com/site/fpsac2014/.

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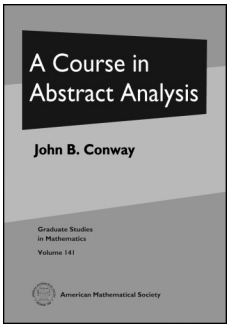
Algebra and Algebraic Geometry



A Course in Abstract Analysis

John B. Conway, *George Washington University, DC*

This book covers topics appropriate for a first-year graduate course preparing students for the doctorate degree. The first half of the book presents the core of measure theory, including an introduction to the Fourier transform. This material can easily be covered in a semester. The second half of the book treats basic functional analysis and can also be covered in a semester. After the basics, it discusses linear transformations, duality, the elements of Banach algebras, and C*-algebras. It concludes with a characterization of the unitary equivalence classes of normal operators on a Hilbert space.

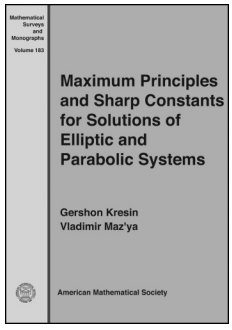
The book is self-contained and only relies on a background in functions of a single variable and the elements of metric spaces. Following the author's belief that the best way to learn is to start with the particular and proceed to the more general, it contains numerous examples and exercises.

Contents: Setting the stage; Elements of measure theory; A Hilbert space interlude; A return to measure theory; Linear transformations; Banach spaces; Locally convex spaces; Duality; Operators on a Banach space; Banach algebras and spectral theory; C*-algebras; Appendix; Bibliography; Indexes.

Graduate Studies in Mathematics, Volume 141

October 2012, approximately 380 pages, Hardcover, ISBN: 978-0-8218-9083-7, 2010 *Mathematics Subject Classification:* 28-01, 46-01, **AMS members US$60**, List US$75, Order code GSM/141

Differential Equations



Maximum Principles and Sharp Constants for Solutions of Elliptic and Parabolic Systems

Gershon Kresin, *Ariel University Center of Samaria, Israel*, and **Vladimir Maz'ya**, *Linköping University, Sweden, and University of Liverpool, England*

The main goal of this book is to present results pertaining to various versions of the maximum principle for elliptic and parabolic systems of arbitrary order. In particular, the authors present necessary and sufficient conditions for validity of the classical maximum modulus principles for systems of second order and obtain sharp constants in inequalities of Miranda-Agmon type and in many other inequalities of a similar nature. Somewhat related to this topic are explicit formulas for the norms and the essential norms of boundary integral operators. The proofs are based on a unified approach using, on one hand, representations of the norms of matrix-valued integral operators whose target spaces are linear and finite dimensional, and, on the other hand, on solving certain finite dimensional optimization problems.

This book reflects results obtained by the authors, and can be useful to research mathematicians and graduate students interested in partial differential equations.

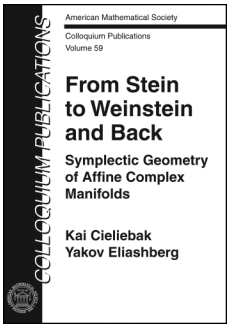
Contents: Introduction; *Elliptic equations and systems:* Prerequisites on operators acting into finite dimensional spaces; Maximum modulus principle for second order strongly elliptic systems; Sharp constants in the Miranda-Agmon inequalities for solutions of certain systems of mathematical physics; Sharp pointwise estimates for solutions of elliptic systems with boundary data from L^p; Sharp constant in the Miranda-Agmon type inequality for derivatives of solutions to higher order elliptic equation; Sharp pointwise estimates for directional derivatives and Khavinson's type extremal problems for harmonic functions; The norm and the essential norm for double layer vector-valued potentials; *Parabolic systems:* Maximum modulus principle for parabolic systems; Maximum modulus principle for parabolic systems with zero boundary data; Maximum norm principle for parabolic systems without lower order terms; Maximum norm

principle with respect to smooth norms for parabolic systems; Bibliography; List of symbols; Index.

Mathematical Surveys and Monographs, Volume 183

September 2012, 317 pages, Hardcover, ISBN: 978-0-8218-8981-7, 2010 *Mathematics Subject Classification:* 35A23, 35B50, 35J47, 35K40; 31B10, 35J30, 35Q35, 35Q74, **AMS members US$76.80**, List US$96, Order code SURV/183

Geometry and Topology



From Stein to Weinstein and Back

Symplectic Geometry of Affine Complex Manifolds

Kai Cieliebak, *Ludwig-Maximilians-Universität, München, Germany*, and **Yakov Eliashberg**, *Stanford University, CA*

A beautiful and comprehensive introduction to this important field.

—***Dusa McDuff, Barnard College, Columbia University***

This excellent book gives a detailed, clear, and wonderfully written treatment of the interplay between the world of Stein manifolds and the more topological and flexible world of Weinstein manifolds. Devoted to this subject with a long history, the book serves as a superb introduction to this area and also contains the authors' new results.

—***Tomasz Mrowka, MIT***

This book is devoted to the interplay between complex and symplectic geometry in affine complex manifolds. Affine complex (a.k.a. Stein) manifolds have canonically built into them symplectic geometry which is responsible for many phenomena in complex geometry and analysis. The goal of the book is the exploration of this symplectic geometry (the road from "Stein to Weinstein") and its applications in the complex geometric world of Stein manifolds (the road "back"). This is the first book which systematically explores this connection, thus providing a new approach to the classical subject of Stein manifolds. It also contains the first detailed investigation of Weinstein manifolds, the symplectic counterparts of Stein manifolds, which play an important role in symplectic and contact topology.

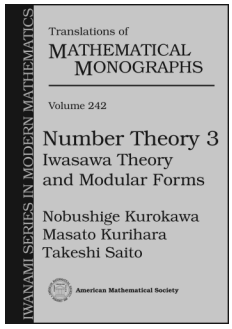
Assuming only a general background from differential topology, the book provides introductions to the various techniques from the theory of functions of several complex variables, symplectic geometry, h-principles, and Morse theory that enter the proofs of the main results. The main results of the book are original results of the authors, and several of these results appear here for the first time. The book will be beneficial for all students and mathematicians interested in geometric aspects of complex analysis, symplectic and contact topology, and the interconnections between these subjects.

Contents: Introduction; *J-convexity:* J-convex functions and hypersurfaces; Smoothing; Shapes for i-convex hypersurfaces; Some complex analysis; *Existence of Stein structures:* Symplectic and contact preliminaries; The h-principles; The existence theorem; *Morse–Smale theory for J-convex functions:* Recollections from Morse theory; Modifications of J-convex Morse functions; *From Stein to Weinstein and back:* Weinstein structures; Modifications of Weinstein structures; Existence revisited; Deformations of flexible Weinstein structures; Deformations of Stein structures; *Stein manifolds and symplectic topology:* Stein manifolds of complex dimension two; Exotic Stein structures; Some algebraic topology; Obstructions to formal Legendrian isotopies; Biographical notes on the main characters; Bibliography; Index.

Colloquium Publications, Volume 59

November 2012, approximately 354 pages, Hardcover, ISBN: 978-0-8218-8533-8, LC 2012019063, 2010 *Mathematics Subject Classification:* 32Q28, 53D35, **AMS members US$62.40**, List US$78, Order code COLL/59

Number Theory



Number Theory 3

Iwasawa Theory and Modular Forms

Nobushige Kurokawa, *Tokyo Institute of Technology, Japan*, **Masato Kurihara**, *Keio University, Yokohama, Japan*, and **Takeshi Saito**, *University of Tokyo, Japan*

This is the third of three related volumes on number theory. (The first two volumes were also published in the Iwanami Series in Modern Mathematics, as volumes 186 and 240.)

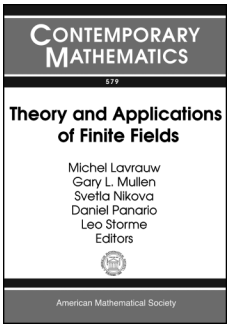
The two main topics of this book are Iwasawa theory and modular forms. The presentation of the theory of modular forms starts with several beautiful relations discovered by Ramanujan and leads to a discussion of several important ingredients, including the zeta-regularized products, Kronecker's limit formula, and the Selberg trace formula. The presentation of Iwasawa theory focuses on the Iwasawa main conjecture, which establishes far-reaching relations between a p-adic analytic zeta function and a determinant defined from a Galois action on some ideal class groups. This book also contains a short exposition on the arithmetic of elliptic curves and the proof of Fermat's last theorem by Wiles.

Together with the first two volumes, this book is a good resource for anyone learning or teaching modern algebraic number theory.

Contents: Modular forms; Iwasawa theory; Modular forms II; Ellliptic curves II; Bibliography; Answers to questions; Answers to exercises; Index.

Translations of Mathematical Monographs (*Iwanami Series in Modern Mathematics*), Volume 242

October 2012, approximately 240 pages, Softcover, ISBN: 978-0-8218-2095-7, LC 99-33556, 2010 *Mathematics Subject Classification:* 11-01; 11Mxx, 11R23, 11Rxx, 11Sxx, 11G05, 11Fxx, **AMS members US$42.40**, List US$53, Order code MMONO/242



Theory and Applications of Finite Fields

Michel Lavrauw, *Universitá Degli Studi di Padova, Vicenza, Italy*, **Gary L. Mullen**, *Pennsylvania State University, State College, PA*, **Svetla Nikova**, *K.U. Leuven, Leuven-Heverlee, Belgium*, **Daniel Panario**, *Carleton University, Ottawa, Ontario, Canada*, and **Leo Storme**, *Ghent University, Belgium*, Editors

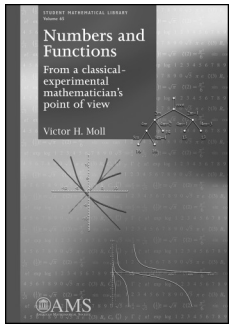
This volume contains the proceedings of the 10th International Congress on Finite Fields and their Applications (Fq 10), held July 11–15, 2011, in Ghent, Belgium.

Research on finite fields and their practical applications continues to flourish. This volume's topics, which include finite geometry, finite semifields, bent functions, polynomial theory, designs, and function fields, show the variety of research in this area and prove the tremendous importance of finite field theory.

Contents: J. Bamberg and **N. Durante**, Low dimensional models of the finite split Cayley hexagon; **G. Bhowmik** and **J.-C. Schlage-Puchta**, Davenport's constant for groups with large exponent; **M. V. Budrevich** and **A. E. Guterman**, Permanent has less zeros than determinant over finite fields; **I. Cardinali** and **A. Pasini**, On a series of modules for the symplectic group in characteristic 2; **F. N. Castro**, **R. Figueroa**, and **L. A. Medina**, Exact divisibility of exponential sums and some consequences; **Z. Chen** and **A. Winterhof**, Additive character sums of polynomial quotients; **J. de la Cruz** and **W. Willems**, 5-designs related to binary extremal self-dual codes of length $24m$; **Y. Hamahata**, Sequences of Dedekind sums in function fields; **T. Helleseth**, **A. Kholosha**, and **S. Mesnager**, Niho bent functions and Subiaco hyperovals; **M. Homma**, A bound on the number of points of a curve in a projective space over a finite field; **M. Kiermaier** and **I. Landjev**, Designs in projective Hjelmslev spaces; **G. Marino** and **O. Polverino**, On the nuclei of a finite semifield; **G. L. Matthews** and **J. D. Peachey**, Small-bias sets from extended norm-trace codes; **A. Ostafe**, **D. Thomson**, and **A. Winterhof**, On the Waring problem with multivariate Dickson polynomials; **M. Rosen**, Polynomials modulo p and the theory of Galois sets; **D. Schipani** and **M. Elia**, Additive decompositions induced by multiplicative characters over finite fields; **S. Ugolini**, Graphs associated with the map $x \mapsto x + x^{-1}$ in finite fields of characteristic two.

Contemporary Mathematics, Volume 579

November 2012, 202 pages, Softcover, ISBN: 978-0-8218-5298-9, 2010 *Mathematics Subject Classification:* 05Bxx, 11Gxx, 11Lxx, 11Txx, 14Gxx, 51Exx, 94A60, 94Bxx, **AMS members US$172.80**, List US$216, Order code CONM/579



Numbers and Functions

From a classical-experimental mathematician's point of view

Victor H. Moll, *Tulane University, New Orleans, LA*

New mathematics often comes about by probing what is already known. Mathematicians will change the parameters in a familiar calculation or explore the essential ingredients of a classic proof. Almost magically, new ideas emerge from this process. This book examines elementary functions, such as those encountered in calculus courses, from this point of view of experimental mathematics. The focus is on exploring the connections between these functions and topics in number theory and combinatorics. There is also an emphasis throughout the book on how current mathematical software can be used to discover and prove interesting properties of these functions.

The book provides a transition between elementary mathematics and more advanced topics, trying to make this transition as smooth as possible. Many topics occur in the book, but they are all part of a bigger picture of mathematics. By delving into a variety of them, the reader will develop this broad view. The large collection of problems is an essential part of the book. The problems vary from routine verifications of facts used in the text to the exploration of open questions.

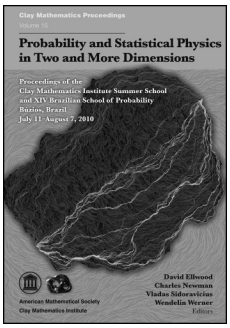
This item will also be of interest to those working in analysis.

Contents: The number systems; Factorials and binomial coefficients; The Fibonacci numbers; Polynomials; Binomial sums; Catalan numbers; The Stirling numbers of the second kind; Rational functions; Wallis' formula; Farey fractions; The exponential function; Trigonometric functions; Bernoulli polynomials; A sample of classical polynomials: Legendre, Chebyshev, and Hermite; Landen transformations; Three special functions: Γ, ψ, and ζ; Bibliography; Index.

Student Mathematical Library, Volume 65

November 2012, approximately 503 pages, Softcover, ISBN: 978-0-8218-8795-0, LC 2012014772, 2010 *Mathematics Subject Classification:* 05A05, 05C05, 11A07, 11A41, 11A55, 11B39, 11B65, 33B10, 33B15, 33F10, **AMS members US$46.40**, List US$58, Order code STML/65

Probability and Statistics



Probability and Statistical Physics in Two and More Dimensions

David Ellwood, *Clay Mathematics Institute, Cambridge, MA*, **Charles Newman**, *Courant Institute, New York University, NY*, **Vladas Sidoravicius**, *IMPA, Rio de Janeiro, Brazil*, and **Wendelin Werner**, *Ecole Normale Supérieure, Paris, France, and Université Paris-Sud, Orsay, France*, Editors

This volume is a collection of lecture notes for six of the ten courses given in Búzios, Brazil by prominent probabilists at the 2010 Clay Mathematics Institute Summer School, "Probability and Statistical Physics in Two and More Dimensions", and at the XIV Brazilian School of Probability.

In the past ten to fifteen years, various areas of probability theory related to statistical physics, disordered systems and combinatorics have undergone intensive development. A number of these developments deal with two-dimensional random structures at their critical points, and provide new tools and ways of coping with at least some of the limitations of Conformal Field Theory that had been so successfully developed in the theoretical physics community to understand phase transitions of two-dimensional systems.

Included in this selection are detailed accounts of all three foundational courses presented at the Clay school—Schramm–Loewner Evolution and other Conformally Invariant Objects, Noise Sensitivity and Percolation, Scaling Limits of Random Trees and Planar Maps—together with contributions on Fractal and Multifractal properties of SLE and Conformal Invariance of Lattice Models. Finally, the volume concludes with extended articles based on the courses on Random Polymers and Self-Avoiding Walks given at the Brazilian School of Probability during the final week of the school.

Together, these notes provide a panoramic, state-of-the-art view of probability theory areas related to statistical physics, disordered systems and combinatorics. Like the lectures themselves, they are oriented towards advanced students and postdocs, but experts should also find much of interest.

This item will also be of interest to those working in mathematical physics.

Titles in this series are co-published with the Clay Mathematics Institute (Cambridge, MA).

Contents: V. Beffara, Schramm-Loewner evolution and other conformally invariant objects; **C. Garban** and **J. E. Steif**, Noise sensitivity and percolation; **J.-F. Le Gall** and **G. Miermont**, Scaling limits of random trees and planar maps; **H. Duminil-Copin** and **S. Smirnov**, Conformal invariance of lattice models; **G. F. Lawler**, Fractal and multifractal properties of Schramm-Loewner evolution; **F. Caravenna**, **F. Den Hollander**, and **N. Pétrélis**, Lectures on random polymers; **R. Bauerschmidt**, **H. Duminil-Copin**, **J. Goodman**, and **G. Slade**, Lectures on self-avoiding walks.

Clay Mathematics Proceedings, Volume 15

October 2012, approximately 410 pages, Softcover, ISBN: 978-0-8218-6863-8, LC 2012017930, 2010 *Mathematics Subject Classification:* 60-06, 60G60, 60K35, 60K37, 82B20, 82B27, 82B28, 82B41, 82B43, 82B44, **AMS members US$91.20**, List US$114, Order code CMIP/15

New AMS-Distributed Publications

Analysis

Arrangements of Hyperplanes—Sapporo 2009

Hiroaki Terao, *Hokkaido University, Japan*, and **Sergey Yuzvinsky**, *University of Oregon, Eugene*, Editors

his book is the proceedings of the conference on Arrangements of Hyperplanes, held in August 2009 as the 2nd Mathematical Society of Japan Seasonal Institute.

The modern study of arrangements of hyperplanes started in the early 1980s. Since the object of study is simple (just a finite set of hyperplanes), there are various mathematical approaches to arrangements including algebra, topology, combinatorics, singularities, integral systems, hypergeometric functions, and statistics. Since numerous world-renowned experts gave talks at the 2nd MSJ-SI, this book covers many pioneering approaches and new topics in the theory of arrangements as well as indispensable classical results.

The book is recommended to any researcher or graduate student interested in arrangements of hyerplanes.

This item will also be of interest to those working in geometry and topology.

Published for the Mathematical Society of Japan by Kinokuniya, Tokyo, and distributed worldwide, except in Japan, by the AMS.

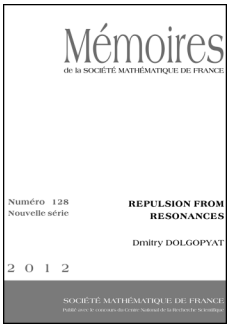
Contents: K. Aomoto, Hypersphere arrangement and imaginary cycles for hypergeometric integrals; **G. Denham** and **M. Schulze**, Complexes, duality and Chern classes of logarithmic forms along hyperplane arrangements; **A. Deza**, **H. Miyata**, **S. Moriyama**, and **F. Xie**, Hyperplane arrangements with large average diameter: A computational approach; **D. C. Cohen**, **G. Denham**, **M. Falk**, and **A. Varchenko**, Vanishing products of one-forms and critical points of master functions; **Y. Haraoka**, Middle convolution for completely integrable systems with logarithmic singularities along hyperplane arrangements; **H. Kimura**, On a problem of arrangements related to the hypergeometric integrals of confluent type; **T. Kohno**, Hyperplane arrangements, local system homology and iterated integrals; **A. Libgober**, On combinatorial invariance of the cohomology of the Milnor fiber of arrangements and the Catalan equation over function fields; **E. Looijenga**, The KZ system via polydifferentials; **K. Mimachi**, Solutions for some families of Fuchsian differential equations free from accessory parameters in terms of the integral of Euler

type; **J. V. Pereira**, Resonance webs of hyperplane arrangements; **F. Mori** and **M. Salvetti**, Discrete topological methods for subspace arrangements; **H. Schenck**, Hyperplane arrangements: Computations and conjectures; **A. I. Suciu**, Resonance varieties and Dwyer–Fried invariants; **H. Kamiya**, **A. Takemura**, and **N. Tokushige**, Application of arrangement theory to unfolding models; **D. Tamaki**, On the homology of configuration spaces associated to centers of mass; **T. Terasoma**, Varieties of lines on Fermat hypersurfaces; **E. Mukhin**, **V. Tarasov**, and **A. Varchenko**, Three sides of the geometric Langlands correspondence for gl_n Gaudin model and Bethe vector averaging maps; **A. K. Singh** and **U. Walther**, A note on Bockstein homomorphisms in local cohomology; **M. Yoshinaga**, Arrangements, multiderivations, and adjoint quotient map of type ADE; **S. Yuzvinsky**, Resonance varieties of arrangement complements.

Advanced Studies in Pure Mathematics, Volume 62

March 2012, 570 pages, Hardcover, ISBN: 978-4-931469-67-9, 2010 *Mathematics Subject Classification:* 14N20; 32S22, 52C35, **AMS members US$83.20**, List US$104, Order code ASPM/62

Differential Equations



Repulsion from Resonances

Dmitry Dolgopyat, *University of Maryland, College Park, MD*

The author considers slow-fast systems with periodic fast motion and integrable slow motion in the presence of both weak and strong resonances. Assuming that the initial phases are random and that appropriate non-degeneracy assumptions are satisfied, he proves that the effective evolution of the adiabatic invariants is given by a Markov process. This Markov process consists of the motion along the trajectories of a vector field with occasional jumps. The generator of the limiting process is computed from the dynamics of the system near strong resonances.

This item will also be of interest to those working in mathematical physics.

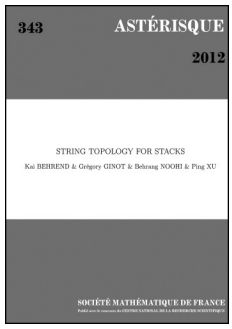
A publication of the Société Mathématique de France, Marseilles (SMF), distributed by the AMS in the U.S., Canada, and Mexico. Orders from other countries should be sent to the SMF. Members of the SMF receive a 30% discount from list.

Contents: Introduction; The proof; A. Asymptotics of the Poincaré map; B. Derivatives of the Poincaré map. Outline of the proof; C. Derivatives of the inner map; D. Derivatives of the outer map; E. Dynamics near the separatrix; F. Captured points; G. Examples; H. Distortion bound; Bibliography.

Mémoires de la Société Mathématique de France, Number 128

May 2012, 119 pages, Softcover, ISBN: 978-2-85629-344-7, 2010 *Mathematics Subject Classification:* 34C29, 70K65, 37D25, 60F17, **Individual member US$43.20**, List US$48, Order code SMFMEM/128

Geometry and Topology



String Topology for Stacks

Kai Behrend, *University of British Columbia, Vancouver, BC, Canada*, **Grégory Ginot**, *Université Paris 13, Cachan, France*, **Behrang Noohi**, *Max Planck Institut für Mathematik, Bonn, Germany*, and **Ping Xu**, *Pennsylvania State University, University Park, PA*

The authors establish the general machinery of string topology for differentiable stacks. This machinery allows them to treat on equal footing free loops in stacks and hidden loops. They construct a bivariant (in the sense of Fulton and MacPherson) theory for topological stacks: it gives them a flexible theory of Gysin maps, which are automatically compatible with pullback, pushforward and products. Then the authors prove an excess formula in this context.

The authors introduce oriented stacks, generalizing oriented manifolds, which are stacks on which they can do string topology. They prove that the homology of the free loop stack of an oriented stack and the homology of hidden loops (sometimes called ghost loops) are Frobenius algebras which are related by a natural morphism of Frobenius algebras. They also prove that the homology of the free loop stack has a natural structure of BV-algebra which, together with the Frobenius structure, fits into homological conformal field theories with closed positive boundaries. They also use their constructions to study an analogue of the loop product for stacks of maps of (n-dimensional) spheres to oriented stacks and compatible power maps in their homology.

Using their general machinery, the authors construct an intersection pairing for (not necessarily compact) almost complex orbifolds which is in the same relation to the intersection pairing for manifolds as Chen-Ruan orbifold cup-product is to ordinary cup-product of manifolds. They show that the hidden product of almost complex orbifolds is isomorphic to the orbifold intersection pairing twisted by a canonical class. Finally they gave some examples, including the case of the classifying stacks $[*/G]$ of a compact Lie group.

A publication of the Société Mathématique de France, Marseilles (SMF), distributed by the AMS in the U.S., Canada, and Mexico. Orders from other countries should be sent to the SMF. Members of the SMF receive a 30% discount from list.

Contents: Topological stacks; Homotopy type of a topological stack; Vector bundles on stacks; Thom isomorphism; Loop stacks; Bounded proper morphisms of topological stacks; Bivariant theory for topological stacks; Regular embeddings, submersions, and normally nonsingular morphisms; Gysin maps; The loop product; Hidden loop product for family of groups over a stack; Frobenius algebra structures; The BV-algebra on the homology of free loop stack; Homological conformal field theory and free loop stacks; Remarks on brane topology for stacks; Orbifold intersection pairing; Examples; Bibliography.

Astérisque, Number 343

April 2012, 169 pages, Softcover, ISBN: 978-2-85629-342-3, 2010 *Mathematics Subject Classification:* 55P50, 14D23, 55Nxx, **Individual member US$54**, List US$60, Order code AST/343

Classified Advertisements

Positions available, items for sale, services available, and more

MASSACHUSETTS

WILLIAMS COLLEGE
Department of Mathematics and Statistics

Williams College invites applications for one tenure-track position in mathematics, beginning fall 2013, at the rank of assistant professor (in an exceptional case, a more advanced appointment may be considered). We are seeking a highly qualified candidate who has demonstrated excellence in teaching, who will establish an active and successful research program, and who will have a Ph.D. by the time of appointment. Williams College is a private, coeducational, residential, highly selective liberal arts college with an undergraduate enrollment of approximately 2,000 students. The teaching load is two courses per 12-week semester and a winter term course every other January. Applicants are encouraged to apply electronically at: http://mathjobs.org or send a vita and have three letters of recommendation on teaching and research sent to Satyan Devadoss, Chair of the Hiring Committee, Department of Mathematics and Statistics, Williams College, 18 Hoxsey Street, Williamstown, MA 01267. Teaching and research statements are also welcome. Evaluations of applications will begin on or after November 15 and will continue until the position is filled. All offers of employment are contingent upon completion of a background check. Further information is available upon request. For more information on the Department of Mathematics and Statistics, visit: http://math.williams.edu/. Williams College is a coeducational liberal arts institution located in the Berkshire Hills of western Massachusetts with easy access to the culturally rich cities of Albany, Boston, and New York City. The college is committed to building and supporting a diverse population of students, and to fostering an inclusive faculty, staff, and curriculum. Williams has built its reputation on outstanding teaching and scholarship and on the academic excellence of its students. Please visit the Williams College website http://www.williams.edu/. Beyond meeting fully its legal obligations for non-discrimination, Williams College is committed to building a diverse and inclusive community where members from all backgrounds can live, learn, and thrive.

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WORCESTER POLYTECHNIC INSTITUTE (WPI)
Department Head, Mathematical Sciences

Worcester Polytechnic Institute (WPI) invites applications for the position of Head of the Mathematical Sciences Department. The department currently comprises 28 full-time faculty and offers outstanding academic programs, including the B.S., M.S., and Ph. D. in Mathematical Sciences; maintains vibrant research programs in applied and computational mathematics and statistics; and is the home of the Center for Industrial Mathematics and Statistics, with strong industry-university alliances. The department boasts over 170 undergraduate majors and 80 graduate students and serves a vital support role for other degree programs. WPI seeks a dynamic individual with demonstrated leadership ability who will build upon the department's strengths, recruit outstanding faculty, promote scholarly initiatives, foster corporate relations, and steer the department to its next level of excellence and visibility. Applicants must have an earned doctorate and a strong international reputation, a distinguished record of scholarly achievement in application-oriented mathematical sciences supporting the department's strengths, administrative experience or clear potential, and a record of excellence in teaching. The department head will be expected to represent the department within both the constituent and academic communities and to coordinate extramural funding activities. More information about the department and its mission, goals and objectives, undergraduate and graduate programs, and faculty research areas is available at: http://www.wpi.edu/academics/math.html. Applications should include a curriculum vitae, a letter of intent that describes professional

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 2012 rate is $3.50 per word with a minimum two-line headline. 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: October 2012 issue–July 28, 2012; November 2012 issue–August 30, 2012; December 2012 issue–October 1, 2012; January 2013 issue–October 29, 2012; February 2013 issue–November 28, 2012; March 2013 issue–January 2, 2013.

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.

interests (research, teaching, and administrative), and contact information for a minimum of three references. Applicants are encouraged to apply through MathJobs (http://www.mathjobs.org), but application materials may also be submitted (as a single PDF file) to: masearch@wpi.edu. Nominations are welcome and should be sent to: masearch@wpi.edu. Applications from women and minority candidates are especially encouraged. For full consideration, applications should be received by November 1, 2012. Questions can be addressed to: kwobbe@wpi.edu.

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NEW YORK

SIMONS FOUNDATION
Content Editor, http://SimonsFoundation.org

The Simons Foundation is seeking a Content Editor (CE) for http://SimonsFoundation.org. http://SimonsFoundation.org is now undergoing re-design and will be re-launched shortly. The CE will not only be in charge of much of the content for the foundation's website, but this person will also be specifically focusing on our Mathematics and Physical Sciences (MPS) material, ensuring that there is an uninterrupted flow of high-level MPS website content for feature articles suitable for, and of interest to, top researchers in the basic sciences and mathematics. To apply for this position, please indicate the position for which you are applying, and send resume, cover letter, and relevant writing sample (or other portfolio materials) to: email: jobs@simonsfoundation.org.

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SIMONS FOUNDATION
Managing Editor, http://SimonsFoundation.org.

The Managing Editor (ME) will be tasked broadly with oversight of all aspects of http://simonsfoundation.org. http://SimonsFoundation.org is now undergoing re-design and will be re-launched shortly. The ME will ensure that the website functions properly and also that it reflects the Simons Foundation brand and mission through excellent design and content. It is expected that the successful candidate will be from an online background in the sciences or mathematics. To apply for this position, please indicate the position for which you are applying, and send resume, cover letter, and relevant writing sample (or other portfolio materials) to: jobs@simonsfoundation.org.

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NORTH CAROLINA

NORTH CAROLINA STATE UNIVERSITY
Department of Mathematics

The Mathematics Department at North Carolina State University invites applications for one or more tenure-track positions beginning Fall 2013, depending on the availability of funding. We are seeking exceptionally well-qualified individuals with research interests compatible with those in the department. All areas of pure and applied mathematics will be considered. Among the several areas of special interest are computational geometry/topology, scientific computation, analysis, numerical analysis, and mathematical biology. Candidates must have a Ph.D. in the mathematical sciences, an outstanding research program, a commitment to effective teaching at the undergraduate and graduate levels and demonstrated potential for excellence in both research and teaching. She or he will likely have had successful postdoctoral experience. The Department of Mathematics has strong research programs in both pure and applied mathematics. Many members of the department participate in interdisciplinary programs and research groups on campus and in the broader Research Triangle community. More information about the department can be found at: http://www.math.ncsu.edu.

To submit your application materials, go to: http://www.mathjobs.org/jobs/ncsu. Include a vita, at least three letters of recommendation, and a description of current and planned research. To be considered for this position, please also go to: http://jobs.ncsu.edu/postings/9937 to apply for this job and complete a Faculty Profile. You can reference Position number 00102680.

Write to: math-jobs@math.ncsu.edu for questions concerning this position. Applications received by November 15, 2012, will be given priority.

AA/EOE. In addition, NC State welcomes all persons without regard to sexual orientation. The College of Physical and Mathematical Sciences welcomes the opportunity to work with candidates to identify opportunities for spouses or partners. For ADA accommodations, please contact Human Resources by email at: employment@ncsu.edu or by calling (919) 515-2135. Final candidates are subject to criminal and sex offender background checks. If highest degree is from an institution outside of the U.S., final candidates are required to have their degrees verified at: http://www.wes.org. Degree must be obtained prior to start date. NC State University participates in E-verify. Federal law requires all employers to verify the identity and employment eligibility of all persons hired to work in the United States.

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HONG KONG

THE UNIVERSITY OF HONG KONG
Tenure-Track Associate Professor/Assistant Professor in the Department of Mathematics (Ref.: 201200445)

Applications are invited for a tenure-track appointment as Associate Professor/Assistant Professor in the Department of Mathematics, from July 1, 2013, or as soon as possible thereafter. The position will initially be made on a three-year term basis, with the possibility of renewal and with consideration for tenure during the second three-year contract.

The position is to be held by an academic in Pure Mathematics. Special consideration will be given to candidates whose expertise overlaps with Algebraic Geometry, Arithmetic Geometry and/or Complex Geometry, but applications from candidates in any area of Pure Mathematics will also be considered. The appointee, who will be a regular professoriate member of the department, will be associated with the Institute of Mathematical Research (IMR) (http://www.hku.hk/math/imr), a centre of the University of Hong Kong attached to the department. He/She is expected to actively participate in research activities of the IMR and to take part in the organization of these activities such as research seminars, workshops and conferences. The appointee will share teaching duties as other regular professoriate members of the department, but efforts will be made by the department so that part of those duties will be fulfilled through the teaching of graduate level and advanced undergraduate level courses. For enquiries about the existing research activities and the specific job requirements, please write to Professor J. Lu, Head of the Department of Mathematics (email: jhlu@maths.hku.hk).

A globally competitive remuneration package commensurate with the appointee's qualifications and experience will be offered. At current rates, salaries tax does not exceed 15% of gross income. The appointment will attract a contract-end gratuity and university contribution to a retirement benefits scheme, totalling up to 15% of basic salary, as well as leave, and medical benefits. Housing benefits will be provided as applicable.

Applicants should send a completed application form, together with a C.V. containing information on educational experience, professional experience, a complete list of publications, a survey of past research and teaching experience, a research plan for the next few years, and a statement on teaching philosophy by email to: scmath@hku.hk. They should also arrange for submission, to the same e-mail address as stated above, three reference letters from senior academics. One of these senior academics should be asked to comment on the applicant's ability in

teaching, or the applicant should arrange to have an additional reference letter on his/her teaching sent to the same email address as stated above. Please indicate clearly "Ref.: 201200445" and which level the candidate is being considered for (Tenure-Track Associate Professor/ Assistant Professor in the Department of Mathematics) in the subject of the email. Application forms (341/1111) can be obtained at: http://www.hku.hk/apptunit/form-ext.doc. Further particulars can be obtained at http://jobs.hku.hk/. Closes November 30, 2012.

The university thanks applicants for their interest, but advises that only short-listed applicants will be notified of the application result.

The university is an equal Opportunity Employer and is committed to a No-Smoking policy.

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MEXICO

INTERNATIONAL YEAR OF STATISTICS, AND MATHEMATICS OF PLANET EARTH CIMAT, Mexico

Visiting positions related to the International Year of Statistics, and Mathematics of Planet Earth. CIMAT, Mexico. CIMAT calls applicants for two 6- or 12-month visiting positions (January to December 2013), one related to the "International Year of Statistics" (http://www.statistics2013.org/) and the other to "Mathematics of Planet Earth 2013" (http://www.mpe2013.org/). Candidates are sought to conduct research and activities oriented by the aims of the 2013 celebrations with impact on CIMAT academic programs. Expected monthly income $4,000 US Cy. Further information at: http://www.cimat.mx/index.php?m=541.

00040

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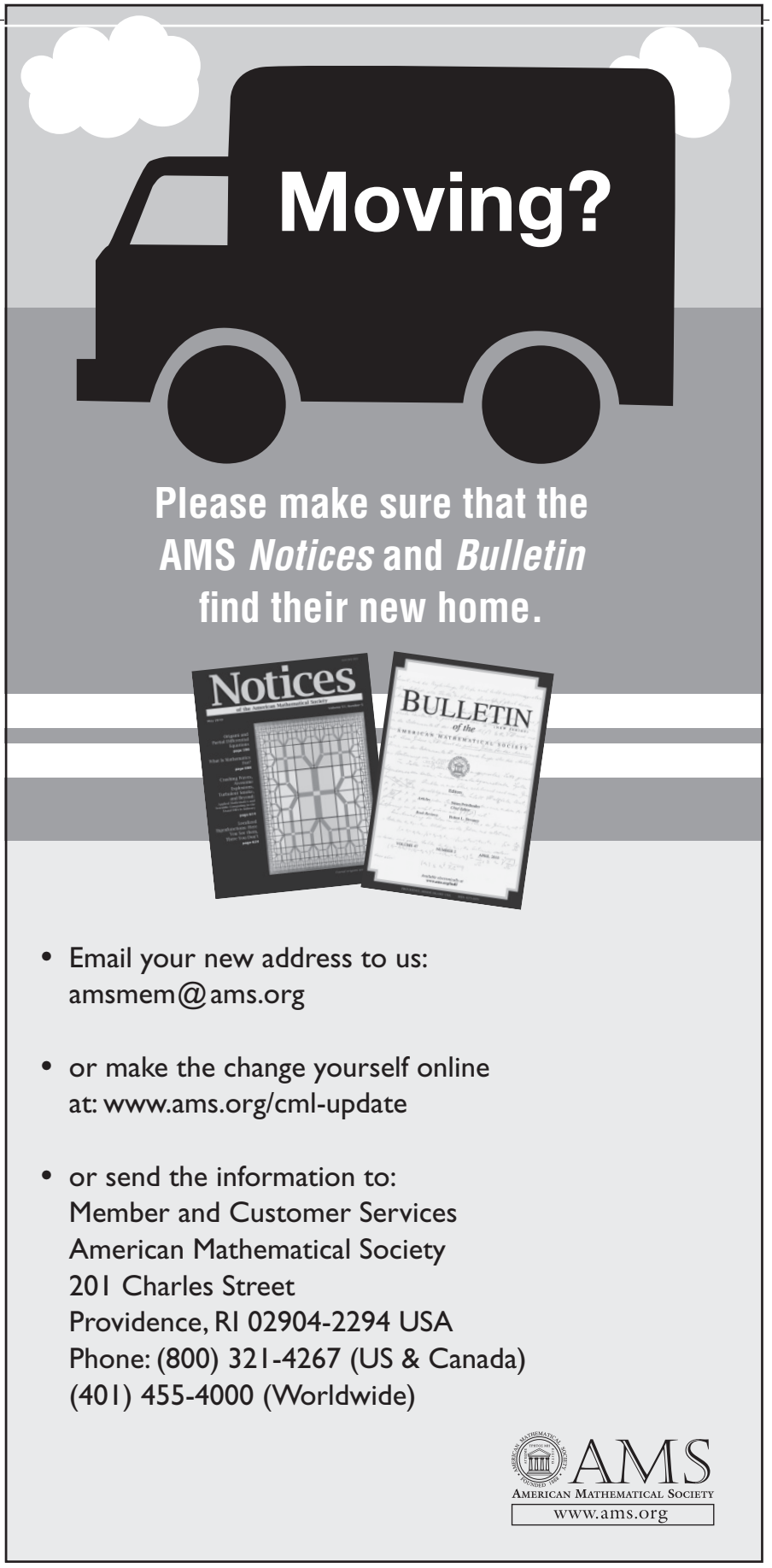

Meetings & Conferences of the AMS

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.

Rochester, New York

Rochester Institute of Technology

September 22–23, 2012

Saturday – Sunday

Meeting #1082

Eastern Section
Associate secretary: Steven H. Weintraub
Announcement issue of *Notices*: July 2012
Program first available on AMS website: July 19, 2012
Program issue of electronic *Notices*: September 2012
Issue of *Abstracts*: Volume 33, Issue 3

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: Expired

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Steve Gonek, University of Rochester, *Title to be announced.*

James Keener, University of Utah, *The mathematics of life—decisions, decisions.*

Dusa McDuff, Barnard College, Columbia University, *Embedding questions in symplectic geometry.*

Peter Winkler, Dartmouth College, *Edge-cover by random walk.*

Special Sessions

Analytic Number Theory, **Steve Gonek**, University of Rochester, and **Angel Kumchev**, Towson University.

Applied and Computational Mathematics, **Ludwig Kohaupt**, Beuth University of Technology, and **Yan Wu**, Georgia Southern University.

Continuum Theory, **Likin C. Simon Romero**, Rochester Institute of Technology.

Difference Equations and Applications, **Michael Radin**, Rochester Institute of Technology.

Financial Mathematics, **Tim Siu-Tang Leung**, Columbia University.

Frontiers in Applied and Industrial Mathematics, **Kara L. Maki** and **David S. Ross**, Rochester Institute of Technology.

Geometric Evolution Equations, **Mihai Bailesteanu**, University of Rochester, and **Mao-Pei Tsui**, University of Toledo.

Geometric, Categorical and Combinatorial Methods in Representation Theory, **David Hemmer** and **Yiqiang Li**, State University of New York at Buffalo.

Inverse Problems and Nonsmooth Optimization: Celebrating Zuhair Nashed's 75th Birthday, **Patricia Clark**, **Baasansuren Jadama**, and **Akhtar A. Khan**, Rochester Institute of Technology, and **Hulin Wu**, University of Rochester.

Mathematical Image Processing, **Nathan Cahill**, Rochester Institute of Technology, and **Lixin Shen** and **Yuesheng Xu**, Syracuse University.

Microlocal Analysis and Nonlinear Evolution Equations, **Raluca Felea**, Rochester Institute of Technology, and **Dan-Andrei Geba**, University of Rochester.

Modern Relativity, **Manuela Campanelli** and **Yosef Zlochower**, Rochester Institute of Technology.

New Advances in Graph Theory, **Jobby Jacob**, Rochester Institute of Technology, and **Paul Wenger**, University of Colorado Denver.

Nonlinear Dynamics of Excitable Media, **Elizabeth Cherry**, Rochester Institute of Technology.

Nonlinear Partial Differential Equations in the Physical and Biological Sciences, **Tony Harkin**, Rochester Institute of Technology, and **Doug Wright**, Drexel University.

Operator Theory and Function Spaces, **Gabriel T. Prajitura** and **Ruhan Zhao**, State University of New York at Brockport.

Permutations Patterns, Algorithms, and Enumerative Combinatorics, **Howard Skogman** and **Rebecca Smith**, State University of New York at Brockport.

Probability and Statistical Physics, **Wenbo Li**, University of Delaware, and **Carl Mueller** and **Shannon Starr**, University of Rochester.

Research in Mathematics by Undergraduates and Students in Post-Baccalaureate Programs, **Bernard Brooks**, **Darren Narayan**, and **Tamas Wiandt**, Rochester Institute of Technology.

Symplectic and Contact Topology, **Dusa McDuff**, Barnard College, and **Vera Vertesi**, Massachusetts Institute of Technology.

Wavelet and Frame Theoretic Methods in Harmonic Analysis and Partial Differential Equations in Memory of Daryl Geller, **Alex Iosevich**, University of Rochester, and **Azita Mayeli**, City University of New York.

New Orleans, Louisiana

Tulane University

October 13–14, 2012

Saturday – Sunday

Meeting #1083

Southeastern Section
Associate secretary: Robert J. Daverman
Announcement issue of *Notices*: June 2012
Program first available on AMS website: September 6, 2012
Program issue of electronic *Notices*: October 2012
Issue of *Abstracts*: Volume 33, Issue 3

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: August 28, 2012

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Anita Layton, Duke University, *Mathematical modeling of renal hemodynamics: Feedback dynamics and coupled oscillators.*

Lenhard Ng, Duke University, *From holomorphic curves to knot invariants via the cotangent bundle.*

Henry K. Schenck, University of Illinois at Urbana-Champaign, *From approximation theory to algebraic geometry: The ubiquity of splines.*

Milen Yakimov, Louisiana State University, *The Andruskiewitsch-Dumas Conjecture.*

Special Sessions

Algebraic Combinatorics: Rook Theory and Applications (Code: SS 4A), **Mahir Bilen Can** and **Michael Joyce**, Tulane University, and **Jeff Remmel**, University of California at San Diego.

Algebraic Structures over Commutative Rings (Code: SS 9A), **Lee Klingler**, Florida Atlantic University, **Aihua Li**, Montclair State University, and **Ralph Tucci**, Loyola University New Orleans.

Algebraic and Topological Combinatorics (Code: SS 10A), **Alexander Engstrom** and **Matthew Stamps**, Aalto University.

Analysis of Pattern Formation in Partial Differential Equations (Code: SS 8A), **Xuefeng Wang**, Tulane University.

Application of Functional Analytic Techniques to Nonlinear Boundary Value Problems (Code: SS 11A), **John R. Graef** and **Lingju Kong**, University of Tennessee at Chattanooga, and **Bo Yang**, Kennesaw State University.

Approximation Theory, Geometric Modelling, and Algebraic Geometry (Code: SS 7A), **Henry Schenck**, University of Illinois at Urbana-Champaign.

Biological Fluid Dynamics: Modeling, Computations, and Applications (Code: SS 5A), **Anita T. Layton**, Duke University, and **Sarah D. Olson**, Worcester Polytechnic Institute.

Combinatorial Commutative Algebra (Code: SS 1A), **Chris Francisco**, Oklahoma State University, **Tai Huy Ha**, Tulane University, and **Adam Van Tuyl**, Lakehead University.

Combinatorial Methods in Knot Theory (Code: SS 13A), **Heather Russell**, University of Southern California, and **Oliver Dasbach**, Louisiana State University.

Diffusion Processes in Biology (Code: SS 2A), **Gustavo Didier**, Tulane University, and **Greg Forest**, University of North Carolina, Charlotte.

Geometric and Algebraic Aspects of Representation Theory (Code: SS 12A), **Pramod N. Achar**, Louisiana State University, and **Dijana Jakelić**, University of North Carolina at Wilmington.

Interactions of Geometry and Topology in Low Dimensions (Code: SS 3A), **John Etnyre**, Georgia Tech, **Rafal Komendarczyk**, Tulane University, and **Lenhard Ng**, Duke University.

Quantum Groups and Noncommutative Algebraic Geometry (Code: SS 6A), **Kailash C. Misra**, North Carolina

State University, and **Milen Yakimov**, Louisiana State University.

Stochastic Analysis: Current Directions and Applications (Code: SS 14A), **Hui-Hsiung Kuo**, **Ambar Sengupta**, and **P. Sundar**, Louisiana State University.

Akron, Ohio

University of Akron

October 20–21, 2012

Saturday – Sunday

Meeting #1084

Central Section
Associate secretary: Georgia Benkart
Announcement issue of *Notices*: August 2012
Program first available on AMS website: September 27, 2012
Program issue of electronic *Notices*: October 2012
Issue of *Abstracts*: Volume 33, Issue 4

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: September 4, 2012

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Tanya Christiansen, University of Missouri, *Title to be announced.*

Tim Cochran, Rice University, *Title to be announced.*

Ronald Solomon, Ohio State University, *Title to be announced.*

Ben Weinkove, University of California San Diego, *Title to be announced.*

Special Sessions

A Survey of Lattice-Valued Mathematics and its Applications (Code: SS 18A), **Austin Melton**, Kent State University, and **Stephen E. Rodabaugh**, Youngstown State University.

Additive and Combinatorial Number Theory (Code: SS 14A), **Tsz Ho Chan**, University of Memphis, **Kevin O'Bryant**, City University of New York, and **Gang Yu**, Kent State University.

Applied Topology (Code: SS 9A), **Peter Bubenik**, Cleveland State University, and **Matthew Kahle**, Ohio State University.

Cayley Graph Computations and Challenges for Permutation Puzzle Groups (Code: SS 20A), **Morley Davidson**, Kent State University, and **Tomas Rokicki**, Radical Eye Software.

Commutative Algebra (Code: SS 8A), **Livia Hummel**, University of Indianapolis, and **Sean Sather-Wagstaff**, North Dakota State University.

Complex Analysis and its Broader Impacts (Code: SS 5A), **Mehmet Celik**, University of North Texas, Dallas, **Alexander Izzo**, Bowling Green State University, and **Sonmez Sahutoglu**, University of Toledo.

Complex Geometry and Partial Differential Equations (Code: SS 4A), **Gabor Szekelyhidi**, University of Notre Dame, **Valentino Tosatti**, Columbia University, and **Ben Weinkove**, University of California San Diego.

Extremal Graph Theory (Code: SS 2A), **Arthur Busch**, University of Dayton, and **Michael Ferrara**, University of Colorado Denver.

Geometry of Algebraic Varieties (Code: SS 12A), **Ana-Marie Castravet**, **Emanuele Macrí**, and **Hsian-Hua Tseng**, The Ohio State University.

Graphs and Polytopes in Algebraic Combinatorics (Code: SS 10A), **Stefan Forcey**, University of Akron, and **Forest Fisher**, NOVA-Manassas.

Groups, Representations, and Characters (Code: SS 1A), **Mark Lewis**, Kent State University, **Adriana Nenciu**, Otterbein University, and **Ronald Solomon**, Ohio State University.

Harmonic Analysis and Convexity (Code: SS 7A), **Benjamin Jaye**, **Dmitry Ryabogin**, and **Artem Zvavitch**, Kent State University.

Interactions Between Geometry and Topology (Code: SS 22A), **Dan Farley**, Miami University, **Jean-Francois Lafont**, Ohio State University, and **Ivonne J. Ortiz**, Miami University.

Issues in the Preparation of Secondary Teachers of Mathematics (Code: SS 21A), **Laurie A. Dunlap** and **Antonio R. Quesada**, University of Akron.

Knot Theory and 4-Manifolds (Code: SS 15A), **Tim Cochran** and **Christopher Davis**, Rice University, and **Kent Orr**, Indiana University.

Noncommutative Ring Theory (Code: SS 6A), **S. K. Jain**, Ohio University, and **Greg Marks** and **Ashish Srivastava**, St. Louis University.

Nonlinear Partial Differential Equations and Harmonic Analysis (Code: SS 19A), **Diego Maldonado**, Kansas State University, **Truyen Nguyen**, University of Akron, and **Nguyen Cong Phuc**, Louisiana State University.

Nonlinear Waves and Patterns (Code: SS 11A), **Anna Ghazaryan** and **Vahagn Manukian**, Miami University.

Separate versus Joint Continuity—a Tribute to I. Namioka (Code: SS 23A), **Zbigniew Piotrowski** and **Eric J. Wingler**, Youngstown State University.

Spectral, Scattering, and Inverse Scattering Theory (Code: SS 3A), **Tanya Christiansen**, University of Missouri, and **Peter Hislop** and **Peter Perry**, University of Kentucky.

Statistical Genetics and Applications (Code: SS 17A), **Omar De La Cruz**, Case Western Reserve University.

Stochastic Processes and Applications (Code: SS 16A), **Oana Mocioalca**, Kent State University.

Toric Algebraic Geometry and Beyond (Code: SS 13A), **Kiumars Kaveh**, University of Pittsburgh, **Benjamin Nill**, Case Western Reserve University, and **Ivan Soprunov**, Cleveland State University.

Tucson, Arizona

University of Arizona, Tucson

October 27–28, 2012

Saturday – Sunday

Meeting #1085

Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: August 2012
Program first available on AMS website: October 4, 2012
Program issue of electronic *Notices*: October 2012
Issue of *Abstracts*: Volume 33, Issue 4

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: September 11, 2012

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Michael Hutchings, University of California Berkeley, *Quantitative invariants in four-dimensional symplectic geometry.*

Kenneth McLaughlin, University of Arizona, Tucson, *Random matrices, integrable systems, asymptotic analysis, combinatorics.*

Ken Ono, Emory University, *Adding and counting* (Erdős Memorial Lecture).

Jacob Sterbenz, University of California San Diego, *Regularity of hypberbolic gauge field equations.*

Goufang Wei, University of California, Santa Barbara, *Comparison results for Ricci curvature.*

Special Sessions

Analytical and Numerical Approaches in Nonlinear Systems: Collapses, Turbulence, Nonlinear Waves in Mathematics, Physics, and Biology (Code: SS 9A), **Alexander Korotkevich** and **Pavel Lushnikov**, University of New Mexico.

Asymptotic Analysis of Random Matrices, Integrable Systems, and Applications (Code: SS 13A), **Ken McLaughlin** and **Nick Ercolani**, University of Arizona.

Biomathematics (Code: SS 17A), **Jim M. Cushing** and **Joseph Watkins**, University of Arizona.

Differential Equations and Biological Systems (Code: SS 16A), **Patrick Shipman**, Colorado State University, and **Zoi Rapti**, University of Illinois at Urbana-Champaign.

Dispersion in Heterogeneous and/or Random Environments (Code: SS 2A), **Rabi Bhattacharya**, Oregon State University, Corvallis, and **Edward Waymire**, University of Arizona.

Geometric Analysis and Riemannian Geometry (Code: SS 4A), **David Glickenstein**, University of Arizona, **Guofang Wei**, University of California Santa Barbara, and **Andrea Young**, Ripon College.

Geometrical Methods in Mechanical and Dynamical Systems (Code: SS 3A), **Akif Ibragimov**, Texas Tech University, **Vakhtang Putkaradze**, Colorado State University, and **Magdalena Toda**, Texas Tech University.

Harmonic Maass Forms and q-Series (Code: SS 1A), **Ken Ono**, Emory University, **Amanda Folsom**, Yale University, and **Zachary Kent**, Emory University.

Hyperbolic Geometry (Code: SS 18A), **Julien Paupert**, Arizona State University, and **Domingo Toledo**, University of Utah.

Inverse Problems and Wave Propagation (Code: SS 7A), **Leonid Kunyansky**, University of Arizona.

Mathematical Fluid Dynamics and its Application in Geosciences (Code: SS 20A), **Bin Cheng**, Arizona State University, and **Nathan Glatt-Holtz**, Indiana University.

Mathematical Physics: Spectral and Dynamical Properties of Quantum Systems (Code: SS 6A), **Bruno Nachtergaele**, University of California, Davis, **Robert Sims**, University of Arizona, and **Günter Stolz**, University of Alabama, Birmingham.

Mathematics of Optical Pulse Propagation: Modeling, Analysis, and Simulations (Code: SS 8A), **Jason Fleischer**, Princeton University, and **Moysey Brio**, **Karl Glasner**, and **Shankar Venkataramani**, University of Arizona.

Motives, Algebraic Cycles, and K-theory (Code: SS 11A), **Deepam Patel**, Indiana University, Bloomington, and **Ravindra Girivaru**, University of Missouri, St. Louis.

Representations of Groups and Algebras (Code: SS 5A), **Klaus Lux** and **Pham Huu Tiep**, University of Arizona.

Special Functions, Combinatorics, and Analysis (Code: SS 15A), **Diego Dominici**, SUNY New Paltz, **Tim Huber**, University of Texas-Pan American, and **Robert Maier**, University of Arizona.

Spectral Theory and Global Analysis (Code: SS 12A), **Lennie Friedlander**, University of Arizona, and **Klaus Kirsten**, Baylor University.

The B.S. Degree in Mathematics in Industry (Code: SS 19A), **William Velez**, University of Arizona.

The Ubiquitous Laplacian: Theory, Applications, and Computations (Code: SS 14A), **Bin Dong** and **Lotfi Hermi**, University of Arizona.

Topics in Commutative Algebra (Code: SS 10A), **Kristen Beck** and **Silvia Saccon**, The University of Arizona.

San Diego, California

San Diego Convention Center and San Diego Marriott Hotel and Marina

January 9–12, 2013

Wednesday – Saturday

Meeting #1086

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: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: September 25, 2012

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/national.html.

Joint Invited Addresses

Kenneth Golden, University of Utah, *Title to be announced* (MAA-AMS-SIAM Gerald and Judith Porter Public Lecture).

Robin Pemantle, David Rittenhouse Laboratories, *Zeros of polynomials and their importance in combinatorics and probability* (AMS-MAA Invited Address).

Emily Shuckburgh, Cambridge University, *Title to be announced* (AMS-MAA Invited Address).

AMS Invited Addresses

Gerard Ben Arous, Courant Institute-NYU, *Title to be announced*.

Jean Bourgain, Institute for Advanced Study, *Title to be announced*.

Laura DeMarco, University of Illinois at Chicago, *Title to be announced*.

Jordan Ellenberg, University of Wisconsin, *Title to be announced*.

Alice Guionnet, Ecole Normale Supérieure de Lyon, *Title to be announced* (AMS Colloquium Lectures).

Robert Guralnick, University of Southern California, *Title to be announced*.

Cedric Villani, Institut Henri Poincaré, *Title to be announced* (AMS Josiah Willard Gibbs Lecture).

AMS Special Sessions

Some sessions are cosponsored with other organizations. These are noted within the parenthesis at the end of each listing, where applicable.

Advances in General Optimization and Global Optimality Conditions for Multiobjective Fractional Programming Based on Generalized Invexity (Code: SS 18A), **Roland Glowinski**, University of Houston, **R. N. Mohapatra**, University of Central Florida, **Ram U. Verma**, International Publications USA, and **Alexander J. Zaslavski**, Technion-Israel Institute of Technology.

Algebraic Combinatorics and Representation Theory (Code: SS 38A), **Julie Beier**, Mercer University, and **Gizem Karaali**, Pomona College.

Algorithmic Problems of Group Theory and Their Complexity (Code: SS 9A), **Delaram Kahrobaei**, CUNY Graduate Center and New York College of Technology, City University of New York, and **Vladimir Shpilrain**, City College of New York and CUNY Graduate Center, City University of New York.

Arithmetic Theory of Quadratic Forms and Lattices (Code: SS 7A), **Wai Kiu Chan**, Wesleyan University, and **Lenny Fukshansky**, Claremont McKenna College.

Arithmetic and Ideal Theory of Integral Domains and Monoids (Code: SS 27A), **Scott T. Chapman**, Sam Houston State University, and **Vadim Ponomarenko**, San Diego State University.

Celestial Mechanics (Code: SS 43A), **Gareth Roberts**, College of the Holy Cross, and **Zhifu Xie**, Virginia State University.

Challenges in Data Assimilation and the Mathematics of Planet Earth and Its Climate (Code: SS 56A), **Lewis Mitchell**, University of Vermont, and **Thomas Bellsky**, Arizona State University.

Commutative Algebra and Algebraic Geometry (Code: SS 54A), **Kuei-Nan Lin**, University of California, Riverside, and **Tai Ha**, Tulane University.

Complex Dynamics (Code: SS 30A), **Laura DeMarco**, University of Illinois, Chicago, and **Rodrigo Perez** and **Roland Roeder**, Indiana University-Purdue University Indianapolis.

Computational Algebraic and Analytic Geometry for Low-dimensional Varieties (Code: SS 36A), **Mike Seppala**, Florida State University, and **Emil Volcheck**, National Security Agency.

Continued Fractions (Code: SS 44A), **James McLaughlin**, West Chester University, and **Nancy J. Wyshinski**, Trinity College.

Coverings of the Integers (Code: SS 53A), **Carrie E. Finch**, Washington and Lee University, and **Lenny Jones**, Shippenburg University.

Creating a Professional Community of Math Teachers K–20 (Code: SS 61A), **Patrick Callahan**, University of California Los Angeles, **William McCallum**, University of Arizona, and **Kristin Umland**, University of New Mexico.

Difference Equations and Applications (Code: SS 11A), **Michael Radin**, Rochester Institute of Technology.

Dirac and Laplace Operators in Global Analysis and Geometry (Code: SS 8A), **Ken Richardson** and **Igor Prokhorenkov**, Texas Christian University.

Discrete Geometry and Algebraic Combinatorics (Code: SS 67A), **Alexander Barg**, University of Maryland, and **Oleg Musin**, University of Texas, Brownsville.

Discrete and Computational Geometry (Code: SS 71A), **Emilie Hogan**, Pacific Northwest National Laboratory, **Elizabeth Munch**, Duke University, **Louis Theran**, Freie Universität, and **Russ Thompson**, Texas A&M University.

Effective Algebra and Model Theory (Code: SS 29A), **Sam Buss**, **Mia Minnes**, and **Jeff Remmel**, University of California, San Diego (AMS-ASL).

Environmental Mathematics: Evaluate the Past Climate Changes and Model the Future Climate Variations (Code: SS 70A), **Phillip Arkin**, University of Maryland, **Samuel Shen**, San Diego State University, **Thomas Smith**, University of Maryland, and **Guang Zhang**, Scripps Institute of Oceanography, University of California, San Diego.

Financial Mathematics (Code: SS 37A), **Maxim Bichuch**, Princeton University, and **Tim Siu-Tang Leung**, Columbia University.

Finite Element Exterior Calculus and Applications (Code: SS 50A), **Douglas Arnold**, University of Minnesota, and **Andrew Gillette** and **Michael Holst**, University of California, San Diego.

Fractional, Hybrid, and Stochastic Dynamic Systems with Applications (Code: SS 13A), **John Graef**, University of Tennessee at Chattanooga, **Gangaram S. Ladde**, University of South Florida, and **Aghalaya Vatsala**, University of Louisiana at Lafayette.

Frontiers in Geomathematics (Code: SS 69A), **Willi Freeden**, University of Kaiserlautern, **Volker Michel**, University of Siegen, and **M. Zuhair Nashed**, University of Central Florida.

Generalized Symmetric Spaces (Code: SS 51A), **Catherine Buell**, Bates College, and **Aloysius G. Helminck**, North Carolina State University.

Geometric and Analytic Methods in Teichmuller Theory and Hyperbolic Geometry (Code: SS 3A), **Ren Guo**, Oregon State University, and **Zheng Huang** and **Marcello Lucia**, City University of New York, Staten Island.

Graph Theory (Code: SS 57A), **Andre Kundgen**, California State University, San Marcos, **Michael Pelsmajer**, Illinois Institute of Technology, and **Douglas West**, University of Illinois, Urbana-Champaign.

Groups, Representations, and Applications (Code: SS 33A), **Robert Guralnick**, University of Southern California, and **Pham Huu Tiep**, University of Arizona.

History of Mathematics (Code: SS 16A), **Patti Hunter**, Westmont College, **Deborah Kent**, Drake University, and **Adrian Rice**, Randolph-Macon College (AMS-MAA).

Homotopy Theory and Commutative Algebra (Code: SS 19A), **Julia Bergner**, **Philip Hackney**, and **Inês Henriques**, University of California, Riverside.

Interplays Between Feynman Operational Calculus, Wiener and Feynman Integrals, Physics, and Analysis on Wiener Space (Code: SS 41A), **Tepper Gill**, Howard University, **Lance Nielsen**, Creighton University, and **Ian Pierce**, St. Olaf College.

Knots, Links, and Three-manifolds (Code: SS 48A), **Christopher Herald**, **Stanislav Jabuka**, and **Swatee Naik**, University of Nevada, Reno.

L-Functions and Arithmetic Geometry (Code: SS 59A), **Alina Bucur** and **Kiran Kedlaya**, University of California, San Diego.

Lie Algebras, Algebraic Transformation Groups, and Representation Theory (Code: SS 6A), **Andrew Douglas**, City University of New York, **Alistair Savage**, University of Ottawa, and **Bart Van Steirteghem**, City University of New York.

Manifolds with Special Holonomy and Generalized Geometries (Code: SS 60A), **Sema Salur**, University of Rochester, and **Albert James Todd**, University of California, Riverside.

Mathematical Underpinnings of Multivariate Complexity Theory and Algorithm Design, and Its Frontiers and the Field of Incrementalization (Code: SS 28A), **Rodney Downey**, Victoria University of Wellington, New Zealand, **Michael Fellows**, Charles Darwin University, Australia, and **Anil Nerode**, Cornell University.

Mathematical and Numerical Analysis of Nonlocal Problems (Code: SS 23A), **Qiang Du** and **Tadele Mengesha**, Pennsylvania State University.

Mathematics and Education Reform (Code: SS 64A), **William Barker**, Bowdoin College, **Cathy Kessel**, Education Consultant, **William McCallum**, University of Arizona, and **Bonnie Saunders**, University of Illinois, Chicago (AMS-MAA).

Mathematics and Social Interactions (Code: SS 32A), **Jeff Suzuki**, Brooklyn College.

Mathematics of Computation: Algebra and Number Theory (Code: SS 46A), **Michael Mossinghoff**, Davidson College, **Cheryl Praeger**, University of Western Australia, and **Igor Shparlinksi**, Macquarie University.

Mathematics of Computation: Differential Equations, Linear Algebra, and Applications (Code: SS 47A), **Susanne C. Brenner**, Louisiana State University, and **Chi-Wang Shu**, Brown University.

Mathematics of Natural Resource Modeling (Code: SS 40A), **Shandelle Henson**, Andrews University, and **Catherine A. Roberts**, College of the Holy Cross.

Nonlinear Evolution Equations and Integrable Systems (Code: SS 10A), **Jennifer Gorsky**, University of San Diego, and **Alex Himonas**, University of Notre Dame.

Nonstandard Finite-Difference Discretizations and Nonlinear Oscillations (In Honor of Ronald Mickens' 70th Birthday) (Code: SS 45A), **Ron Buckmire**, Occidental College, **Abba Gumel**, University of Manitoba, and **Talitha Washington**, Howard University.

Number Theory and Geometry (Code: SS 34A), **Jordan Ellenberg**, University of Wisconsin, Madison, and **Akshay Venkatesh**, Stanford University.

Patterns in Permutations and Words (Code: SS 35A), **Jeffrey Liese**, California State Polytechnic University, San Luis Obispo, **Brian K. Miceli**, Trinity University, and **Jeffrey Remmel**, University of California, San Diego.

Progress in Free Probability and Free Analysis (Code: SS 20A), **Ken Dykema**, Texas A&M University, and **Scott McCullough**, University of Florida.

Quantum Walks and Related Topics (Code: SS 5A), **Yusuke Ide**, Kanagawa University, **Chaobin Liu** and **Nelson Petulante**, Bowie State University, and **Salvador E. Venegas-Andraca**, Tecnológico de Monterrey, Campus Estado de México.

Recent Advances and New Challenges in Applied Analysis (Code: SS 55A), **Marian Bocea**, Loyola University, Chicago.

Research in Mathematics by Undergraduates and Students in Post-Baccalaureate Programs (Code: SS 12A), **Bernard Brooks** and **Jobby Jacob**, Rochester Institute of Technology, **Jacqueline Jensen**, Sam Houston State Uni-

versity, and **Darren Narayan** and **Tamas Wiandt**, Rochester Institute of Technology (AMS-MAA-SIAM).

Set-Valued Optimization and Variational Problems with Applications (Code: SS 68A), **Andreas H. Hamel**, Yeshiva University, **Akhtar Khan**, Rochester Institute of Technology, **Miguel Sama**, Universidad Nacional de Educacin a Distancia, and **Christiane Tammer**, Martin Luther University of Halle-Wittenberg.

Several Complex Variables Techniques in Operator Theory (Code: SS 4A), **Zeljko Cuckovic** and **Sonmez Sahutoglu**, University of Toledo.

Several Complex Variables and Multivariable Operator Theory (Code: SS 14A), **Joseph Ball**, Virginia Tech University, and **Ronald Douglas**, Texas A&M University.

Singularities in Geometry and Algebra (Code: SS 49A), **John Brevik**, California State University, Long Beach, and **Scott Nollet**, Texas Christian University.

Stochastic Analysis of Stochastic Differential Equations and Stochastic Partial Differential Equations (Code: SS 22A), **Edward Allen**, Texas Tech University, **Armando Arciniega**, The University of Texas at San Antonio, **Gangaram Ladde**, University of South Florida, and **Sivapragasam Sathananthan**, Tennessee State University.

Stochastic and Functional Analysis (Code: SS 63A), **Mark Burgin**, University of California Los Angles, and **Alan Krinik** and **Randall Swift**, California State Polytechnic University, Pomona.

The Brauer Group in Algebra and Geometry (Code: SS 24A), **Asher Auel**, Emory University, **Kelly McKinnie**, University of Montana, and **V. Suresh**, Emory University (AMS-AWM).

The Mathematics of Decisions, Elections, and Games (Code: SS 52A), **Karl-Dieter Crisman**, Gordon College, **Michael A. Jones**, Mathematical Reviews, and **Michael Orrison**, Harvey Mudd College.

The Present and Future of Mathematics on the Web (Code: SS 62A), **Douglas Meade**, University of South Carolina, and **Philip Yasskin**, Texas A&M University.

Theory and Applications of Differential Equations on Graphs (Code: SS 25A), **Sergei Avdonin**, University of Alaska, Fairbanks, and **Jonathan Bell**, University of Maryland, Baltimore County.

Theory and Interdisciplinary Applications of Dynamical Systems (Code: SS 42A), **Sukanya Basu**, Grand Valley State University.

Topics and Issues in Electronic Publishing (Code: SS 21A), **Klaus Kaiser**, University of Houston, **Steven Krantz**, Washington University in St. Louis, and **Elizabeth Loew**, Springer.

Topological Combinatorics (Code: SS 58A), **Thomas Engstrom**, Aalto University, **Steven Klee**, University of California, Davis, and **Matthew Stamps**, Aalto University.

Tropical Geometry (Code: SS 66A), **Florian Block**, University of Warwick, and **Melody Chan**, University of California, Berkeley.

Understanding Planet Earth via Reaction Diffusion Equations (Code: SS 26A), **Jerome Goddard II**, Auburn University, Montgomery, **Eun Kyung Lee**, Pusan National University, Korea, **Junping Shi**, College of William and Mary, and **Ratnasingham Shivaji**, University of North Carolina, Greensboro.

Water Waves, Tsunamis, and Extreme Waves (Code: SS 31A), **Walter Craig**, McMaster University, Canada, **Philippe Guyenne**, University of Delaware, and **David Nicholls**, University of Illinois, Chicago.

Witt Vectors, Descent and Lifting (Code: SS 39A), **James Borger**, Australia National University, **Alexandru Buium** and **Taylor Dupuy**, University of New Mexico, and **Lance Miller**, University of Utah.

q-series in Mathematical Physics and Combinatorics (Code: SS 2A), **Mourad Ismail**, University of Central Florida.

The Influence of Ramanujan on his 125th Birthday (Code: SS 1A), **George Andrews**, Pennsylvania State University, **Bruce Berndt**, University of Illinois Urbana-Champaign, and **Ae Ja Yee**, Pennsylvania State University.

The Mathematics Teacher Education Partnership and the Common Core Standards (Code: SS 17A), **W. Gary Martin**, Auburn University, and **Michael Mays**, West Virginia University.

Oxford, Mississippi

University of Mississippi

March 1–3, 2013

Friday – Sunday

Meeting #1087

Southeastern Section
Associate secretary: Robert J. Daverman
Announcement issue of *Notices*: December 2012
Program first available on AMS website: December 13, 2012
Program issue of electronic *Notices*: March 2013
Issue of *Abstracts*: Volume 34, Issue 2

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: October 16, 2012
For abstracts: December 4, 2012
The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Patricia Hersh, North Carolina State University, *Title to be announced.*

Daniel Krashen, University of Georgia, *Title to be announced.*

Washington Mio, Florida State University, *Title to be announced.*

Slawomir Solecki, University of Illinois at Urbana-Champaign, *Title to be announced.*

Special Sessions

Algebraic Combinatorics (Code: SS 1A), **Patricia Hersh**, North Carolina State University, and **Dennis Stanton**, University of Minnesota.

Fractal Geometry and Ergodic Theory (Code: SS 2A), **Manav Das**, University of Louisville, and **Mrinal Kanti Roychowdhury**, University of Texas-Pan American.

Chestnut Hill, Massachusetts

Boston College

April 6–7, 2013

Saturday – Sunday

Meeting #1088

Eastern Section
Associate secretary: Steven H. Weintraub
Announcement issue of *Notices*: January 2013
Program first available on AMS website: February 21, 2013
Program issue of electronic *Notices*: April 2013
Issue of *Abstracts*: Volume 34, Issue 2

Deadlines

For organizers: September 6, 2012
For consideration of contributed papers in Special Sessions: December 18, 2012
For abstracts: February 12, 2013

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Roman Bezrukavnikov, Massachusetts Institute of Technology, *Title to be announced.*

Marston Conder, University of Auckland, *Title to be announced.*

Alice Guionnet, Ecole Normale Supérieure de Lyon, *Title to be announced.*

Yanir Rubinstein, Stanford University, *Title to be announced.*

Special Sessions

Algebraic and Geometric Structures of 3-manifolds (Code: SS 3A), **Ian Biringer**, Yale University, and **Tao Li** and **Robert Meyerhoff**, Boston College.

Complex Geometry and Microlocal Analysis (Code: SS 2A), **Victor W. Guillemin** and **Richard B. Melrose**, Massachusetts Institute of Technology, and **Yanir A. Rubinstein**, Stanford University.

Homological Invariants in Low-dimensional Topology. (Code: SS 1A), **John Baldwin**, **Joshua Greene**, and **Eli Grigsby**, Boston College.

Moduli Spaces in Algebraic Geometry (Code: SS 4A), **Dawei Chen** and **Maksym Fedorchuk**, Boston College, and **Joe Harris** and **Yu-Jong Tzeng**, Harvard University.

Boulder, Colorado

University of Colorado Boulder

April 13–14, 2013

Saturday – Sunday

Meeting #1089

Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: January 2013
Program first available on AMS website: February 28, 2013
Program issue of electronic *Notices*: April 2013
Issue of *Abstracts*: Volume 34, Issue 2

Deadlines

For organizers: September 12, 2012
For consideration of contributed papers in Special Sessions: December 26, 2012
For abstracts: February 19, 2013

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Gunnar Carlsson, Stanford University, *Title to be announced.*

Joseph A. De Loera, University of California, Davis, *Title to be announced.*

Brendan Hassett, Rice University, *Title to be announced.*

Raphael Rouquier, University of California Los Angeles, *Title to be announced.*

Special Sessions

Algebras, Lattices and Varieties (Code: SS 5A), **Keith A. Kearnes** and **Ágnes Szendrei**, University of Colorado, Boulder.

Associative Rings and Their Modules (Code: SS 1A), **Greg Oman** and **Zak Mesyan**, University of Colorado, Colorado Springs.

Dynamics and Arithmetic Geometry (Code: SS 2A), **Suion Ih**, University of Colorado at Boulder, and **Thomas J. Tucker**, University of Rochester.

Extremal Graph Theory (Code: SS 3A), **Michael Ferrara**, University of Colorado Denver, **Stephen Hartke**, University of Nebraska-Lincoln, and **Michael Jacobson**, University of Colorado Denver.

Themes in Applied Mathematics: From Data Analysis through Fluid Flows and Biology to Topology (Code: SS 4A), **Hanna Makaruk**, Los Alamos National Laboratory, and **Robert Owczarek**, University of New Mexico, and Enfitek, Inc..

Ames, Iowa

Iowa State University

April 27–28, 2013
Saturday – Sunday

Meeting #1090
Central Section
Associate secretary: Georgia Benkart
Announcement issue of *Notices*: February 2013
Program first available on AMS website: March 14, 2013
Program issue of electronic *Notices*: April 2013
Issue of *Abstracts*: Volume 34, Issue 2

Deadlines
For organizers: September 27, 2012
For consideration of contributed papers in Special Sessions: January 18, 2013
For abstracts: March 5, 2013

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Kevin Costello, Northwestern University, *Title to be announced.*

Marianne Csornyei, University of Chicago, *Title to be announced.*

Vladimir Markovic, California Institute of Technology, *Title to be announced.*

Eitan Tadmor, University of Maryland, *Title to be announced.*

Special Sessions

Algebraic and Geometric Combinatorics (Code: SS 4A), **Sung Y. Song**, Iowa State University, and **Paul Terwilliger**, University of Wisconsin-Madison.

Commutative Algebra and its Environs (Code: SS 6A), **Olgur Celikbas** and **Greg Piepmeyer**, University of Missouri, Columbia.

Commutative Ring Theory (Code: SS 8A), **Michael Axtell**, University of St. Thomas, and **Joe Stickles**, Millikin University.

Extremal Combinatorics (Code: SS 7A), **Steve Butler** and **Ryan Martin**, Iowa State University.

Generalizations of Nonnegative Matrices and Their Sign Patterns (Code: SS 3A), **Minerva Catral**, Xavier University, **Shaun Fallat**, University of Regina, and **Pauline van den Driessche**, University of Victoria.

Operator Algebras and Topological Dynamics (Code: SS 1A), **Benton L. Duncan**, North Dakota State University, and **Justin R. Peters**, Iowa State University.

Zero Forcing, Maximum Nullity/Minimum Rank, and Colin de Verdiere Graph Parameters (Code: SS 2A), **Leslie Hogben**, Iowa State University and American Institute of Mathematics, and **Bryan Shader**, University of Wyoming.

Alba Iulia, Romania

June 27–30, 2013
Thursday – Sunday

Meeting #1091
First Joint International Meeting of the AMS and the Romanian Mathematical Society, in partnership with the "Simion Stoilow" Institute of Mathematics of the Romanian Academy.
Associate secretary: Steven H. Weintraub
Announcement issue of *Notices*: January 2013
Program first available on AMS website: Not applicable
Program issue of electronic *Notices*: Not applicable
Issue of *Abstracts*: Not applicable

Deadlines
For organizers: To be announced
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/internmtgs.html.

Invited Addresses

Viorel Barbu, Universitatea Cuza, *Title to be announced.*

Sergiu Klainerman, Princeton University, *Title to be announced.*

George Lusztig, Massachusetts Institute of Technology, *Title to be announced.*

Stefan Papadima, Institute of Mathematicsof the Romanian Academy of Sciences, *Title to be announced.*

Dan Timotin, Institute of Mathematics of the Romanian Academy of Sciences, *Title to be announced.*

Srinivasa Varadhan, New York University, *Title to be announced.*

Louisville, Kentucky

University of Louisville

October 5–6, 2013
Saturday – Sunday

Meeting #1092
Southeastern Section
Associate secretary: Robert J. Daverman
Announcement issue of *Notices*: June 2013
Program first available on AMS website: August 22, 2013
Program issue of electronic *Notices*: October 2013
Issue of *Abstracts*: Volume 33, Issue 3

Deadlines
For organizers: March 5, 2013
For consideration of contributed papers in Special Sessions: June 18, 2013

For abstracts: August 13, 2013

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Michael Hill, University of Virginia, *Title to be announced.*

Suzanne Lenhart, University of Tennessee, *Title to be announced.*

Ralph McKenzie, Vanderbilt University, *Title to be announced.*

Victor Moll, Tulane University, *Title to be announced.*

Special Sessions

Set Theory and Its Applications (Code: SS 1A), **Paul Larson**, Miami University, **Justin Moore**, Cornell University, and **Grigor Sargsyan**, Rutgers University.

Philadelphia, Pennsylvania

Temple University

October 12–13, 2013

Saturday – Sunday

Meeting #1093

Eastern Section
Associate secretary: Steven H. Weintraub
Announcement issue of *Notices*: June 2013
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: October 2013
Issue of *Abstracts*: Volume 33, Issue 3

Deadlines

For organizers: March 12, 2013
For consideration of contributed papers in Special Sessions: June 25, 2013
For abstracts: August 20, 2013

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Barry Mazur, Harvard University, *Title to be announced* (Erdős Memorial Lecture).

Special Sessions

Geometric and Spectral Analysis (Code: SS 3A), **Thomas Krainer**, Pennsylvania State Altoona, and **Gerardo A. Mendoza**, Temple University.

Higher Structures in Algebra, Geometry and Physics (Code: SS 2A), **Jonathan Block**, University of Pennsylvania, **Vasily Dolgushev**, Temple University, and **Tony Pantev**, University of Pennsylvania.

History of Mathematics in America (Code: SS 4A), **Thomas L. Bartlow**, Villanova University, **Paul R. Wolfson**, West Chester University, and **David E. Zitarelli**, Temple University.

Recent Advances in Harmonic Analysis and Partial Differential Equations (Code: SS 1A), **Cristian Gutiérrez** and **Irina Mitrea**, Temple University.

St. Louis, Missouri

Washington University

October 18–20, 2013

Friday – Sunday

Meeting #1094

Central Section
Associate secretary: Georgia Benkart
Announcement issue of *Notices*: August 2013
Program first available on AMS website: September 5, 2013
Program issue of electronic *Notices*: October 2013
Issue of *Abstracts*: Volume 33, Issue 4

Deadlines

For organizers: March 20, 2013
For consideration of contributed papers in Special Sessions: July 2, 2013
For abstracts: August 27, 2013

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Ronny Hadani, University of Texas at Austin, *Title to be announced.*

Effie Kalfagianni, Michigan State University, *Title to be announced.*

Jon Kleinberg, Cornell University, *Title to be announced.*

Vladimir Sverak, University of Minnesota, *Title to be announced.*

Special Sessions

Algebraic and Combinatorial Invariants of Knots (Code: SS 1A), **Heather Dye**, McKendree University, **Allison Henrich**, Seattle University, and **Louis Kauffman**, University of Illinois.

Riverside, California

University of California Riverside

November 2–3, 2013

Saturday – Sunday

Meeting #1095

Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: August 2013
Program first available on AMS website: September 19, 2013
Program issue of electronic *Notices*: November 2013
Issue of *Abstracts*: Volume 33, Issue 4

Deadlines

For organizers: April 2, 2013
For consideration of contributed papers in Special Sessions: July 15, 2013
For abstracts: September 10, 2013

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Michael Christ, University of California, Berkeley, *Title to be announced.*

Mark Gross, University of California, San Diego, *Title to be announced.*

Matilde Marcolli, California Institute of Technology, *Title to be announced.*

Paul Vojta, California Institute of Technology, *Title 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

Knoxville, Tennessee

University of Tennessee, Knoxville

March 21–23, 2014

Friday – Sunday
Southeastern Section
Associate secretary: Robert J. Daverman
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 21, 2013
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Albuquerque, New Mexico

University of New Mexico

April 5–6, 2014

Saturday – Sunday
Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: April 2014
Issue of *Abstracts*: To be announced

Deadlines

For organizers: September 5, 2013
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: February 11, 2014

Lubbock, Texas

Texas Tech University

April 11–13, 2014
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: September 18, 2013
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Tel Aviv, Israel

Bar-Ilan University, Ramat-Gan and Tel-Aviv University, Ramat-Aviv

June 16–19, 2014
Monday – Thursday
The 2nd Joint International Meeting between the AMS and the Israel Mathematical Union.
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines
For organizers: To be announced
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/internmtgs.html`.

AMS Special Sessions

Nonlinear Analysis and Optimization, **Boris Mordukhovich**, Wayne State University, and **Simeon Reich** and **Alexande Zaslavski**, The Technion-Israel Institute of Technology.

Eau Claire, Wisconsin

University of Wisconsin-Eau Claire

September 20–21, 2014
Saturday – 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: February 20, 2014
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: August 5, 2014

San Francisco, California

San Francisco State University

October 25–26, 2014
Saturday – Sunday
Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: October 2014
Issue of *Abstracts*: To be announced

Deadlines
For organizers: March 25, 2014
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: September 3, 2014

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

Porto, Portugal

University of Porto

June 11–14, 2015

Thursday – Sunday
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*: Not applicable

Deadlines

For organizers: To be announced
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Seattle, Washington

Washington State Convention Center and the Sheraton Seattle Hotel

January 6–9, 2016

Wednesday – Saturday
Joint Mathematics Meetings, including the 122nd Annual Meeting of the AMS, 99th Annual Meeting of the Mathematical Association of America, annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association of Symbolic Logic, with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: October 2015
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: January 2016
Issue of *Abstracts*: Volume 37, Issue 1

Deadlines

For organizers: April 1, 2015
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Atlanta, Georgia

Hyatt Regency Atlanta and Marriott Atlanta Marquis

January 4–7, 2017

Wednesday – Saturday
Joint Mathematics Meetings, including the 123rd Annual Meeting of the AMS, 100th Annual Meeting of the Mathematical Association of America, annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association of Symbolic Logic, with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).
Associate secretary: Georgia Benkart
Announcement issue of *Notices*: October 2016
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: January 2017
Issue of *Abstracts*: Volume 38, Issue 1

Deadlines

For organizers: April 1, 2016
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

San Diego, California

San Diego Convention Center and San Diego Marriott Hotel and Marina

January 10–13, 2018

Wednesday – Saturday
Joint Mathematics Meetings, including the 124th Annual Meeting of the AMS, 101st 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: Matthew Miller
Announcement issue of *Notices*: October 2017
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: April 1, 2017
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Meetings and Conferences of the AMS

Associate Secretaries of the AMS

Western Section: Michel L. Lapidus, Department of Mathematics, University of California, Surge Bldg., Riverside, CA 92521-0135; e-mail: lapidus@math.ucr.edu; telephone: 951-827-5910.

Central Section: **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.

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: **Robert J. Daverman,** Department of Mathematics, University of Tennessee, Knoxville, TN 37996-6900, e-mail: daverman@math.utk.edu; telephone: 865-974-6900.

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:

2012

September 22–23	Rochester, New York	p. 1186
October 13–14	New Orleans, Louisiana	p. 1187
October 20–21	Akron, Ohio	p. 1188
October 27–28	Tucson, Arizona	p. 1189

2013

January 9–12	San Diego, California Annual Meeting	p. 1189
March 1–3	Oxford, Mississippi	p. 1192
April 6–7	Chestnut Hill, Massachusetts	p. 1193
April 13–14	Boulder, Colorado	p. 1193
April 27–28	Ames, Iowa	p. 1194
June 27–30	Alba Iulia, Romania	p. 1194
October 5–6	Louisville, Kentucky	p. 1194
October 12–13	Philadelphia, Pennsylvania	p. 1195
October 18–20	St. Louis, Missouri	p. 1195
November 2–3	Riverside, California	p. 1196

2014

January 15–18	Baltimore, Maryland Annual Meeting	p. 1196
March 21–23	Knoxville, Tennessee	p. 1196
April 5–6	Albuquerque, New Mexico	p. 1196
April 11–13	Lubbock, Texas	p. 1197
June 16–19	Tel Aviv, Israel	p. 1197
September 20–21	Eau Claire, Wisconsin	p. 1197
October 25–26	San Francisco, California	p. 1197

2015

January 10–13	San Antonio, Texas Annual Meeting	p. 1197
June 11–14	Porto, Portugal	p. 1198

2016

January 6–9	Seattle, Washington	p. 1198

2017

January 4–7	Atlanta, Georgia Annual Meeting	p. 1198

2018

January 10–13	San Diego, California Annual Meeting	p. 1198

Important Information Regarding AMS Meetings

Potential organizers, speakers, and hosts should refer to page 111 in the the January 2012 issue of the *Notices* for general information regarding participation in AMS meetings and conferences.

Abstracts

Speakers should submit abstracts on the easy-to-use interactive Web form. No knowledge of LaTeX is necessary to submit an electronic form, although those who use LaTeX may submit abstracts with such coding, and all math displays and similarily coded material (such as accent marks in text) must be typeset in LaTeX. Visit http://www.ams.org/cgi-bin/abstracts/abstract.pl. Questions about abstracts may be sent to abs-info@ams.org. Close attention should be paid to specified deadlines in this issue. Unfortunately, late abstracts cannot be accommodated.

Conferences: (see http://www.ams.org/meetings/ for the most up-to-date information on these conferences.)

October 3–8, 2012: International Conference on Group Theory, Combinatorics, and Computing, at Florida Atlantic University, Boca Raton, FL (held in cooperation with the AMS). Please see http://www.math.fau.edu/ for more information.

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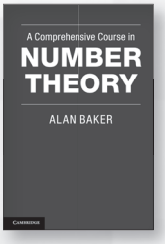

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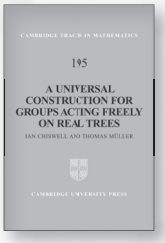

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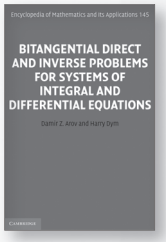

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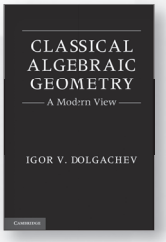

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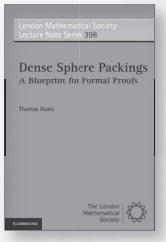

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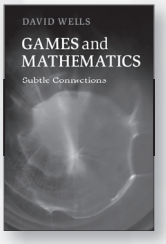

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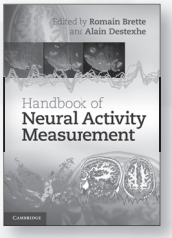

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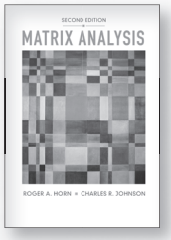

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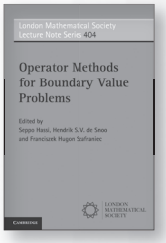

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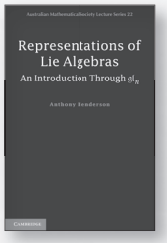

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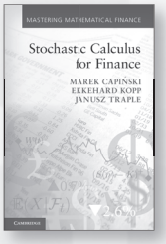

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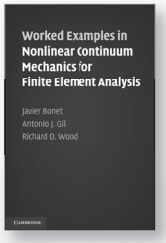

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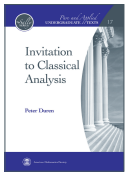

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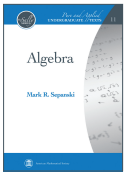

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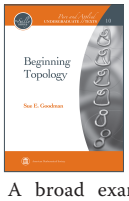

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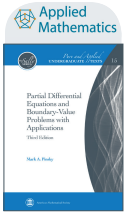

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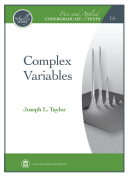

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