ISSN 0002-9920

Notices

of the American Mathematical Society

August 2009

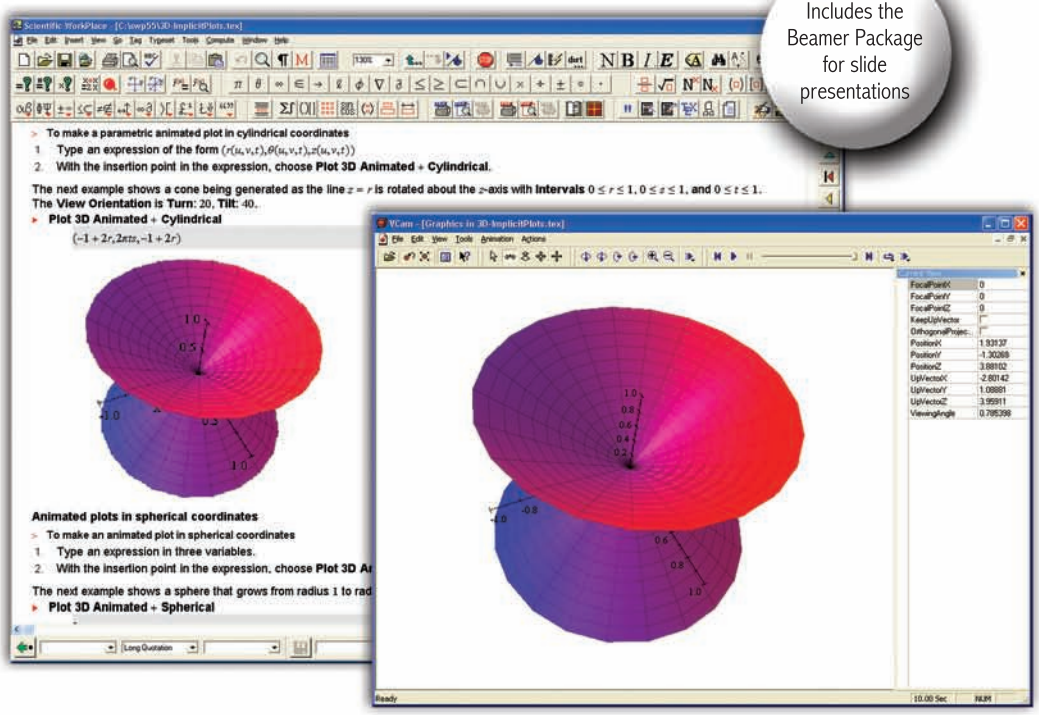
Volume 56, Number 7

The complexity of factorization (see page 808)

Scientific WorkPlace®
Scientific Word®

- Mathematical Word Processing
- LaTeX Typesetting
- Computer Algebra

Includes the Beamer Package for slide presentations



The Gold Standard for Mathematical Publishing

Scientific WorkPlace and ***Scientific Word Version 5.5*** make writing, sharing, and doing mathematics easier. You compose and edit your documents directly on the screen, without having to think in a programming language. A click of a button allows you to typeset your documents in LaTeX. You choose to print with or without LaTeX typesetting, or publish on the web. ***Scientific WorkPlace*** and ***Scientific Word*** enable both professionals and support staff to produce stunning books and articles. Also, the integrated computer algebra system in ***Scientific WorkPlace*** enables you to solve and plot equations, animate 2D and 3D plots, rotate, move, and fly through 3D plots, create 3D implicit plots, and more.

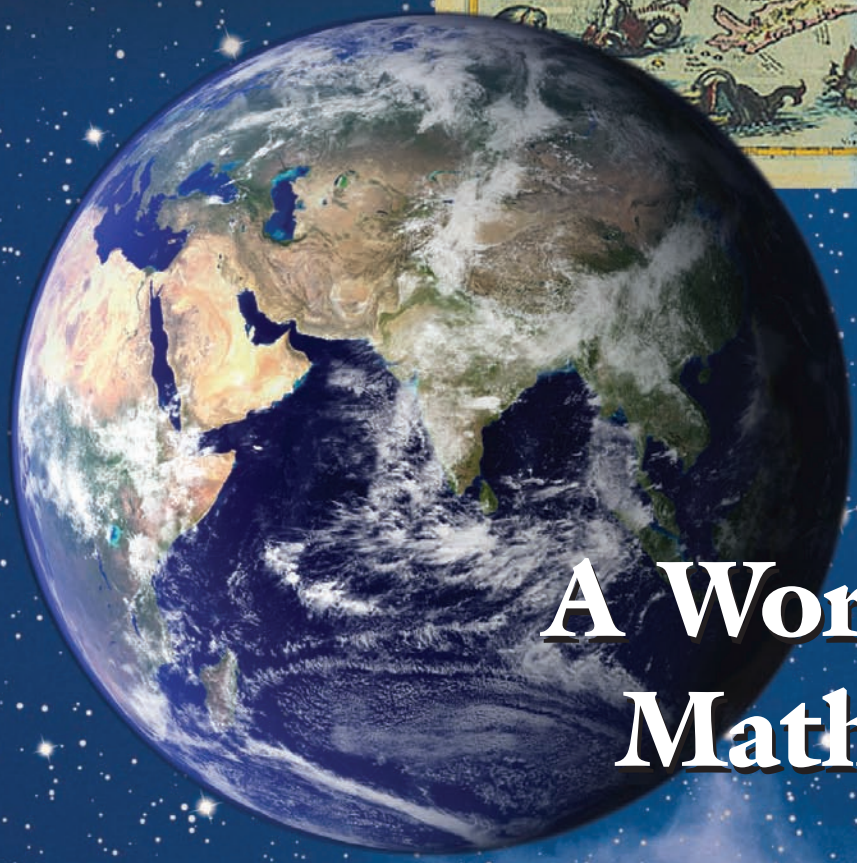
MacKichan SOFTWARE, INC.

Visit our website for free trial versions of all our products.

www.mackichan.com/notices • Email: info@mackichan.com • Toll free: 877-724-9673

A World *Without* Mathematics ...

Courtesy of Map Collection, Yale University Library



A World *With* Mathematics

Support the future of mathematics

Give to the American Mathematical Society

Your donations support:

- Career paths of young mathematicians
- Recognition of important work
- Public awareness and appreciation of mathematics
- Inspiration of young scholars (Epsilon Fund)
- International outreach

Learn about giving opportunities and estate planning
www.ams.org/giving-to-ams

Contact the AMS Development Office 1.800.321.4267 (U.S. and Canada) or 1.401.455.4000 (worldwide)
email: development@ams.org

AMS
American Mathematical Society
www.ams.org

06/04

New and Forthcoming

BIRKHÄUSER

Winner of the Ferran Sunyer-i-Balaguer Prize 2009

Quantitative Arithmetic of Projective Varieties

Timothy D. Browning, Bristol University, UK

This book is concerned with counting rational points of bounded height on projective algebraic varieties. This is a fertile and vibrant topic that lies at the interface of analytic number theory and Diophantine geometry. The goal of the book is to give a systematic account of the field with an emphasis on the role that analytic number theory has to play in its development.

2010. APPROX. 170 P. HARDCOVER
ISBN 978-3-0346-0128-3 $ 99.00
PROGRESS IN MATHEMATICS, VOL. 277

Symmetry and Spaces

In Honor of Gerry Schwarz

H.E.A. Campbell, Memorial University of Newfoundland, St. John's, NF, Canada; **Loek Helminck**, North Carolina State University, Raleigh, NC, USA; **Hans-Peter Kraft**, Universität Basel, Switzerland; **David Wehlau**, Queen's University, Kingston, ON, Canada (Eds.)

This volume covers the wide range of mathematics to which Gerry Schwarz has either made fundamental contributions or stimulated others to pursue. The articles are a sampling of modern day algebraic geometry with associated group actions written by leading experts in the field. Three papers examine various aspects of modular invariant theory (Broer, Elmer and Fleischmann, Shank and Wehlau), and seven papers concentrate on characteristic 0 (Brion, Daigle and Freudenberg, Greb and Heinzner, Helminck, Kostant, Kraft and Wallach, Traves).

2009. APPROX. 220 P. 10 ILLUS.
HARDCOVER
ISBN 978-0-8176-4874-9 CA. $ 99.00
PROGRESS IN MATHEMATICS, VOL. 278

Fourier Analysis on Finite Abelian Groups

Bao Luong, Department of Defense, Ft. Meade, MD, USA

This unified, self-contained book examines the mathematical tools used for decomposing and analyzing functions, specifically, the application of the [discrete] Fourier transform to finite Abelian groups. With countless examples and unique exercise sets at the end of each section, *Fourier Analysis on Finite Abelian Groups* is a perfect companion to a first course in Fourier analysis.

2009. APPROX. 170 P. HARDCOVER
ISBN 978-0-8176-4915-9 CA. $ 59.95
APPLIED AND NUMERICAL HARMONIC ANALYSIS

Four Short Courses on Harmonic Analysis

Wavelets, Frames, Time-Frequency Methods, and Applications to Signal and Image Analysis

Peter Massopust, Helmholtz Zentrum München, Germany; **Brigitte Forster-Heinlein**, Technische Universität München, Germany (Eds.)

This state-of-the-art textbook covers four research directions in harmonic analysis and presents some of its latest applications. It is the first work that combines spline theory, wavelets, frames, and time-frequency methods up to construction on manifolds other then Rn.
Written by internationally renowned mathematicians, the interdisciplinary chapters have expository character, allowing the reader to understand the theory behind modern image and signal processing methodologies.
Contributions by **D. Labate, G. Weiss, O. Christensen, K. Gröchening, P. Vandergheynst, Y. Wiaux.**

2009. APPROX. 305 P. 40 ILLUS.
HARDCOVER
ISBN 978-0-8176-4890-9 CA. $ 49.95
APPLIED AND NUMERICAL HARMONIC ANALYSIS

Spacetime, Geometry and Gravitation

Pankaj Sharan, Jamia Millia Islamia, New Delhi, India

This introductory textbook on the general theory of relativity presents a solid foundation for those who want to learn about relativity, which is covered here in a broad and deep manner. The subject is presented in a physically intuitive, but mathematically rigorous style. One of the main goals of the work is to allow students to read advanced texts on general relativity with very little or no discouragement.

2009. APPROX. 350 P. HARDCOVER
ISBN 978-3-7643-9970-2 $ 99.95
PROGRESS IN MATHEMATICAL PHYSICS, VOL. 56

New in Softcover

Complex Analysis

Fundamentals of the Classical Theory of Functions

John Stalker, Princeton University, Princeton, NJ, USA

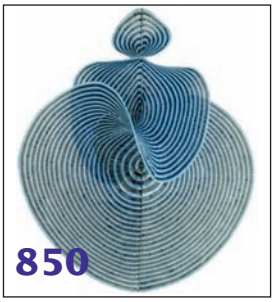
"The first chapter deals with a beautiful presentation of special functions... The third chapter covers elliptic and modular functions...in much more detail, and from a different point of view, than one can find in standard introductory books... For [the] subjects that are omitted, the author has suggested some excellent references for the reader who wants to go through these topics. The book is read easily and with great interest. It can be recommended to both students as a textbook and to mathematicians and physicists as a useful reference." —Mathematical Reviews

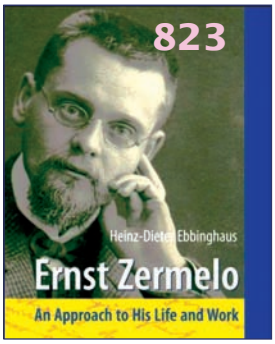
2009. 1ST ED. 1998. 2ND PRINTING.
APPROX. 245 P. 5 ILLUS. SOFTCOVER
ISBN 978-0-8176-4918-0 CA. $ 49.95
MODERN BIRKHÄUSER CLASSICS

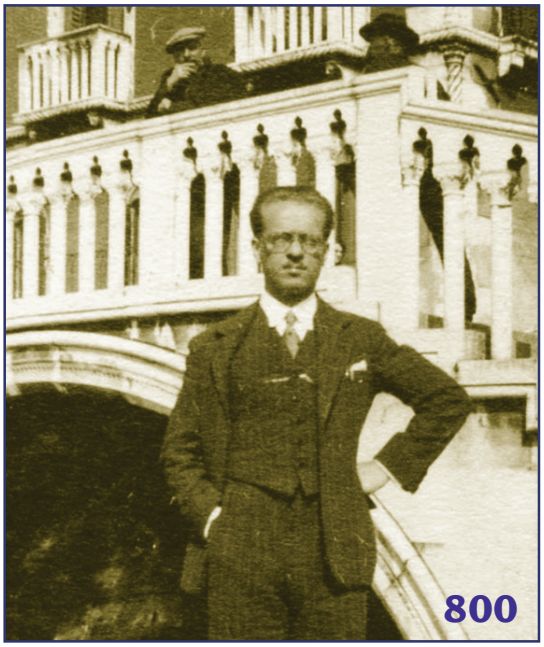
Notices

of the American Mathematical Society

August 2009







Communications

Commentary

Features

Notices

of the American Mathematical Society

EDITOR: Andy Magid

ASSOCIATE EDITORS:
Daniel Biss, Susanne C. Brenner, Bill Casselman (*Graphics Editor*), Robert J. Daverman, Susan Friedlander, Robion Kirby, Steven G. Krantz, Lisette de Pillis, Peter Sarnak, Mark Saul, John Swallow, Lisa Traynor

SENIOR WRITER and DEPUTY EDITOR:
Allyn Jackson

MANAGING EDITOR: Sandra Frost

CONTRIBUTING WRITER: Elaine Kehoe

PRODUCTION ASSISTANT: Muriel Toupin

PRODUCTION: Kyle Antonevich, Stephen Moye, Erin Murphy, Lori Nero, Karen Ouellette, Donna Salter, Deborah Smith, Peter Sykes, Patricia Zinni

ADVERTISING SALES: Anne Newcomb

SUBSCRIPTION INFORMATION: Subscription prices for Volume 56 (2009) are US$488 list; US$390 institutional member; US$293 individual member. (The subscription price for members is included in the annual dues.) A late charge of 10% of the subscription price will be imposed upon orders received from nonmembers after January 1 of the subscription year. Add for postage: Surface delivery outside the United States and India—US$27; in India—US$40; expedited delivery to destinations in North America—US$35; elsewhere—US$88. Subscriptions and orders for AMS publications should be addressed to the American Mathematical Society, P.O. Box 845904, Boston, MA 02284-5904 USA. All orders must be prepaid.

ADVERTISING: *Notices* publishes situations wanted and classified advertising, and display advertising for publishers and academic or scientific organizations. Advertising material or questions may be sent to `classads@ams.org` (classified ads) or `notices-ads@ams.org` (display ads).

SUBMISSIONS: Articles and letters may be sent to the editor by email at `notices@math.ou.edu`, by fax at 405-325-5765, or by postal mail at Department of Mathematics, 601 Elm, PHSC 423, University of Oklahoma, Norman, OK 73019-0001. Email is preferred. Correspondence with the managing editor may be sent to `notices@ams.org`. For more information, see the section "Reference and Book List".

NOTICES ON THE AMS WEBSITE: Supported by the AMS membership, most of this publication is freely available electronically through the AMS website, the Society's resource for delivering electronic products and services. Use the URL `http://www.ams.org/notices/` to access the *Notices* on the website.

[*Notices of the American Mathematical Society* (ISSN 0002-9920) is published monthly except bimonthly in June/July by the American Mathematical Society at 201 Charles Street, Providence, RI 02904-2294 USA, GST No. 12189 2046 RT****. Periodicals postage paid at Providence, RI, and additional mailing offices. POSTMASTER: Send address change notices to *Notices of the American Mathematical Society,* P.O. Box 6248, Providence, RI 02940-6248 USA.] Publication here of the Society's street address and the other information in brackets above is a technical requirement of the U.S. Postal Service. Tel: 401-455-4000, email: `notices@ams.org`.

© Copyright 2009 by the
American Mathematical Society.
All rights reserved.

Printed in the United States of America.The paper used in this journal is acid-free and falls within the guidelines established to ensure permanence and durability.

Opinions expressed in signed *Notices* articles are those of the authors and do not necessarily reflect opinions of the editors or policies of the American Mathematical Society.

Departments

From the AMS Secretary

Congressional Testimony in Support of NSF

On April 2, 2009, AMS Past-President James Glimm presented public testimony, in support of FY 2010 National Science Foundation (NSF) appropriations, to the House Committee on Commerce, Justice, Science, and Related Agencies Appropriations Subcommittee. His testimony was coordinated with testimonies given to the Committee by the American Chemical Society (ACS), the American Physical Society (APS), and the Federation of American Societies for Experimental Biology (FASEB). As director of the AMS Washington Office, I worked with representatives of ACS, APS, and FASEB, and with Jim to develop the coordinated testimonies. The general theme of the four testimonies was to thank appropriators for the recent NSF budget increase realized through the American Recovery and Reinvestment Act (ARRA) and the FY 2009 NSF Appropriations. However, if future yearly appropriations to NSF do not grow at a sufficient rate, everything gained through the combination of ARRA and FY 2009 Appropriations will be lost, thereby negatively affecting the U.S. science enterprise. Glimm's testimony follows.

—Samuel M. Rankin, director, AMS Washington Office

Chairman Mollohan, Ranking Member Wolf, and members of the Subcommittee, I am James Glimm, past president of the American Mathematical Society. Also testifying before this committee today are representatives from the American Chemical Society, American Physical Society, and Federation of American Societies for Experimental Biology. **These organizations together represent more than 300,000 scientists, engineers, and mathematicians in a diversity of fields, and we are united in our request for an FY 2010 budget for the National Science Foundation (NSF) of US$7 billion**. This investment will allow the NSF to continue innovative and transformational scientific research that fuels the American economy, upholds national security, maintains our global competitiveness, and improves health and quality of life for millions of Americans.

I would like to begin by thanking you for the recent investments in NSF. These investments will increase the ability of NSF to support highly rated proposals that heretofore have gone unfunded because of inadequate budgets. Moreover, these investments allow NSF to concentrate on funding young investigators who will be key to building the research infrastructure needed for facing critical problems requiring technical expertise, problem areas such as climate change and its effects, energy conservation and alternative sources, and environmental and ecological consequences of human activity.

The Fiscal Year 2009 Omnibus provided strong increases for NSF. We are also extremely gratified about the US$3 billion investment in NSF through the American Recovery and Reinvestment Act (ARRA). With funding from ARRA and the FY 2009 Omnibus Appropriations Act, the NSF FY 2009 budget has reached US$9.49 billion. This budget level comes close to the US$9.84 billion authorized for NSF in FY 2007 under Public Law 107-368, the 2002 NSF Authorization Act, and is more than the US$8.13 billion FY 2010 budget authorized in Public Law 110-69, the America COMPETES Act. In constant dollars, NSF budgets decreased each year from 2004 to 2008. This year's increases in the NSF budget help reverse that decline. However, given that the funding from ARRA is temporary, it is important that future NSF budgets continue to grow at rates that will sustain the research and innovation enterprise and allow the United States to maintain its scientific leadership and technological competitiveness.

We are mindful that if future NSF budgets do not grow adequately, all that will be gained through the new funding will be lost. If this were to happen, it could have a debilitating affect on our science enterprise, squashing morale and causing current and future generations of scientists to look at other career paths. I strongly emphasize the necessity of adequate yearly investments in NSF. Dependable increases allow for planning, infrastructure development, feasible expectations, a manageable pipeline of graduate and postdoctoral students, and the creation of jobs that can be sustained over time. A predictable pattern of funding will facilitate a continuous stream of high-level research and researchers.

NSF is very important to the mathematical sciences. NSF accounts for 60 percent of federally funded mathematical research in colleges and universities and is the only agency that funds mathematics research broadly across all subfields. Many NSF-supported mathematical sciences research projects have benefited society. For example, mathematical research taking place at the University of Houston led to an improved design of vascular prostheses called stents and stentgraphs used in non-surgical repair of aortic abdominal aneurysms and coronary artery disease. In another project—combining mathematical modeling with new experimental data—a University of Maryland researcher and his team are proposing a new low-risk, clinical approach to enhancing the effect of drug therapy for Chronic Myelogenous Leukemia, possibly leading to a cure for the disease. A University of Utah mathematician's current work on polar sea ice promises to improve forecasts of how global warming will affect Earth's icepacks and how polar ecosystems may respond. These are just a few of the contributions of the mathematical sciences; with sustained NSF funding there will be many more to come.

Thank you for the opportunity to offer my support for NSF. I would be delighted to answer any questions the committee has.

—James Glimm
University at Stony Brook
glimm@ams.sunysb.edu

Letters to the Editor

The Mathematician Is a Poet

I would like to comment on the article "Birds and Frogs" by Freeman Dyson that appeared in the *Notices* of the AMS, February 2009.

First, a crucial question arises: "Who is a mathematician and what does he/she do?" And before gathering mathematicians into two groups: "birds" and "frogs", I ask: "Are mathematicians researchers, teachers, employees, or employers? Are they academia or industry or independent people?"

It is obvious that a mathematician is a scientist. However, he/she is mainly an artist, a poet—or perhaps more—as he/she is creative, innovative, and inventive. For instance, one cannot invent the circle when it was already invented many millennia ago. This ridiculous instance is similar to a person who claims to discover the moon, just because he claims to be the first one to see it! However, one can teach about circles, implement historical research about all its related topics…or even use circles in advanced domains such as dynamical systems, algebraic geometry…just to mention a few of the hottest contemporary domains of mathematical research.

On the other hand, to be a poet is to create a beautiful implementation in whatsoever domain of art and science. A painter as Da Vinci or Renoir is a poet, i.e., a creator. Likewise, a musician such as Beethoven or Schubert is also a poet. Also, great mathematicians, such as Euclid, Archimedes, Descartes, Bacon, Newton, Pascal, Einstein, Mandelbrot, Gromov…and many, many others, are all poets before being "birds" or "frogs". Their contributions to mathematics have raised mankind upward.

On the other hand, I would like to mention a singular category of mathematicians. History is very stingy in geniuses, particularly in "mathematicians AND poets" at the same time. For instance, great men like Pascal have contributed in many domains of thought. In truth Pascal is more than a poet or a mathematician, he is a mystic. To evaluate well the fullness of this word, one has to delve into the history of the religion of the Orient. In effect, in the couple of centuries preceding Christ, and in the Orient—i.e., the actual Middle East, or countries on the east of the Mediterranean Sea—the mystery religion or "religion à mystère" was born.

In every local community there was a special person, named the "myst" who was the one and only one, designed to hold the whole of the mysteries of the religious world. No one but this person could communicate with the gods (or with God). Later, with Judaism, Christianity, and Islam, the mystics became people who taste within some few flashes, say some lonesome little moment of their lives, an extraordinary joy which opens to them the door of heavenly revelations. Those persons are named "saints" by the Christians, "prophets" by the Jews and "Sufis" by the Muslims.

Mathematicians are mystical people. They have some lonely revelations, like flashes, that Heaven inspires to them. Their work consists in receiving and then "sculpting" the precious raw material embedded in the revelation. Both these two steps of their work are charismas which are not given to everyone; a revelation with no continuous and rigorous correction succeeding it is a chaotic nonsense. Also, a work, even very laborious, with no inspiration is cumbersome and leads nowhere.

Finally, to conclude with a poetical image, I think that the mathematician has three eyes, or I's. With those, he/she sees the world with the eye of "Inspiration", of "Intuition", and of "Insight". This is why he/she can see truths which remain invisible for billions and billions of human beings. Both "birds" and "frogs" have those three eyes and neither one is better than the other. Both are the two lungs of mathematics and both are indispensible.

—Dr. Hadi Alfred Murr
Université du Saint Esprit, Kaslik, USEK
Beirut, Lebanon
gloires-mariales@hotmail.com

(Received April 27, 2009)

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.

Identifications

Affiliations of authors of "Letters to the Editor" are provided for identification purposes only. Opinions expressed in letters are those of the authors and do not necessarily reflect those of their employers or, in the case of American Mathematical Society officers or committee members, policies of the Society. Committee reports to the Council of the Society and official communications of officers of the Society, when published in the *Notices*, appear in the section of the *Notices* "From the AMS Secretary".

“ME, MYSELF & WEBASSIGN.”

WELCOME TO THE NEW ECONOMICS OF TEACHING.

This economic crisis will test the resourcefulness of every instructor and administrator, from the smallest private college to the ivy league. In this new economics of teaching, there will be fewer resources and even fewer assistants and supporting staff.

Oh, and you’ll be expected to teach more courses to more students. Which is why, more than ever, you need WebAssign.

With WebAssign, it’s like having two of you to go around. That’s because WebAssign helps you do more, more effectively, with less. Our large enrollment course features allow a single person to easily administer multiple sections. Automated features eliminate administrative tasks such as grading, so fewer graders are needed. Departments can even sell their own text materials and eLabs online, providing new revenue streams. And that’s just the beginning. More time-saving features are on the way to make WebAssign an even greater value for you, your school and your students.

So, what will it take to survive, even thrive, in the new economics of teaching? Three things: You. Yourself. And WebAssign.

800.955.8275 webassign.net

Guido Castelnuovo and Francesco Severi: Two Personalities, Two Letters

Donald Babbitt and Judith Goodstein

The Italian school of algebraic geometry flourished from the latter part of the nineteenth century through the early part of the twentieth century. Some of the main contributors were Luigi Cremona, Eugenio Bertini, Giuseppe Veronese, Corrado Segre, Guido Castelnuovo, Federigo Enriques, and Francesco Severi. There were, of course, other important schools of algebraic geometry in other countries, but the Italian school stood out because of its unique mathematical style, especially its strong appeal to geometric intuition. Between 1896 and 1900 two members of this school, Guido Castelnuovo and Federigo Enriques, developed the classification of algebraic surfaces, one of the great achievements of algebraic geometry.[1] A few years later (1904–1908), together with Francesco Severi, they significantly deepened that understanding of surfaces.

In this article, we present excerpts[2] from two letters to Beniamino Segre, a distinguished algebraic geometer in his own right and a distant relative of Corrado Segre: one from Severi in 1932 and the other from Castelnuovo in 1938. Severi's letter provides his frank assessment of his own and others' contributions to algebraic geometry, including those of several of the Italian geometers mentioned above. Castelnuovo's letter discusses his collaborations with Enriques and Severi in the 1904–1908 period and assesses the contributions due solely to Severi. The tone and content of the letters reflect remarkably the enormous personality differences between these two giants of Italian mathematics.

Donald Babbitt is professor of mathematics emeritus at the University of California, Los Angeles. His email address is dgbabbitt@sbcglobal.net.

Judith Goodstein is university archivist and faculty associate in history at the California Institute of Technology. Her email address is jrg@caltech.edu.

[1] *An accessible account of the classification is given in [Gray99].*

[2] *Translated by Elisa Piccio and edited by the authors.*

Guido Castelnuovo (1865–1952) was born and raised in Venice, the son of Enrico Castelnuovo, director of the Scuola Superiore di Commercio and a popular nineteenth-century author of novels and short stories. He completed his doctor's degree at the University of Padua in 1886 under the direction of Giuseppe Veronese, one of the leading algebraic geometers of that period. On the advice of Veronese, Castelnuovo spent the following year in Rome on a postgraduate scholarship and then spent three years as assistant to geometer Enrico D'Ovidio at the University of Turin. In 1890, Castelnuovo won a *concorso*, or national competition, for a new chair of analytical and projective geometry at the University of Rome—an award that was subsequently withdrawn by the Italian Ministry of Public Instruction on the grounds that the candidate's publications did not match the subject matter covered by the chair, although the ministry had judged his work itself to be of higher quality than that of the competition. Thus, Castelnuovo remained in Turin for another year as D'Ovidio's assistant, during which time he broadened his research interests to include linear systems of curves in a plane and the geometry of algebraic surfaces. He won the next *concorso* handily, and in 1891, at age twenty-six, he was appointed to the Rome chair, which he held until his retirement in 1935. A turning point in Castelnuovo's scientific life occurred early in his tenure at Rome, in 1892, when Federigo Enriques, a gifted geometer who had earned his degree in mathematics at the Scuola Normale in Pisa, came to Rome to attend a course in higher geometry taught by Luigi Cremona, the first occupant of the chair of higher geometry at Bologna and founder of the Italian school of geometry. Enriques deemed Castelnuovo, only five and a half years his senior, much

Guido Castelnuovo, ca. 1890.

Fonti iconografiche, Biblioteca Matematica Giuseppe Peano, Department of Mathematics, University of Turin.

more open and welcoming than Cremona, whose lectures completely befuddled him. The two young mathematicians quickly became friends and several years later, when Castelnuovo married Elbina Enriques, brothers-in-law. As they strolled the streets of Rome, talking mainly about algebraic geometry, Enriques would update his new friend daily on his progress, while Castelnuovo listened attentively and offered critical comments. "It is probably not an exaggeration to assert that the theory of algebraic surfaces from the Italian point of view was created during these conversations," Castelnuovo notes in a eulogy delivered at the Accademia Nazionale dei Lincei following Enriques' death in 1946 [Cast47]. The Castelnuovo-Enriques collaboration culminated in their classification of algebraic surfaces, which has been hailed as "one of the lasting contributions to mathematics made by the Italian geometers of a century ago" [Gray99].

Castelnuovo eventually stopped working actively in algebraic geometry. After 1906 he published only two original papers relating to the field, including his notable 1921 paper on Abelian functions [Cast21]. Although best known outside Italy for his contributions to algebraic geometry, Castelnuovo explored other fields, including probability, mathematical pedagogy, and the philosophical implications of Einstein's theories of special and general relativity (an interest he shared with Enriques)—lecturing, writing, and publishing on all these topics. Nevertheless, he continued to keenly follow the developments of algebraic geometry at home and abroad and made penetrating judgments on them throughout his life.

Castelnuovo was an unabashed champion of the role of intuition in the success of the Italian school. At the 1928 International Congress of Mathematicians held in Bologna, he delivered one of the major addresses, an overview of the work in algebraic geometry not just in his own country but in Germany, France, and the United States. At the end of his talk, he issued the following warning with regard to its future development: "[A]bandoning geometric intuition—the only means that so far has allowed us to find the way in this tangled territory—would mean extinguishing the feeble flame that can lead us into the dark forest" [Cast28]. This may have been a criticism of the then-current "algebraizing of algebraic geometry" by Emmy Noether and B. L. van der Waerden [Sch07].

A student of his, Oscar Zariski, offers the following sketch of the great man [Parikh91].

> Castelnuovo was a somewhat distant fellow, he wouldn't be chummy with you, he was not that type. He was very dignified, long beard. He looked like the Moses of Michelangelo. When he smiled, his face was transformed. But mostly he was very serious.

Beniamino Segre paints a rather more attractive picture, describing Castelnuovo's house in the Via Veneto section of Rome as "modest but welcoming", and as an academic gathering place [Segre54].

> … a center where every Saturday for several years colleagues and students, Italians or foreign visitors, gathered for friendly conversation on a wide variety of subjects; his influence on those present was enormous, with his display of calm wisdom, his interest in each idea expressed, his offering of serene and objective opinions and thoughtful advice, his courtly presence, his genuine modesty. These qualities, even if chastely veiled by a certain reserve, made him loved and appreciated by everybody: you can be certain that he did not have any enemies or detractors.

Francesco Severi (1879–1961) was a man of a very different stripe. His personality is described thus in an obituary in the *Journal of the London Mathematical Society* [Roth63].

> Personal relationships with Severi, however complicated in appearance, were always reducible to two basically simple situations: either he had just taken offence or else he was in the process of giving it—and quite often genuinely unaware that he was doing so. Paradoxically, endowed as he was with even more wit than most of his fellow Tuscans, he showed a childlike incapacity either for self-criticism or for cool judgment. Thus he meddled in politics, whereas it would have been far better had he left them alone.

Oscar Zariski's biographer, Carol Parikh, describes her subject's relations with Severi [Parikh91].

Photograph of Francesco Severi previously published in *Civiltà delle Macchine*, 1957 (furnished by authors).

> A tall heavy man from Tuscany, he lectured in a way that was particularly disquieting to Zariski. Lacking both the playfulness of Enriques…and the meticulous formality of Castelnuovo, Severi's dictatorial style seemed designed to make it impossible for his students to distinguish between guesses and assertions, hunches and hypotheses.
>
> Outside of mathematics Severi was also a forceful and disquieting presence. 'I love you, Zariski, but you don't love me,' he once said, a surprising statement from a man as vain as he seemed to be. His wild driving was legendary; oblivious to the pleading of his passengers, he would careen through the hills above Rome. Even old age seems not to have slowed him down behind the wheel; Zariski remembered with terror being driven through Rome by Severi, when Severi was already eighty-one.

Severi was born in Arezzo, the last of nine children, to a family with deep roots in Tuscany. His father, Cosimo Severi, a notary who also wrote and published poetry and hymns, committed suicide when Severi was nine, leaving his widow broke and too proud to ask for help raising the four surviving children who were still living at home. During an impoverished childhood, Severi held down a variety of tutoring jobs to help support the family and did not abandon the tutoring until he had graduated with a doctorate in pure mathematics from the University of Turin in 1900. A prodigious and frenetic worker throughout his life, Severi later joked with Beniamino Segre, his student, that he had been "sentenced to a life of hard labor in a penal colony" [Segre62].

At Turin, Severi came under the spell of the geometer Corrado Segre and dedicated his first mathematical work, self-published while he was still an undergraduate, to Segre, calling him an "incomparable teacher", the one who "trained my intellect", taught him to appreciate "rigorous scientific investigations", and stirred his "heart to the highest filial sentiments" [Sev59]. Severi would apparently disavow these sentiments by the 1930s, as we shall see.

He spent several years as an assistant, first in Turin with D'Ovidio, then in Bologna with Enriques, and finally in Pisa with the geometer Eugenio Bertini, before moving in 1904 to Parma following his appointment there as professor of projective and descriptive geometry. A year later, Severi transferred to Padua, where he joined the Socialist Party; there he remained until the call from the faculty of mathematical sciences at Rome came in 1922. At Rome, Severi taught a variety of courses, from calculus to higher geometry, and in 1923 he became rector of the university as well, a position he resigned to protest the assassination of the Socialist deputy Giacomo Matteotti by Fascist thugs in June of the following year.

Francesco Severi, 1915, the year that he received the Accademia dei Lincei Mathematics Prize.

Severi also signed (as did his Rome colleagues Vito Volterra, Castelnuovo, and Tullio Levi-Civita) the philosopher Benedetto Croce's anti-Fascist manifesto in 1925. Taking aim at the philosopher Giovanni Gentile's manifesto of the Fascist intellectuals published ten days earlier, Croce's manifesto advocated acceptance of a universal culture, not one confined to a particular political system. Soon after, however, perhaps because of his outsized ambition, Severi began to ingratiate himself with Benito Mussolini's regime. Severi's election in 1929 to Mussolini's new Academy of Italy as a last-minute substitution for Federigo Enriques—Enriques, now a member of the Rome faculty, had not signed either manifesto—thrust Severi into the limelight as the regime's spokesman for Italian mathematics. Like Castelnuovo, Levi-Civita, and Volterra, Enriques was Jewish, which explains his name's deletion from the list of candidates forwarded to the Academy's president-elect. The Fascists denied that there was any ban against Jewish members at the outset. In its fourteen years of existence, the Fascist academy never admitted any Jews to its ranks. Situated directly across the street from the venerable and anti-Fascist-leaning Accademia dei Lincei, its rise was a highly visible first step in the chain of events leading up to the formal annexation of the Lincei in 1939.

Beniamino Segre (1903–1977) entered Severi's life in 1927, two years after Mussolini had turned Italy into a dictatorship. A native of Turin who trained as a geometer there (he counted Guido Fubini, Gino Fano, and his distant cousin Corrado among his teachers), Segre moved briskly through the academic ranks after receiving a doctor's degree in mathematics in 1923 with a dissertation in algebraic geometry. After holding several positions in Turin (assistant to the chair of rational mechanics; assistant to the chair of analytical, projective,

Beniamino Segre in Venice, 1932. Photograph courtesy of Sergio Segre.

and descriptive geometry; and associate of analytical mathematics at the Military Academy of Artillery and Engineers), and studying with Élie Cartan and Émile Picard in Paris on a Rockefeller fellowship, in 1927 the twenty-four-year-old Segre accepted Severi's invitation to become his assistant in Rome. By then, Segre had also obtained the libera docenza, a license to teach at the university level, in analytic and projective geometry.

Physically, the two mathematicians—Severi towered over Segre—could not have been more dissimilar. After meeting both men on a visit to Rome in 1928, W. E. Tisdale of the Rockefeller Foundation described Severi in his interview log as "a huge, bearded man, decidedly teutonic in general appearance" and Segre as "a nice appearing young fellow" who spoke decent French and seemed to rank high in Severi's estimation [RFA28]. The self-assured, flamboyant Severi showered attention on his able new assistant, delighted in calling Segre "my favorite" (a play on the double meaning of Segre's first name in Italian), and cultivated his interest in algebraic geometry, the field in which Severi had done his most significant work. In 1931, after four years as Severi's assistant, Segre won the nationwide *concorso* for the chair of higher geometry at Bologna. By then, he had become Severi's star pupil, his sounding board, the protégé who occasionally had to endure his maestro's harsh editorial judgments (on the occasion described below, certainly), but he distanced himself from Severi's pro-Fascist politics.

The Letters

When Beniamino Segre was appointed to the chair in geometry at Bologna in 1931, he was required to give an inaugural lecture, which he entitled "Italian Geometry from Cremona to the Present Day". He evidently sent a draft to Severi asking for his comments. The letter in question, dated January 2, 1932, is Severi's response.

> My dear Segre,
>
> …[T]he general outline [of B. Segre's draft–ed.] is mediocre in several places, especially where you talk about algebraic geometry.
>
> It lacks perspective so that a reader who doesn't know much will not be able to understand the hierarchy of ideas and names.
>
> 1) The work of C. Segre has been overrated…Segre, for example, did not prove anything major in the field of geometry of curves although he did carry out a very significant revision of the subject. His contributions to higher dimensional projective geometry are overrated when compared, for example, with those of Veronese. This exaggerated evaluation is probably explained by your love of him as a disciple…
>
> 2) The work by Veronese is underrated. In Italy he was the true creator of higher dimensional projective geometry.
>
> 3) The work of Castelnuovo has been overrated as has been that of Enriques, especially when compared to that of [Max] Noether, whose name you have completely neglected in your discussion of surfaces.
>
> 4) My work has been underrated, which seems odd to me since you were my student, and, in addition, your affection for your first teacher [Segre] has caused you to overestimate his work.

In elaborating on this third point, Severi lists many of the important things that were known in algebraic geometry before Castelnuovo and Enriques did their work on the classification of surfaces, some of which were essential to their classification. These include the notions of the geometric and arithmetic genus of a surface (Cayley, Zeuthen, M. Noether), the Zeuthen-C. Segre invariant, the Brill-Noether Theorem, and the work of Picard on surfaces. He thus suggests that the classification of Castelnuovo and Enriques was built on the shoulders of giants and that Segre did not appreciate the importance of this fact. Severi ends this part of his discourse by saying: "And in this article you write that before Castelnuovo-Enriques there were only 'a few developments that had only created difficulties'. Poor Noether!"

On his fourth point, he has this to say:

> Beginning in 1904 I developed new ideas that untied the Gordian knots that had been bound so tightly up to that time. I myself untied most of them, such as the characterization of irregular surfaces from both the transcendental and algebraic point of view.…Even setting aside my work on conceptual clarifications as well as my work on the hyperelliptic surfaces with Enriques, which I am willing to do, this does not justify the humiliating description of my status as "arrived" that you have written on page 12, thus putting my work and that of Castelnuovo-Segre's [Severi may have meant Enriques here–ed.] on two completely different levels. You need to weigh your words!
>
> Also forgotten by you were my Theorem of the Base [Sev06] and my work on the geometry of varieties of higher dimension. How could you have done this when you discuss Italian geometry? In addition, there is no mention of the fact that I am the only one among living Italian algebraic geometers who has created a school.
>
> You have also underestimated my contributions to enumerative geometry. If only you could understand them. All of this is not to reproach you, because you certainly have done your best. Although your mathematical knowledge is wide, you currently do not have a deep enough understanding in the vast field of algebraic geometry to allow you to have a reliable perspective on the subject. But I am also surprised that the comparative evaluations that we discussed many times in the past did not have an effect on you even though I was always very conscientious about being objective.

We do not have the original draft that Segre sent to Severi, so we do not know how Severi's criticisms affected the content of Segre's inaugural lecture. There is, however, the paper that resulted from the lecture, which appeared in the *Annali di Matematica* in 1932 [Segre33]. In it, one notices that Cremona is mentioned sixteen times (including twice in footnotes); Max Noether is mentioned twice; Corrado Segre is mentioned six times, as is Guido Castelnuovo (and one footnote); Enriques is mentioned a total of seven times (four in footnotes). Severi is mentioned nine times, including four footnotes. The fact that Noether is now mentioned twice indicates that Segre took Severi's comments to heart at least as far as Noether is concerned. It is easy to conjecture that Segre gave Severi more attention in his lecture and in this paper than in the draft that provoked Severi's hectoring letter.

And here is the excerpt from Castelnuovo's letter to Segre in 1938. It contains comments, perhaps solicited by Segre, on a recent paper by Segre in the *Annali di Matematica Pura ed Applicata* [Segre38]. The excerpt deals with some historical commentary of Segre's in the preface on the work of Castelnuovo, Enriques, and Severi in the 1904–1908 period:

> One last comment regarding the historical issues.…The notion of a continuous system [now called an algebraic system–ed.] of curves on some special surfaces already appears in some works of Enriques and mine that precede the work of Severi.…In some special cases I suggested the definition of the characteristic series of a continuous system to Severi. But since this suggestion had been given in an unpublished letter, and subsequently Severi brilliantly developed the idea mentioned in it, it is not useful to make a claim of priority here. I only mention this matter to show you how much caution is needed when you assign scientific priorities in periods in which the research was often done in collaboration, or was suggested by elders to their more youthful colleagues. It was the good fortune of the Italian school of algebraic geometry to have this disinterested collaboration between 1890 and 1910. But this makes it necessary to smooth out certain overly clean divisions between the work of one and the other.
>
> What is undoubtedly due to Severi in the period 1904–08 are the following: the theorem that the existence of Picard integrals of the 1st and 2nd kind on an algebraic surface depends on the irregularity of the surface (1904), a theorem that was successively stated precisely by both of us; the theory of the algebraic equivalence of curves on a surface; and the Theorem of the Base [this has evolved into the Néron-Severi Theorem–ed.]. That is more than enough to show his great worth.

The first contribution to which Castelnuovo refers is contained in a beautiful and fundamental theorem due collectively to Pierre Humbert, Picard, Enriques, Castelnuovo, and Severi concerning the dimension of the space of Picard integrals of the

first and second kind on an algebraic surface F over the complex numbers C. Its statement requires the notion of the irregularity q of an algebraic surface F which is defined to be the nonnegative integer $p_g - p_a$, where p_g is the usual geometric genus of F and p_a = the arithmetic genus of F (a notion somewhat more difficult to define, which we will not do here). The theorem states if F is an algebraic surface defined over C of irregularity q, then the vector space I_1 of Picard integrals of the first kind has dimension q and the vector space I_2 of Picard integrals of the second kind has dimension $2q$. Picard integrals of the first kind are ones whose integrands are closed and regular 1-forms, and Picard integrals of the second kind are those whose integrands are closed 1-forms with only polar, as opposed to logarithmic, singularities on F. It is interesting to note that F must be irregular in order to have nontrivial Picard integrals of the first or second kind.

All the mathematicians mentioned above contributed to the proof of the theorem [Roth63], [Zar34,Ch.6]. The final steps were furnished in 1905 by Severi, who showed that $\dim(I_1) \leq q, \dim(I_2) \leq 2q$, and by Castelnuovo, who showed that $q \leq \dim(I_1)$. Castelnuovo's proof depended on a technical "Theorem" due to Enriques [Enrq04], based on a suggestion of Severi (in 1904), whose algebro-geometric proof was shown later by Severi [Sev21] to be fundamentally flawed.[3] Fortunately, Henri Poincaré gave a valid transcendental proof of the Enriques-Severi assertion in 1910, so that at least from this date on, the theorem was legitimate.

The second and third contributions discussed by Castelnuovo are closely related. Again, they concern an algebraic surface F over C. We need to introduce some additional notions. The divisor group of $F, \mathrm{Div}(F)$, is the free Abelian group over the integers Z generated by the irreducible (algebraic) curves on F. Its elements are referred to as the divisors on F. Following [Mum66], we say that two curves C_1 and C_2 on F are algebraically equivalent if they are parametrized by a connected algebraic variety S. We denote by $G_a(F)$ the subgroup of $\mathrm{Div}(F)$ generated by divisors of the form $C_0 - C_1$, where C_0 and C_1 on F are algebraically equivalent curves. The Néron-Severi group is the quotient group $\mathrm{Div}(F)/G_a(F)$. The Theorem of the Base in Castelnuovo's discussion says that the Néron-Severi group is finitely generated. The paper where the proof appeared (*Math. Ann.* [Sev06]) was solicited by its editor, Max Noether. (This is perhaps why he is mentioned so solicitously in Severi's 1932 letter.) Subsequently, in 1952, Néron [Nér52] refined and extended Severi's Theorem of the Base and gave a modern (rigorous) proof of it—that is, one acceptable to the Franco-American school of algebraic geometry.

[3] *Controversy over the proof of this "Theorem", especially between Enriques and Severi, raged until a valid algebro-geometric proof was obtained by Grothendieck in 1960. Grothendieck's proof utilized in a nontrivial way non-reduced schemes and other powerful machinery due to Cartier and Kodaira and Spencer [Mum66].*

Epilogue

The Fascist racial laws enacted in the summer of 1938 barred Jewish students from attending public schools and universities; Jewish authors from publishing works under their own names; and scores of Jewish academics, including some of Italy's best and brightest mathematicians, from teaching. Vito Volterra, the dean of Italian mathematics, had already forfeited his position at the University of Rome in 1931, by refusing to sign the Fascist loyalty oath. Guido Castelnuovo had retired from teaching at Rome in 1935 at the age of seventy, capping a career spanning nearly forty-five years in the classroom. But their younger Jewish university colleagues, including Tullio Levi-Civita and Federigo Enriques in Rome, Beppo Levi and Beniamino Segre in Bologna, and Guido Fubini, Gino Fano, and Alessandro Terracini in Turin, felt the full brunt of the racial legislation. Levi and Terracini found new jobs in Argentina; Fano emigrated to Lausanne, Switzerland; and Fubini went to Princeton.

Beniamino Segre woke up that September to find that he had been dismissed from his position as director of Bologna's mathematical institute, relieved of his duties as an editor of Italy's oldest scientific journal, the *Annali di Matematica Pura ed Applicata*, expelled from numerous scientific academies and organizations, including the Italian Mathematical Union (UMI), of which he had been a founding member, and denied any form of compensation. Deeply offended by the anti-Semitic legislation, Segre immediately renounced his membership in the Fascist Party, reportedly telling Bologna's rector, Alessandro Ghigi, "Since his Excellency the Head of the Government has declared that a Jew is not an Italian, I took it as a given that I could no longer wear the fascist insignia as it might have been interpreted as an insincere gesture" [Finzi94]. Having tried and failed to find a position in the United States, Segre took refuge in England in the spring of 1939 with his wife and their three children. In September, when Britain declared war on Germany, he was interned for several months on the Isle of Man as an enemy alien, while his wife and children stayed with the mathematician Leonard Roth and his wife in London. The youngest daughter fell ill with measles, which turned into blood poisoning during an air raid attack over the city. The hospitals overflowed with emergencies, making it impossible to get the little girl admitted in time, and she died early the next morning. In 1942 the family moved to Manchester, where Segre taught for several years

Photograph of Mussolini and Severi previously published in *L'Illustrazione Italiana*, 1939 (furnished by authors).

Mussolini (in front) at the University City (Città Universitaria) in Rome to visit the new building of the Royal Institute of Higher Mathematics. Severi is next to him on the right.

before returning to the University of Bologna in 1946. Four years later, Segre succeeded Severi as professor of geometry at the University of Rome.

In the wake of the 1938 racial laws, Jewish elementary and secondary schools sprang up in Rome and other major Italian cities with the permission of the authorities, who had banned any university-level coursework. In December 1941 Guido Castelnuovo organized a clandestine university, recruited a host of professors, including himself, and arranged for the students to register (in absentia) at the privately run Istituto Politecnico di Friburgo, in Switzerland. The ad-hoc university, as well as the Jewish schools, ceased operations when the Germans occupied Rome in September 1943. At the end of the war the students enrolled at the University of Rome, and their transcripts from the Fribourg Polytechnic were submitted as evidence of their advanced standing. During the occupation, Castelnuovo and his wife were sheltered briefly by Tullio Viola, a young mathematician at Rome. The couple later took refuge in a religious institute, and when that arrangement became too dangerous, they lived for many months in a small pensione off the Via Veneto, using an assumed name, Cafiero [NM04].

After the liberation of Rome in June 1944, Castelnuovo, then seventy-nine, came out of retirement to reconstitute Italy's pre-Fascist scientific organizations. Formally reinstated as professor emeritus at Rome, he served as general commissioner of Italy's National Research Council and president of its mathematics committee and played a leading role in reviving both organizations. He contributed in a major way to the rebirth of the Lincei, whose president he became in December 1946, a post he held until his death in 1952. Castelnuovo was named a Senator for Life in Italy's parliament in 1949, and soon after his death the building that houses the University of Rome's ("La Sapienza") Institute of Mathematics was named in his honor.

From late 1938 until the liberation of Rome, Francesco Severi, forever a loyal Fascist, was undeniably Italy's most prominent mathematician, especially now that any possible competitors were either in hiding or had emigrated. During most of this time, he was the president of the Italian National Institute for Higher Mathematics (INDAM), also based at "La Sapienza" near the Rome Termini train station. Shortly after the liberation, a High Commission for Sanctions against Fascism was established. The commission's specific charge was to look into allegations of wartime collaboration against party members who had been accused of taking an active part in Fascist political life or who had remained loyal to Mussolini after he was deposed in September 1943. The commissioners initially suspended Severi from university teaching. He appealed the ruling and received *sanzioni minori*, simple censures involving nothing more than a letter placed in his university personnel file. When Severi got in touch with Segre again after the war, he enclosed with his letter a "To whom it may concern" document issued by the Italian Ministry of Public Instruction stating that the ministry had not subjected him "to any sanction provided for by current legislation on the cleansing of the Italian Civil Service" [MPI46] for Fascist activities. Severi also received a clean bill of health from another commission assigned to examine the behavior of former members of the Academy of Italy, which concluded that he "had not received from Fascism anything more than was his due as a distinguished scientist." His "moral rectitude", the commission added, was never called into question [Sev45]. Severi also defended his behavior during the war, pointing out to Segre in 1945 that he had worked diligently to save the assets of the local bank in Arezzo, his hometown. However, a committee (including Castelnuovo) that was given the task of rebuilding the Lincei, refused to reelect Severi, and he regained membership only in 1948, after the government declared a general nationwide amnesty. Severi, who had lost his position as president of INDAM, also recovered that post following the amnesty and held it until his death.

Appendix

As is well known in the algebraic geometry community, there was increasing skepticism among algebraic geometers outside the Italian school about the way the Italians did algebraic geometry. In particular, there was concern about the mathematical precision of some of the key definitions and the logical rigor of the proof of some of the important theorems. This was especially the case among members of the Franco-American school of algebraic geometry, beginning with Castelnuovo's student Oscar Zariski in the mid-1930s, soon after he had written his well-known book on algebraic surfaces [Zar34]. He was later joined, most prominently, by André Weil, Claude Chevalley, and Pierre Samuel. The Italian school was very sensitive to these criticisms. Francesco Severi, especially, tried unsuccessfully to address them. (See, for example, [Sev49] and Chevalley's review in *Mathematical Reviews* [Chev52].) There was also a well-known

confrontation between Severi and Weil at the 1954 International Congress of Mathematicians at Amsterdam over the rigor of Severi's theory of the intersection of subvarieties on a projective variety and rational equivalence. (See, for example, [VdW70].) Posterity has shown that Weil won the argument.

Below is a translated[4] excerpt from the preface by Guido Castelnuovo to the posthumous (1949) magnum opus of Federigo Enriques on algebraic surfaces [Enrq49] in which Castelnuovo defends the more intuitive approach to mathematics of an earlier era—which certainly included Italian algebraic geometry in its heyday—as opposed to the new stress on formal rigor espoused by the Franco-American school.

> Will someone come along soon who will continue the work of the Italian and French schools [here Castelnuovo presumably is referring to the French school prior to the dominance of the Franco-American school–ed.][5] who will succeed in developing the theory of algebraic surfaces that has already been accomplished for the theory of algebraic curves? I hope so, but I doubt it… mathematics has now taken a different course from that of the past [i.e., the nineteenth century]. Fantasy and intuition characterized research then, but now these are treated with suspicion, as there is the fear that they could lead to errors. Theories were developed by mathematicians to make more precise many ideas that were already vaguely in their mind. It was the exploration of a vast territory seen from a distant shore. In this way such jewels of mathematics as the theory of analytic functions, elliptic functions, and Abelian functions were created during this past century. Nowadays there is more interest in the road that leads to a field of exploration rather than to the field itself. And this tendency will not be short-lived, as we can also see in other fields such as in music and in the arts, where fantasy is banned and where the technique or the way of expression is more interesting than the work itself. It would be an exaggeration to extend these pessimistic judgments to the evolution that mathematics is undergoing nowadays, but if we compare these fifty years to the corresponding years of the last century, when people like Gauss, Abel, Jacobi, Cauchy, and many others rose, we certainly worry about the future of our science.
>
> One day, sooner or later, the love for the great theories will be born again and on that day people will read the treatise by Enriques as a report wherein many gems have been unearthed and many others wait to be discovered.

[4] *Translated by the authors.*

[5] *For an interesting discussion of the relations between the Italian and French schools in the early twentieth century, see [Brig84].*

Acknowledgments

We thank G. Fabre, L. Giacardi, D. Goodstein, S. Lippincott, C. S. Roero, and S. Segre for useful suggestions in the course of preparing this manuscript for publication.

References

[Brig84] A. BRIGAGLIA, Sur les relations des mathematicians français et italiens au début du XXe siècle, *Cahiers du séminaire des mathématiques* **5** (1984), 21–48.

[Cast21] G. CASTELNUOVO, Sulle funzioni abeliane, *Rend. R. Acc. Lincei* (5) **30** (1921), 50–55; 99–103; 195–200; 355–359.

[Cast28] _____ , La geometria algebrica e la scuola italiana, *Conferenza tenuta al Congresso Internazionale dei Matematici di Bologna, Atti*, **1** (1928), 191–201.

[Cast47] _____ , Commemorazione del socio Federigo Enriques, *Rend. Acc. Naz. Lincei* (8) **2** (1947), 3–21.

[Chev52] C. CHEVALLEY, Review of "La géométrie algébrique italienne. Sa rigeur, ses méthodes, ses problèmes" in *Mathematical Reviews*, **MR0038094** (12,353f).

[Enrq04] F. ENRIQUES, Sulla proprietà caratteristica delle superficie algebriche irregolari, *Rend. Acc. Sci. Bologna* **9** (1904–05), 5–13.

[Enrq49] _____ , *Le Superficie Algebriche*, Zanichelli, Bologna, 1949.

[Finzi94] R. FINZI, Leggi razziali e politica accademica: il caso di Bologna, in *Cultura ebraica e cultura scientifica in Italia* (Antonio Di Meo, ed.), Editori Riuniti, 1994.

[Gray99] J. GRAY, The classification of algebraic surfaces by Castelnuovo and Enriques, *Mathematical Intelligencer* **21** (1999), 59–66.

[MPI46] F. Severi to B. Segre, January 10, 1946, with enclosure, The Beniamino Segre Papers, Private Collection.

[Mum66] D. MUMFORD, *Lectures on Curves on an Algebraic Surface*, Princeton University Press, 1966.

[Nér52] A. NÉRON, La théorie de la base pour les diviseurs sur les variétés algébrique, *Colloque de Géométrie Algébrique*, Liège, 1952.

[NM04] R. NATALINI and M. MATTALIANO, Colloquio con Emma Castelnuovo: la fantasia e la memoria, *Lettera matematica PRISTEM* **52** (2004), 4–7.

[Parikh91] C. PARIKH, *The Unreal Life of Oscar Zariski*, Academic Press, 1991.

[RFA28] Rockefeller Foundation Archives, Record Group 12.1 Officer's Diaries, box.139, folder 3.

[Roth63] L. ROTH, Francesco Severi, *J. London Math. Soc.* **38** (1963), 282–307.

[Sch07] N. SCHAPPACHER, A historical sketch of B. L. van der Waerden's work in algebraic geometry: 1926–1946. *Episodes in the History of Modern*

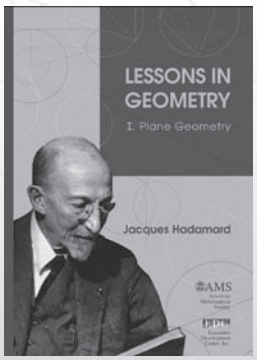
About the Cover

The complexity of factorization

This month's cover was produced by a mild variant of Eratosthenes' sieve.The fascination with the mixture of determinism and randomness associated with factorization has lasted over 2,000 years. As the WHAT IS … article by Friedlander and Iwaniec (page 817) reminds us, optimism still reigns in this field.

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

AMERICAN MATHEMATICAL SOCIETY



Lessons in Geometry TEXTBOOK

I. Plane Geometry

Jacques Hadamard

This internationally renowned geometry text goes well beyond the basics of plane Euclidean geometry, in a way that is both pleasingly classic and surprisingly modern. This book established the tradition of teaching geometry throughout the world. Much of its value lies in more than 450 problems, whose solutions open worlds to the engaged reader.

2008; 330 pages; Hardcover; ISBN: 978-0-8218-4367-3; List US$59; AMS members US$47; Order code MBK/57

1-800-321-4AMS (4267), in the U. S. and Canada, or 1-401-455-4000 (worldwide); fax: 1-401-455-4046; email: cust-serv@ams.org.
American Mathematical Society, 201 Charles Street, Providence, RI 02904-2294 USA

For many more publications of interest, visit the AMS Bookstore
AMS BOOKSTORE www.ams.org/bookstore

AMS AMERICAN MATHEMATICAL SOCIETY

Algebra (1800–1950) (Jeremy J. Gray and Karen Parshall, eds.), History of Mathematics, **32**, Amer. Math. Soc., 245–283, Providence, RI, 2007.

[Segre33] B. SEGRE, La geometria in Italia, dal Cremona ai giorni nostri, *Ann. di Mat.* (4) **11** (1933), 1–16.

[Segre38] _____ , Un teorema fondamentale della geometria sulle superficie algebriche ed il principio di spezzamento, *Ann. di Mat. Pura Appl.* (4) **17** (1938), 107–126.

[Segre54] _____ , Onoranze alla memoria di Guido Castelnuovo, *Univ. Roma. Ist. Naz. Alta Mat. Rend. Mat. e Appl.* (5) **13** (1954), 19–41.

[Segre62] _____ , Francesco Severi (13 aprile 1879–8 dicembre 1961), *Ann. di Mat. Pura Appl.* (4) **61** (1963), i-xxxvi.

[Sev06] F. SEVERI, Sulla totalità delle curve algebriche tracciate sopra una superficie algebrica, *Math. Ann.* **62** (1906).

[Sev21] _____ , Sulla teoria degl'integrali semplici di 1^a specie appartenenti ad una superficie algebrica (7 Notes), *Rend. R. Acc. Lincei.* (5) **30** (1921), 163–167, 204–208, 231–235, 276–280, 296–301, 328–332, 365–367.

[Sev45] F. Severi to B. Segre, October 15, 1945, The Beniamino Segre Papers, Private Collection.

[Sev49] F. SEVERI, La géométrie algébrique italienne. Sa rigeur, ses méthodes, ses problèmes, *Colloque de Géométrie Algébrique*, Liège, 1949, Masson et Cie, Paris, 1950.

[Sev59] _____ , *Dalla scienza alla fede*, Edizioni Pro Civitate Christiana, 1959.

[VdW70] B. L. Van der Waerden, The theory of equivalence systems of cycles on a variety, 1971 Symposia Mathematics, Vol. V (INDAM, Rome, 1969/70), pp. 255–262,Academic Press, London.

[Zar34] O. Zariski, *Algebraic Surfaces* (second supplemented edition), Springer-Verlag, 1971, New York–Heidelberg.

The Dixmier-Douady Invariant for Dummies

Claude Schochet

The Dixmier-Douady invariant is the primary tool in the classification of continuous trace C^*-algebras. These algebras have come to the fore in recent years because of their relationship to twisted K-theory and via twisted K-theory to branes, gerbes, and string theory.

This note sets forth the basic properties of the Dixmier-Douady invariant using only classical homotopy and bundle theory. Algebraic topology enters the scene at once since the algebras in question are algebras of sections of certain fibre bundles.

The results stated are all contained in the original papers of Dixmier and Douady [5], Donovan and Karoubi [7], and Rosenberg [23]. Our treatment is novel in that it avoids the sheaf-theoretic techniques of the original proofs and substitutes more classical algebraic topology. Some of the proofs are borrowed directly from the recent paper of Atiyah and Segal [1]. Those interested in more detail and especially in the connections with analysis should consult Rosenberg [23], the definitive work of Raeburn and Williams [21], as well as the recent paper of Karoubi [13] and the book by Cuntz, Meyer, and Rosenberg [4]. We briefly discuss twisted K-theory itself, mostly in order to direct the interested reader to some of the (exponentially-growing) literature on the subject.

It is a pleasure to acknowledge the assistance of Alan Carey, Dan Isaksen, Max Karoubi, N. C. Phillips, and Jonathan Rosenberg in the preparation of this paper.

Fibre Bundles

Suppose that G is a topological group and $G \to T \to X$ is a principal G-bundle over the compact space X. Then up to equivalence it is classified by a map f to the classifying space BG and there is a pullback diagram

$$\begin{array}{ccc} G & \longrightarrow & G \\ \downarrow & & \downarrow \\ T & \longrightarrow & EG \\ \downarrow & & \downarrow \\ X & \xrightarrow{f} & BG \end{array}$$

where the right column is the universal principal G-bundle.

Suppose further that F is some G-space. Then following Steenrod [24] we may form the associated fibre bundle

$$F \longrightarrow T \times_G F \longrightarrow X$$

with fibre F and structural group G. Pullbacks commute with taking associated bundles, so there is a pullback diagram

$$\begin{array}{ccc} F & \longrightarrow & F \\ \downarrow & & \downarrow \\ T \times_G F & \longrightarrow & EG \times_G F \\ \downarrow & & \downarrow \\ X & \xrightarrow{f} & BG. \end{array}$$

Now suppose that M is some fixed C^*-algebra, soon to be either the matrix ring $M_n = M_n(\mathbb{C})$ for some $n < \infty$ or the compact operators $\mathcal{K}$ on some separable Hilbert space $\mathcal{H}$. Take $G = U(M)$, the group of unitaries of the C^*-algebra. (If M is not unital then we modify by first adjoining a unit canonically to form the unital algebra M^+ and then define $U(M)$ to be the kernel of the natural homomorphism $U(M^+) \to U(M^+/M) \cong S^1$.) Then $U(M)$ acts naturally on M by conjugation; denote M with this action as M^{ad}. The center $ZU(M)$ of $U(M)$ acts trivially, and so the action descends to an action of the *projective unitary*

Claude Schochet is professor of mathematics at Wayne State University, Detroit, MI. His email address is claude@math.wayne.edu.

group $PU(M) = U(M)/ZU(M)$ on M, denoted M^{ad}. Note that if M is simple then its center is just $\mathbb{C}$ and $ZU(M) \cong S^1$ so that $PU(M)$ is just the quotient group $(U(M))/S^1$.

Having fixed M, let

$$\zeta : PU(M) \longrightarrow T \to X$$

be a principal $PU(M)$-bundle over a compact space X. Form the associated fibre bundle

$$\mathbb{P}\zeta : M^{ad} \longrightarrow T \times_{PU(M)} M^{ad} \xrightarrow{p} X.$$

This fibre bundle always has non-trivial sections. Define A_ζ to be the space of sections:

$$A_\zeta = \Gamma(\mathbb{P}\zeta) = \{s : X \longrightarrow T \times_{PU(M)} M^{ad} \mid ps = 1\}.$$

This is a C^*-algebra with pointwise operations that are well defined because we are using the adjoint action. It is unital if M is unital. If $M = M_n$ or $M = \mathcal{K}$ then this is a continuous trace C^*-algebra. If X is locally compact but not compact then A_ζ is still defined by using sections that vanish at infinity and it is not unital.

Note that if $\mathbb{P}\zeta$ is a trivial fibre bundle then sections correspond to functions $X \to M$ and hence

$$A_\zeta \cong C(X) \otimes M,$$

where $C(X)$ denotes the C^*-algebra of continuous complex-valued functions on X. (If X is only locally compact then we use C_o to denote continuous functions vanishing at infinity.)

Continuous trace C^*-algebras may be defined intrinsically, of course. Here is one approach. If A is a (complex) C^*-algebra, then let $\hat{A}$ denote the set of unitary equivalence classes of irreducible $*$-representations of A with the Fell topology (cf. [21]).

Definition. Let X be a second countable locally compact Hausdorff space. A *continuous trace C^*-algebra with $\hat{A} = X$* is a C^*-algebra A with $\hat{A} = X$ such that the set

$$\{x \in A \mid \text{the map } \pi \to tr(\pi(a)\pi(a)^*) \text{ is finite and continuous on } \hat{A}\}$$

is dense in A.

From the definition it is easy to see that commutative C^*-algebras $C_o(X)$ as well as stable commutative C^*-algebras $C_o(X, M_n)$ and $C_o(X, \mathcal{K})$ are continuous trace. In fact every continuous trace algebra arises as a bundle of sections of the type we have been discussing.

Products

Vector spaces come equipped with natural direct sum and tensor product operations, and these pass over to vector bundles. Thus if $E_1 \to X$ and $E_2 \to X$ are complex vector bundles of dimension r and s respectively then we may form bundles $E_1 \oplus E_2 \to X$ of dimension $r + s$ and $E_1 \otimes E_2 \to X$ of dimension rs. There are two corresponding operations on classifying spaces. The one that concerns us is the tensor product operation. Fix some unitary isomorphism of vector spaces

$$\mathbb{C}^r \otimes \mathbb{C}^s \cong \mathbb{C}^{rs}.$$

(This isomorphism is unique up to homotopy, since the various unitary groups are connected.) Let $U_n = U(M_n(\mathbb{C}))$. This determines a homomorphism

$$U_r \times U_s \xrightarrow{\otimes} U_{rs}$$

and the associated map on classifying spaces

$$BU_r \times BU_s \xrightarrow{\otimes} BU_{rs}$$

given by the composite

$$BU_r \times BU_s \cong B(U_r \times U_s) \xrightarrow{B(\otimes)} BU_{rs}.$$

Let $[X, Y]$ denote homotopy classes of maps and recall that if X is compact and connected then isomorphism classes of complex n-plane vector bundles over X correspond to elements of $[X, BU_n]$. Then this construction induces an operation

$$[X, BU_r] \times [X, BU_s] \xrightarrow{\otimes} [X, BU_{rs}],$$

which does indeed correspond to the tensor product operation on bundles. Precisely, if $E_1 \to X$ and $E_2 \to X$ are represented by f_1 and f_2 respectively, then the tensor product bundle $E_1 \otimes E_2 \to X$ is represented by $f_1 \otimes f_2$. (This holds at once for compact connected spaces. If X is not connected then one checks this on each component.)

The inclusion

$$U_r \cong U_r \times \{1\} \to U_r \times U_s \to U_{rs}$$

is denoted

$$\alpha_{rs} : U_r \to U_{rs}.$$

The center of U_k is the group S^1 regarded as matrices of the form zI, where z is a complex number of norm 1. The quotient group PU_k is the *projective unitary group*. The fibration $S^1 \to U_k \to PU_k$ induces the sequence

$$0 \to \mathbb{Z} \xrightarrow{k} \mathbb{Z} \to \mathbb{Z}/k \to 0$$

on fundamental groups, and, in particular, $\pi_1(PU_k) \cong \mathbb{Z}/k$.

There is a natural induced map and commuting diagram

$$\begin{array}{ccc} S^1 \times S^1 & \longrightarrow & S^1 \\ \downarrow & & \downarrow \\ U_r \times U_s & \longrightarrow & U_{rs} \\ \downarrow & & \downarrow \\ PU_r \times PU_s & \longrightarrow & PU_{rs} \end{array}$$

and this induces a tensor product operation and a commuting diagram

$$\begin{array}{ccc} BU_r \times BU_s & \longrightarrow & BU_{rs} \\ \downarrow & & \downarrow \\ BPU_r \times BPU_s & \longrightarrow & BPU_{rs}. \end{array}$$

It is easy to see that

$$\pi_2(BPU_k) \cong \pi_1(PU_k) \cong \mathbb{Z}/k$$

and that the natural map $\alpha_{rs} : PU_r \to PU_{rs}$ induces a commuting diagram

$$\begin{array}{ccc} \pi_2(BP_r) & \xrightarrow{(\alpha_{rs})_*} & \pi_2(BP_{rs}) \\ \downarrow\cong & & \downarrow\cong \\ \mathbb{Z}/r & \xrightarrow{s} & \mathbb{Z}/rs. \end{array}$$

There is a similar structure in infinite dimensions. Fix some separable Hilbert space $\mathcal{H}$ with associated group of unitaries $\mathcal{U}$ on which we impose the strong operator topology. The group $\mathcal{U}$ is contractible in this topology (cf. [21], Lemma 4.72). Fix some unitary isomorphism $\mathcal{H} \otimes \mathcal{H} \cong \mathcal{H}$. This is unique up to homotopy since $\mathcal{U}$ is path-connected. Then there is a canonical homomorphism

$$\mathcal{U} \times \mathcal{U} \xrightarrow{\otimes} \mathcal{U}$$

and associated maps on classifying spaces

$$\begin{array}{ccc} B\mathcal{U} \times B\mathcal{U} & \xrightarrow{\otimes} & B\mathcal{U} \\ \downarrow & & \downarrow \\ BP\mathcal{U} \times BP\mathcal{U} & \xrightarrow{\otimes} & BP\mathcal{U} \end{array}$$

where $P\mathcal{U}$ denotes the infinite projective unitary group.

The action of S^1 on $\mathcal{U}$ is free and thus

$$P\mathcal{U} \simeq BS^1 \simeq K(\mathbb{Z}, 2).$$

This implies that

$$BP\mathcal{U} \simeq K(\mathbb{Z}, 3).$$

It is simpler to separate the discussion of finite and infinite dimensional bundles at this point.

A Note on Cohomology for Compact Spaces

If X is a finite complex then the Eilenberg-Steenrod uniqueness theorem guarantees for us that singular, simplicial, representable, and Čech cohomology theories all coincide. Moving up to compact spaces one must pause to reconsider the question. The natural choice in the classical Dixmier-Douady context is Čech cohomology, as this relates best to sheaf theories, and so the Dixmier-Douady invariant was originally defined to take values in $\check{H}^3(X;\mathbb{Z})$. However, a classical homotopy approach dictates defining $H^3(X;\mathbb{Z}) = [X, K(\mathbb{Z}, 3)]$. Fortunately these two functors agree on compact spaces; the result is again due to Eilenberg and Steenrod.

Proposition ([8]). *On the category of compact spaces, Čech cohomology is representable. That is, there is a natural isomorphism*

$$\check{H}^n(X;\mathbb{Z}) \cong [X, K(\mathbb{Z}, n)].$$

Proof. The natural isomorphism is well known for X a finite complex, by the Eilenberg-Steenrod uniqueness theorem. Suppose that X is a compact space. Then write $X = \varprojlim X_j$ for some inverse system of finite complexes. (See [8], Chapters IX, X, and XI for open covers, nerves, and inverse limits.) Continuity of Čech theory implies that

$$\check{H}^n(X;\mathbb{Z}) \cong \varinjlim H^n(X_j;\mathbb{Z}).$$

The maps $X \to X_j$ induce natural maps

$$[X_j, K(\mathbb{Z}, n)] \to [X, K(\mathbb{Z}, n)]$$

and these coalesce to form

$$\Phi : \varinjlim [X_j, K(\mathbb{Z}, n)] \to [X, K(\mathbb{Z}, n)].$$

Claim: the map Φ is a bijection. The key fact needed is the following result of Eilenberg-Steenrod ([8], p. 287, Theorem 11.9): if $X = \varprojlim X_j$ is compact, Y is a simplicial complex, and $f : X \to Y$, then up to homotopy f factors through one of the X_j. This implies immediately that Φ is onto. On the other hand, if $g : X_j \to Y$ and the composite $X \to X_j \to Y$ is null-homotopic then the null-homotopy factors through some $X_k \times [0,1]$ and hence $[g] = 0$. □

Bundles with Fibre $\mathcal{K}$

Recall that $\mathcal{K} = \mathcal{K}(\mathcal{H})$ denotes the algebra of compact operators on a separable Hilbert space $\mathcal{H}$. Let

$$\zeta : P\mathcal{U} \longrightarrow T \longrightarrow X$$

be a principal $P\mathcal{U}$-bundle with associated C^*-algebra A_ζ. All automorphisms of $\mathcal{K} = \mathcal{K}(\mathcal{H})$ are given by conjugation by unitary operators on the Hilbert space $\mathcal{H}$, so the group of unitaries $\mathcal{U}$ acts on $\mathcal{K}$ by the adjoint action. The center of the group is just S^1, and it acts trivially, of course, and so

$$\mathrm{Aut}(\mathcal{K}) \cong \mathcal{U}/S^1 = P\mathcal{U},$$

the infinite projective unitary group. Thus

$$[X, BP\mathcal{U}] \cong [X, K(\mathbb{Z}, 3)] \cong H^3(X;\mathbb{Z}).$$

We may regard maps $X \to BP\mathcal{U}$ as *projective vector bundles* in analogy with projective representations.

The resulting C^*-algebras A_ζ are *stable* in the sense that $A_\zeta \otimes \mathcal{K} \cong A_\zeta$.

Define the *Dixmier-Douady* invariant $\delta(A_\zeta)$ of the C^*-algebra A_ζ to be the homotopy class of a map

$$f : \hat{A} \to BP\mathcal{U} \cong K(\mathbb{Z}, 3)$$

that classifies the bundle $E \to X$.

We note that given A_ζ then its Dixmier-Douady invariant lies naturally in the group $H^3(\hat{A}_\zeta;\mathbb{Z})$. The identification of $\hat{A}_\zeta$ with X is only given mod the group of homeomorphisms of X, and hence the Dixmier-Douady invariant is only defined modulo the action of the homeomorphism group of X on $H^3(X;\mathbb{Z})$. Of course this action preserves the order of the element $\delta(A_\zeta)$.

So we have established the first parts of the following Dixmier-Douady result:

Theorem ([5], [23]). *Let X be a compact space. Then:*

(1) *There is a natural isomorphism*

$$\delta : [X, BP\mathcal{U}] \xrightarrow{\cong} \check{H}^3(X,\mathbb{Z}).$$

(2) *Suppose we are given a principal $P\mathcal{U}$-bundle ζ, associated fibre bundle $\mathbb{P}\zeta$, and associated C^*-algebra A_ζ. Then $\delta(A_\zeta) = 0$ if and only if $\mathbb{P}\zeta$ is equivalent to a trivial matrix bundle, and in that case*

$$A_\zeta \cong C(X) \otimes \mathcal{K}.$$

(3) *The Dixmier-Douady invariant is additive, in the sense that*

$$\delta(A_{\zeta_1 \otimes \zeta_2}) = \delta(A_{\zeta_1}) + \delta(A_{\zeta_2}).$$

(4) *The invariant respects conjugation:*

$$\delta(A_{\zeta^*}) = -\delta(A_\zeta).$$

(5) *Every element of $\check{H}^3(X;\mathbb{Z})$ may be realized as the Dixmier-Douady invariant of some infinite-dimensional bundle and associated C^*-algebra.*

Proof. Only (3) and (4) remain to be demonstrated. Part (3) comes down to an analysis of the commutative diagram

$$\begin{array}{ccc} BP\mathcal{U} \times BP\mathcal{U} & \xrightarrow{\simeq} & K(\mathbb{Z},3) \times K(\mathbb{Z},3) \\ \downarrow \otimes & & \downarrow \\ BP\mathcal{U} & \xrightarrow{\simeq} & K(\mathbb{Z},3) \end{array}$$

which deloops to

$$\begin{array}{ccc} P\mathcal{U} \times P\mathcal{U} & \xrightarrow{\simeq} & K(\mathbb{Z},2) \times K(\mathbb{Z},2) \\ \downarrow \otimes & & \downarrow m \\ P\mathcal{U} & \xrightarrow{\simeq} & K(\mathbb{Z},2). \end{array}$$

The map m is determined up to homotopy by its representative in

$$\check{H}^2(K(\mathbb{Z},2) \times K(\mathbb{Z},2);\mathbb{Z}) \cong \mathbb{Z} \oplus \mathbb{Z}$$

and this class is $(1,1)$ so that m is indeed the map inducing addition in $H^2(-;\mathbb{Z})$.

Part (4) is a similar argument, which we omit. □

This result may be viewed in a more bundle-theoretic manner. The fibration

$$S^1 \to \mathcal{U} \to P\mathcal{U}$$

induces an exact sequence

$$[X, K(\mathbb{Z},2)] \to [X, B\mathcal{U}] \xrightarrow{\epsilon} [X, BP\mathcal{U}] \xrightarrow{\delta} [X, K(\mathbb{Z},3)]$$

which, after identifications, becomes

$$Vect_1(X) \to Vect_\infty(X) \xrightarrow{\epsilon} PVect_\infty(X) \xrightarrow{\delta} \check{H}^3(X;\mathbb{Z})$$

where $Vect_k(X)$ denotes isomorphism classes of vector bundles over X of dimension k, $PVect_\infty(X)$ denotes isomorphism classes of projective vector bundles over X, and we have identified

$$[X, K(\mathbb{Z},2)] \cong \check{H}^2(X;\mathbb{Z}) \cong Vect_1(X)$$

using the first Chern class of the bundle.

The map ϵ takes an infinite-dimensional vector bundle $V \to X$ and associates to it the matrix bundle

$$\epsilon(V \to X) \;=\; End(V) \to X$$

where $End(V)_x = End(V_x)$, and so if $\delta(A_\zeta) = 0$ then the bundle $\mathbb{P}\zeta$ is isomorphic to a bundle of endomorphisms: $\mathbb{P}\zeta \cong End(V)$ as bundles. Then we use the fact that every vector bundle over X with infinite-dimensional fibres is trivial as a vector bundle (since $\mathcal{U}$ is contractible), and thus there are bundle isomorphisms

$$\mathbb{P}\zeta \cong End(V) \cong End(X \times \mathcal{H}) \cong X \times \mathcal{K}$$

so that

$$A_\zeta \cong C(X) \otimes \mathcal{K}$$

as C^*-algebras. In fact, recalling that $\mathcal{U}$ is contractible, $\mathcal{U} \simeq *$, we may extend the sequence above to read

$$[X, K(\mathbb{Z},2)] \to [X, *] \xrightarrow{\epsilon} [X, BP\mathcal{U}]$$
$$\xrightarrow{\delta} [X, K(\mathbb{Z},3)] \to [X, *]$$

and then deduce that δ is also onto.

Bundles with Fibre $M_n(\mathbb{C})$

The inclusion of S^1 as the center of U_n gives rise to a fibration sequence

$$S^1 \to U_n \to PU_n \to K(\mathbb{Z},2)$$
$$\to BU_n \to BPU_n \xrightarrow{\delta} K(\mathbb{Z},3).$$

For $n \geq 2$ the map $U_n \to PU_n$ induces an isomorphism on homotopy. Passing to classifying spaces, this yields

$$\pi_2(BPU_n) \cong \mathbb{Z}/n$$

as previously noted, and

$$\pi_j(BU_n) \cong \pi_j(BPU_n), \qquad j > 2.$$

The *Dixmier-Douady invariant* is defined to be the induced map

$$\delta : [X, BPU_n] \to [X, K(\mathbb{Z},3)] \cong \check{H}^3(X;\mathbb{Z}).$$

There is a long exact sequence

$$[X, K(\mathbb{Z},2)] \to [X, BU_n]$$
$$\xrightarrow{\epsilon} [X, BPU_n] \xrightarrow{\delta} [X, K(\mathbb{Z},3)]$$

which translates into

$$\check{H}^2(X;\mathbb{Z}) \to Vect_n(X) \xrightarrow{\epsilon} PVect_n(X) \xrightarrow{\delta} \check{H}^3(X;\mathbb{Z}).$$

The map ϵ is defined as follows. Given a complex vector bundle $V \to X$, then

$$\epsilon(V \to X) \;=\; \mathrm{End}(V) \to X$$

where $\mathrm{End}(V) \to X$ is the endomorphism bundle of V; the fibre over a point x is just $\mathrm{End}(V_x)$. This yields the third Dixmier-Douady result:

Proposition. *Suppose that X is compact. Let ζ be a principal PU_n-bundle over X with associated bundle $\mathbb{P}\zeta$ and C^*-algebra A_ζ. Suppose that $\delta(A_\zeta) = 0$. Then there is a complex vector bundle $V \to X$ of dimension n over X and a bundle isomorphism*

$$\begin{array}{ccc} \mathbb{P}\zeta & \xrightarrow{\cong} & \mathrm{End}(V) \\ \downarrow & & \downarrow \\ X & \xrightarrow{1} & X. \end{array}$$

Note that, in contrast to the infinite-dimensional case, endomorphism bundles need not be trivial bundles. There is one improvement possible, and we are indebted to Peter Gilkey for this explicit construction.

Corollary. *The vector bundle $V \to X$ in the Proposition may be taken to have trivial first Chern class, so that its structural bundle may be reduced to an SU_n-bundle.*

Proof. Suppose that $\mathbb{P}\zeta \cong \mathrm{End}(V)$ as in the Proposition. Let L be a complex line bundle over X with $c_1(L) = -c_1(V)$. Let $V' = V \otimes L$. Then using the fact that $L \otimes L^*$ is a trivial line bundle we have

$$\begin{aligned} \mathrm{End}(V') &\cong (V')^* \otimes V' \cong V \otimes V^* \otimes L \otimes L^* \\ &\cong V \otimes V^* \cong \mathrm{End}(V) \end{aligned}$$

so we may replace V by V' and obtain the same endomorphism bundle. □

Note that even though V and V' have isomorphic endomorphism bundles, in general they will not themselves be isomorphic. In fact, $End(V) \cong End(V')$ if and only if $V' \cong V \otimes L$ for some line bundle L.

We can refine this observation as follows. The diagram above expands to a natural commuting diagram (below)

The Dixmier-Douady map $\delta : BPU_n \to K(\mathbb{Z},3)$ factors as

$$BPU_n \xrightarrow{\gamma} K(\mathbb{Z}/n,2) \xrightarrow{\beta} K(\mathbb{Z},3).$$

The map β induces the Bockstein homomorphism

$$\beta : \check{H}^2(X;\mathbb{Z}/n) \to \check{H}^3(X;\mathbb{Z})$$

with

$$Ker(\beta) = Image[\check{H}^2(X;\mathbb{Z}) \longrightarrow \check{H}^2(X;\mathbb{Z}/n)]$$

and

$$Image(\beta) = \{x \in \check{H}^3(X;\mathbb{Z}) \;:\; nx = 0\}$$

whose image lies in the torsion subgroup of $\check{H}^3(X;\mathbb{Z})$.

Theorem. *Let X be a compact space and let $n \in \mathbb{N}$. Then:*

(1) *There is a natural exact sequence*

$$0 \to \check{H}^2(X;\mathbb{Z}) \xrightarrow{\sigma} Vect_n(X) \xrightarrow{\epsilon} [X, BPU_n] \xrightarrow{\delta} \check{H}^3(X;\mathbb{Z}).$$

(2) *Suppose we are given a principal PU_n-bundle ζ over a compact space X and associated C^*-algebra A_ζ. Then*
   (a) *If $\gamma(A_\zeta) \neq 0$ but $\delta(A_\zeta) = 0$ then $\gamma(A_\zeta)$ lifts to an integral class in $\check{H}^2(X;\mathbb{Z})$.*
   (b) *If $\gamma(A_\zeta) = 0$ then $\mathbb{P}\zeta \cong End(V)$ with $c_1(V) = 0$.*

(3) *The Dixmier-Douady invariant is additive, in the sense that*

$$\delta_{\zeta_1 \otimes \zeta_2} = \delta_{\zeta_1} + \delta_{\zeta_2}.$$

(4) *The invariant respects conjugation:*

$$\delta_{\zeta^*} = -\delta_\zeta.$$

(5) *For any M_n-bundle ζ, it is the case that $n\delta_\zeta = 0$.*

Proof. Most of this result has already been established. The map σ takes a class $c \in \check{H}^2(X;\mathbb{Z})$ and associates to it a vector bundle of the form $L \oplus \theta^{n-1}$ where L is a line bundle with first Chern class c and θ^{n-1} is a trivial bundle of dimension $n-1$. This map is one-to-one since it is split by the first Chern class map

$$c_1 : \mathrm{Vect}_n(X) \to \check{H}^2(X;\mathbb{Z}).$$

Parts (3) and (4) follow as in the infinite-dimensional case. □

The various maps $\alpha_{rs} : PU_r \to PU_{rs}$ induce maps on classifying spaces that by abuse of language are also denoted $\alpha_{rs} : BPU_r \to BPU_{rs}$. These maps

$$\begin{array}{ccccccccc} SU_n & \longrightarrow & PU_n & \longrightarrow & K(\mathbb{Z}/n,1) & \longrightarrow & BSU_n & \longrightarrow & BPU_n \xrightarrow{\gamma} K(\mathbb{Z}/n,2) \\ \downarrow & & \downarrow 1 & & \downarrow & & \downarrow & & \downarrow 1 \qquad \downarrow \beta \\ U_n & \longrightarrow & PU_n & \longrightarrow & K(\mathbb{Z},2) & \longrightarrow & BU_n & \xrightarrow{\epsilon} & BPU_n \xrightarrow{\delta} K(\mathbb{Z},3). \end{array}$$

form a directed system $\{BPU_r, \alpha_{rs}\}$. Write BPU_∞ for the colimit. Note that this is *not* the same as $BP\mathcal{U} = K(\mathbb{Z}, 3)$.

Proposition (Serre, [9], pp. 228–229).

(1) *The natural map*
$$\varinjlim \pi_j(BPU_n) \to \pi_j(BPU_\infty)$$
is an isomorphism.
(2) $\pi_2(BPU_\infty) \cong \mathbb{Q}/\mathbb{Z}$.
(3) If $j \geq 2$ *then* $\pi_{2j}(BPU_\infty) \cong \mathbb{Q}$.
(4) If $j \geq 2$ *then* $\pi_{2j-1}(BPU_\infty) = 0$.
(5) *There is a natural splitting*
$$BPU_\infty \simeq K(\mathbb{Q}/\mathbb{Z}, 2) \times F$$
with $\pi_j(F) = \mathbb{Q}$ for $j \geq 4$ *and even and* $\pi_j(F) = 0$ *otherwise.*

Proof. Each map $\alpha_{rs} : BPU_r \to BPU_{rs}$ is a cofibration and so (1) is immediate. We showed previously that $\pi_2(BPU_r) \cong \mathbb{Z}/r$. The map induced by α_{rs} takes the generator of $\pi_2(BPU_r)$ to s times the generator of $\pi_2(BPU_{rs})$ and so
$$\pi_2(BPU_\infty) = \varinjlim(\mathbb{Z}/r, \alpha_*) = \mathbb{Q}/\mathbb{Z}.$$
For $n >> j > 2$, $\pi_{2j}(BPU_n) \cong \pi_{2j}(BU_n) \cong \mathbb{Z}$ by Bott periodicity, and it follows easily that
$$\pi_{2j}(BPU_\infty) \cong \varinjlim(\pi_{2j}(BPU_n), \alpha_*) = \mathbb{Q}.$$
Similarly, in odd degrees homotopy groups vanish, and calculation yields the result. There results a fibration $BPU_\infty \to K(\mathbb{Q}/\mathbb{Z}, 2)$; call the fibre F. Then the homotopy of F is as stated, and as the base space has trivial rational cohomology this implies that the fibration is trivial. □

The various Dixmier-Douady maps
$$\delta : [X, BPU_n] \longrightarrow \check{H}^3(X; \mathbb{Z})$$
are coherent and hence pass to the limit to produce an induced Dixmier-Douady map
$$\delta^\infty : [X, BPU_\infty] \longrightarrow \check{H}^3(X; \mathbb{Z}).$$

It is obvious that δ^∞ takes values in the torsion subgroup of $\check{H}^3(X; \mathbb{Z})$. In fact, more is true:

Proposition. *Let X be a compact space. Then:*

(1) *The image of the map δ^∞ is the whole torsion subgroup of $\check{H}^3(X; \mathbb{Z})$.*
(2) *Let $x \in \check{H}^3(X; \mathbb{Z})$ be a torsion class. Then there is some finite n and some principal PU_n-bundle ζ over X such that $\delta(A_\zeta) = x$.*

Proof. The lattice of cyclic subgroups of $\mathbb{Q}/\mathbb{Z}$ induces an equivalence
$$\varinjlim K(\mathbb{Z}/n, 2) \longrightarrow K(\mathbb{Q}/\mathbb{Z}, 2).$$
Furthermore, the various Bockstein maps $K(\mathbb{Z}/n, 2) \longrightarrow K(\mathbb{Z}, 3)$ all factor as
$$K(\mathbb{Z}/n, 2) \longrightarrow K(\mathbb{Q}/\mathbb{Z}, 2) \xrightarrow{\tilde{\beta}} K(\mathbb{Z}, 3).$$
The exactness of the coefficient sequence
$$\check{H}^2(X; \mathbb{Q}/\mathbb{Z}) \xrightarrow{\tilde{\beta}} \check{H}^3(X; \mathbb{Z}) \longrightarrow \check{H}^3(X; \mathbb{Q})$$
implies that the image of $\tilde{\beta}$ is exactly the torsion subgroup of $\check{H}^3(X; \mathbb{Z})$. This shows (1).

For (2), let x be a torsion class. Then it is in the image of the Bockstein map
$$\tilde{\beta}' : \check{H}^2(X; \mathbb{Q}/\mathbb{Z}) \to \check{H}^3(X; \mathbb{Z})$$
and thus may be represented as $x = \tilde{\beta}(y)$ where $y \in [X, K(\mathbb{Q}/\mathbb{Z}, 2)]$. The map
$$[X, BPU_\infty] \longrightarrow [X, K(\mathbb{Q}/\mathbb{Z}, 2)]$$
is onto, and so the class y lifts to some class
$$z \in [X, BPU_\infty] \cong \varinjlim [X, BPU_n].$$
Choose some $\zeta \in [X, BPU_k]$ representing z. (Note that if x has order n then n divides k but in general $n \neq k$.) Then $\delta(A_\zeta) = x$ as required. □

Twisted K-theory

Twisted K-theory was first introduced by Donovan and Karoubi [7] for finite-dimensional bundles and then by Rosenberg [23] in the general case. In our context the point is to look at the $\mathbb{Z}/2$-graded group $K_*(A_\zeta)$. Let A_ζ denote a continuous trace algebra over X. Recall that K_0 is defined for any unital ring as the Grothendieck group of finitely projective modules. For our purposes a topological definition is cleaner and so we may simply define
$$K_j(A_\zeta) \cong \pi_{j+1}(U(A_\zeta \otimes \mathcal{K})), \qquad j \in \mathbb{Z}/2,$$
where in all cases we grade as $K_j = K^{-j}$ (and then note that by periodicity there are only two groups anyhow). If the bundle is infinite dimensional then it is not necessary to tensor with $\mathcal{K}$ since the algebra is already stable. These groups are denoted in the literature by (for instance)
$$K^*(X; \zeta) \text{ or } K^*(X; \delta(\zeta)) \text{ or } K^*_{\delta(\zeta)}(X) \text{ or } K^*_\Delta(X).$$
The point is that once one specifies X and $\Delta = \delta(\zeta) \in \check{H}^3(X; \mathbb{Z})$ then A_ζ is specified up to equivalence, and hence $K^*_\Delta(X)$ makes sense as notation for $K_j(A_\zeta)$. Here are the basic properties:

Proposition.

(1) Domain: *The groups $K^*_\Delta(X)$ are defined for locally compact spaces X and principal PU_n or $P\mathcal{U}$-bundles ζ over X with associated Dixmier-Douady class $\Delta = \delta(\zeta) \in H^3(X; \mathbb{Z})$.*
(2) Naturality: *Given (X, Δ) together with a continuous function $f : Y \to X$ then there is an induced map*
$$f^* : K^*_\Delta(X) \longrightarrow K^*_{f^*\Delta}(Y)$$
and twisted K-theory is natural with respect to these maps.
(3) Periodicity: *The groups $K^*_\Delta(X)$ are periodic of period 2.*
(4) Product: *There is a cup product operation*
$$K^*_{\Delta_1}(X) \times K^*_{\Delta_2}(X) \longrightarrow K^*_{\Delta_1+\Delta_2}(X).$$

(5) Relation to untwisted K-theory: *There is a natural isomorphism*

$$K_0^*(X) \cong K^*(X),$$

where if X is locally compact but not compact then K-theory with compact support is intended.

□

Karoubi notes that the cup product is not canonically defined at the level of cohomology classes. For instance, in the finite-dimensional case, one must choose representatives from among the various algebra bundles; i.e. choose Morita equivalences that are not canonical in general.

Rosenberg [22] points out the simplest case where twisted K-theory actually does something interesting. Take $X = S^3$. Then the Dixmier-Douady invariant takes values in $H^3(S^3;\mathbb{Z}) \cong \mathbb{Z}$ and hence is determined by an integer m. Rosenberg shows that

$$K_m^0(S^3) = 0, \qquad K_m^{-1}(S^3) = \mathbb{Z}/m.$$

He takes us further by introducing a twisted Atiyah-Hirzebruch spectral sequence (for X a finite complex) converging to $K_\Delta^*(X)$ and with

$$E_2^* = H^*(X; K_*(\mathbb{C})).$$

Just as with the classical Atiyah-Hirzebruch spectral sequence we have $d_2 = 0$. The differential d_3 is determined by the integral Steenrod operation $Sq^3_{\mathbb{Z}}$ (as is the case classically) and (the first mention of the twist) the class Δ:

$$d_3(x) = Sq^3_{\mathbb{Z}}(x) - \Delta x.$$

This spectral sequence is developed further by Atiyah and Segal [1], [2] who show, for instance, that the spectral sequence does not collapse after rationalization.

There are other ways to twist K-theory and to make it equivariant, to make it real (rather than complex) or both, and the reader should consult the papers of Atiyah and Segal [1], [2], Freed, Hopkins, and Teleman [11], and especially the fine survey paper of Karoubi [13] before burying oneself in the physics literature. That physics comes into the picture goes back to the observation of Witten that D-brane charges in type IIB string theory over a space M are elements of $K_\delta^0(M)$—see for instance [3], where the role of the Dixmier-Douady invariant in the classification of bundle gerbes is summarized along with a differential geometric model for twisted K-theory. See [10], [16], [17], [19] for further developments.

Rational Homotopy

For stable continuous trace algebras, the groups $\pi_*(UA_\zeta)$ are periodic of period 2 and in fact correspond to the twisted K-theory groups. However, if ζ is a principal PU_n-bundle where n is finite then the natural map

$$\pi_j(UA_\zeta) \to K_{j-1}(A_\zeta)$$

is neither injective nor surjective in general. Furthermore, K-theory obscures the geometric dimension of the space X, since $K^0(S^{2n})$ doesn't depend on n and hence cannot detect it. In this situation a more natural question is to calculate $\pi_*(UA_\zeta)$ itself. This is impossible even in very elementary cases (e.g., when $A = M_2(\mathbb{C})$). A more reasonable project is to calculate the rational homotopy groups

$$\pi_j(UA_\zeta) \otimes \mathbb{Q},$$

and this has been done in general for X compact by [15], [14]. The answer depends upon the individual groups $H^j(X;\mathbb{Q})$ and upon n. It turns out to be independent of the principal bundle. This is to be expected, at least after the fact, since the Dixmier-Douady invariant is finite when the bundle is finite dimensional and hence is trivial in the world of rational homotopy.

Generalizations

What if X is assumed to be a CW-complex or, more generally, a compactly generated space that is not necessarily compact? First, the definition of A_ζ does not lead to a C^*-algebra since infinite CW-complexes are not locally compact. These would be pro-C^*-algebras such as those studied by N. C. Phillips [20]. The good news is that some of the proofs in this note generalize. The bundle classification results require restriction to Dold's numerable bundles [6], [12]. These are bundles that are trivial with respect to a locally finite cover, and so one can assume, for instance, that X is paracompact. In the infinite-dimensional case the isomorphism

$$[X, BP\mathcal{U}] \cong [X, K(\mathbb{Z}, 3)]$$

is tautological, since $BP\mathcal{U} \simeq K(\mathbb{Z}, 3)$.

In the finite-dimensional situation we obtain maps

$$\mathrm{Vect}_n^{num}(X) \xrightarrow{\epsilon} [X, BPU_n] \xrightarrow{\delta} H^3_{\mathrm{sing}}(X;\mathbb{Z}),$$

where $\mathrm{Vect}_n^{num}(X)$ denotes isomorphism classes of numerable vector bundles, and the Dixmier-Douady results still hold when singular cohomology is understood throughout.

What if X is assumed to be locally compact but not necessarily compact? In that case the definition of A_ζ is modified to include only those sections that vanish at infinity, so that the sup norm is defined and then A_ζ is a C^*-algebra again. The Dixmier-Douady results still hold, but it is probably better in this setting to shift back to the

sheaf-theoretic setting of the original proofs, since the classification of vector bundles over locally compact spaces is somewhat awkward.

References

[1] M. Atiyah and G. Segal, Twisted K-theory, *Ukr. Mat. Visn.* **1** (2004), no. 3, 287–330; translation in *Ukr. Math. Bull.* **1** (2004), no. 3, 291–334

[2] ———, Twisted K-theory and cohomology, Inspired by S. S. Chern, 5–43, *Nankai Tracts Math.* **11** (2006), World Sci. Publ., Hackensack, NJ, 2006.

[3] P. Bouwknegt, A. L. Carey, V. Mathai, M. K. Murray, D. Stevenson, Twisted K-theory and K-theory of bundle gerbes, *Comm. Math. Phys.* **228** (2002), no. 1, 17–45.

[4] J. Cuntz, R. Meyer, and J. Rosenberg, *Topological and Bivariant K-Theory*, Oberwolfach Seminars, 36, Birkhäuser Verlag, Basel, 2007. xii+262 pp.

[5] J. Dixmier and D. Douady, Champs continus d'espaces Hilbertiens et de C^*-algébres, *Bull. Soc. Math. France* **91** (1963), 227–284.

[6] A. Dold, Partitions of unity in the theory of fibrations, *Ann. Math.* **78** (1963), 223–255.

[7] P. Donovan and M. Karoubi, Graded Brauer groups and K-theory with local coefficients, *Inst. Hautes Etudes Sci. Publ. Math.* **38** (1970), 5–25.

[8] S. Eilenberg and N. Steenrod, *Foundations of Algebraic Topology*, Princeton University Press, Princeton, 1952.

[9] *Correspondance Grothendieck-Serre.* (P. Colmez and J.-P. Serre, eds.), Documents Mathématiques (Paris), 2, Soc. Math. de France, Amer. Math. Soc. 2001.

[10] D. Freed and M. Hopkins, On Ramond-Ramond fields and K-theory, *J. High Energy Phys. 2000*, no. 5, Paper 44, 14 pp.

[11] D. Freed, M. Hopkins, and C. Teleman, Twisted equivariant K-theory with complex coefficients, *J. Topology* **1** (2008), no. 1, 16–44.

[12] D. Husemoller, *Fibre Bundles*, Graduate Texts in Math., 20, Second Edition, Springer-Verlag, New York, 1975.

[13] M. Karoubi, Twisted K-Theory, old and new, `http://arxiv.org/abs/math.KT/0701789v3` (to appear in *Proceedings: K-theory and noncommutative geometry*) (G. Cortias, J. Cuntz, M. Karoubi, R. Nest and C.A. Weibel, eds.), European Mathematical Society, Zurich, 2008.

[14] J. Klein, C. L. Schochet, and S. B. Smith, Continuous trace C^*-algebras, gauge groups and rationalization, arXiv:0811.0771v1 [math.AT].

[15] G. Lupton, N. C. Phillips, C. L. Schochet, S. B. Smith, Banach algebras and rational homotopy theory, *Trans. Amer. Math. Soc.* **361** (2009), 267–295.

[16] V. Mathai, R. B. Melrose, and I. M. Singer, Fractional analytic index, *J. Differential Geom.* **74** (2006), no. 2, 265–292.

[17] V. Mathai and J. Rosenberg, T-duality for torus bundles with H-fluxes via noncommutative topology, *Comm. Math. Phys.* **253** (2005), no. 3, 705–721.

[18] J. P. May, *A Concise Course in Algebraic Topology*, Chicago Lectures in Math., University of Chicago Press, Chicago, 1999.

[19] V. Nistor and E. Troitzky, An index for gauge-invariant operators and the Dixmier-Douady invariant, *Trans. Amer. Math. Soc.* **356** (2004), no. 1, 185–218.

[20] N. C. Phillips, C^∞ loop algebras and noncommutative Bott periodicity, *Trans. Amer. Math. Soc.* **325** (1991), no. 2, 631–659.

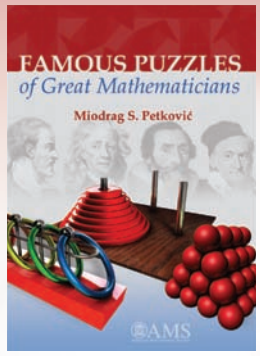
[21] I. Raeburn and D. Williams, *Morita Equivalence and Continuous Trace C^*-Algebras*, Math. Surveys and Monographs, Vol. 60, Amer. Math. Soc., 1998.

[22] J. Rosenberg, Homological invariants of extensions of C^*-algebras, *Operator algebras and applications, Part 1* (Kingston, Ont., 1980), pp. 35–75, Proc. Sympos. Pure Math., 38, Amer. Math. Soc., Providence, RI, 1982.

[23] ———, Continuous-trace algebras from the bundle-theoretic point of view, *J. Austral. Math. Soc. (Series A)* **47** (1989), 368–381.

[24] N. Steenrod, *The Topology of Fibre Bundles*, Princeton University Press, Princeton, 1951.

American Mathematical Society



Famous Puzzles of Great Mathematicians

Miodrag S. Petković, *University of Nis, Serbia*

This is the only collection in English of puzzles and challenging elementary mathematical problems posed, discussed and solved by great mathematicians. The book is intended to amuse and entertain while bringing the reader closer to the distinguished mathematicians through their works and some compelling personal stories. The selected problems simply require pencil and paper and a healthy amount of persistence.

2009; 324 pages; Softcover; ISBN: 978-0-8218-4814-2;
List US$36; AMS members US$29; Order code MBK/63

1-800-321-4AMS (4267), in the U. S. and Canada, or 1-401-455-4000 (worldwide); fax: 1-401-455-4046; email: cust-serv@ams.org.

American Mathematical Society, 201 Charles Street, Providence, RI 02904-2294 USA

For many more publications of interest, visit the AMS Bookstore
www.ams.org/bookstore

AMS
American Mathematical Society

WHAT IS . . .

the Parity Phenomenon?

John Friedlander and Henryk Iwaniec

Sometimes it almost seems as though there is a ghost in the House of Prime Numbers.

When you enter the front door of the house you come first to the Elementary Room. This is the oldest part of a structure which has been assembled piecemeal over a period of many centuries. In the Elementary Room lots of people just sit around counting prime numbers, and one of their favourite ways to do so is with sieve methods. This circle of ideas dates from the inclusion-exclusion principle of Eratosthenes. Perhaps it is revered simply because it is about as old as the house itself but, whatever the reason, people have been ignoring their failure to make things work as hoped and continue to push forward their efforts. Only with Brun, a little less than one hundred years ago, did one begin to have some movement toward success.

Recall that the sieve of Eratosthenes is applied by starting with your favourite sequence of integers, then casting out the multiples of each small prime, noting that some integers have been cast out more than once and then using inclusion-exclusion to rectify the count so that each unwanted number is cast out exactly once. One can describe the result of this both precisely and rather succinctly by using the Möbius function. However, the result is worthless for purposes of estimation because it expresses the number of primes in the sequence as a sum having a huge number of terms not so easy to add, and such that even an excellent approximation to the size of each individual term is not enough to give a useful approximation to the sum.

John Friedlander is University Professor of Mathematics at the University of Toronto. His email address is frdlndr@utsc.utoronto.ca.

Henryk Iwaniec is State of New Jersey Professor of Mathematics at Rutgers University. His email address is iwaniec@math.rutgers.edu.

Brun got the idea of replacing the Möbius function by another arithmetic function (the sieve weights) having somewhat similar properties but supported only on a finite set of integers so that he could truncate the sum at will and get a manageable error. It was too much to hope (indeed not possible) to do this in such a way that one could get an identity for the number of primes, as one did with the Möbius function, but it turned out that there were lots of ways to choose the sequence of sieve weights so that one got an upper bound (or, choosing differently, a lower bound) for the number of survivors of the sifting process.

During the next few decades the main emphasis in sieve theory was on the search for optimal weights, those that would make the upper bound as small as possible and others that would make the lower bound as large as possible. Because these weights are somewhat complicated, it is not easy to see at once whether or not a specific lower bound might turn out to be negative, in which case the bound is even worse than trivial. The upper bound weights do much better, at least in some sense. In practice, even an upper bound very far from the truth will at least give a result of the right order of magnitude. After the introduction of the Selberg sieve one could begin in some important problems to approach the optimal sieve weights.

There is a second aspect to the sieve problem. Just as in the original inclusion-exclusion procedure, the new sieve weights reduce the problem of counting primes to the problem of counting multiples of various integers d, those composed of the small primes. As one might expect, the larger you can take d, say all $d < D$, and still get useful estimates for the number of its multiples, the more successful will be the sieving procedure. The best one can do in this regard depends on the sequence of integers with which you began, and this largest value of D is called the level of

distribution of the sequence. There is a natural limitation to how large the level can be. To take a simple example, suppose you consider a segment of 409 consecutive integers and ask how many multiples of 666 it contains. The answer is either zero or one and depends on which segment of integers you started with. But the sieve wants to assume that the number of multiples is 409/666.

Once one is armed with optimal sieve weights and given a sequence with optimal level of distribution, one naturally asks:

1) How large is the upper bound one obtains for the number of primes?

2) Do we get a positive lower bound for the number of primes?

The answers are:

1) Just twice what one expects (from heuristic arguments based on randomness assumptions).

2) No, but we miss by the narrowest of margins.

To see that these two answers cannot be improved one may consider the counterexamples provided, in the first case, by the sequence of positive integers having an odd number of prime factors and, in the second case, by those with an even number of prime factors.

These observations are due to Selberg (around 1949), who named the phenomenon the "principle of parity" (the name came quite a bit later; see Vol. II, page 204 of his *Collected Papers*). It has also become known under the names "parity phenomenon" and "parity problem". Some twenty-five years afterward Bombieri [1] went much further along these lines. He showed that, given a "linear" sieve problem with optimal level of distribution, one could say that the contribution to the sequence, in a certain normalized sense, coming from the integers with r prime factors was the same for each odd r and was the same for each even r, and of course, though these two non-negative numbers could be quite different, they total twice the amount that was the expectation for each.

So, in retrospect, one sees now the upper bound and the lower bound are equally unsuccessful. The fact that the lower bound just misses barely crushes the hope of getting prime numbers directly from the sieve. But the fact that we only just miss improving the factor two in the upper bound is equally tantalizing and is related to a much larger story.

There is only time to touch the beginnings of that story, and for this we need to move next into the Analytic Room. The people who live in the Analytic Room also like to count prime numbers but they try to do this using properties of generating functions defined by Euler products and called L-functions. Since Euler is only three hundred years old some of the analytic people like to make fun of the old-fashioned methods used by the elementary people. It turns out that there are crucial facts about counting primes that are hidden in the location of the zeros of these functions. One tries to find regions of the complex plane where there are no such zeros, and an almost universal principle that guides the argument is that these guys are anti-social: the possible existence of two of them in close proximity is not so hard to disprove. The difficult case, which happens for real zeros of real character Dirichlet L-functions, occurs when a badly placed zero has no obvious companion nearby to help rule out its existence. It can be shown without too much effort that a slight improvement of the constant two in the sieve upper bound would disprove the possible existence of any such "exceptional" zeros. We know by the above counterexamples that this is too much to hope for. But what about other arguments? The Riemann Hypothesis would more than suffice. How about something we can actually prove?

There are many ways to try to attack this problem and all of them seem doomed to fail, an amazing number of them by the most narrow of margins. Spilling into the Algebraic Room, we look at the "exceptional" characters whose L-functions could conceivably possess such a bad zero. We nearly find "Selberg counterexamples" in this setting as well. Why does the ring of algebraic integers in the field $Q(\sqrt{-163})$ have unique factorization? Why does the corresponding character (Legendre symbol) look so darn much like the Möbius function? Why does the polynomial $x^2 - x + 41$ take prime values for $0 \le x \le 40$? Do these things ever happen again? No? Well, do they almost happen? Why can one just exactly prove, for a family of seemingly irrelevant L-functions, that at least 50 percent of their central values are positive, when almost all might be expected to, and when proving it for 51 percent would suffice to banish the bad guys? Could there be such zeros, such characters?

Sometimes it almost seems as though there is a ghost in the House of Prime Numbers. Perhaps that will be ruled out some day. There are suggestions of a youngster who might do this, one who will come from the Automorphic Room of the house. In the meanwhile, happy-go-lucky prime counters remain temporarily free, see [2], to base some fantastic theorems on either of the two assumptions (that exceptional characters exist or don't exist), whichever one their superstitions dictate.

Further Reading

[1] E. Bombieri, The asymptotic sieve, *Mem. Acad. Naz. dei XL* **1/2** (1975/76), 243–269.

[2] J. Friedlander and H. Iwaniec, The illusory sieve, *Int. J. Number Theory* **1** (2005), 459–494.

[3] H. Iwaniec, Conversations on the exceptional character, *Analytic Number Theory*, Cetraro, Italy, 2002 (A. Perelli and C. Viola, eds.), pp. 97–132, Lecture Notes in Math., 1891, Springer (Berlin), 2006.

Why Publish Mathematics?

Klaus Peters

This article is reprinted, with permission, from *Publikationsstrategien einer Disziplin: Mathematik in Kaiserreich und Weimarer Republik*, edited by Volker R. Remmert and Ute Schneider, (2008; Mainzer Studien zur Buchwissenschaft 19), Harrassowitz Verlag, Wiesbaden, Germany.

On June 16, 1964, I had a conversation with Karl Stein (1913–2000), the renowned mathematician whose name became synonymous with holomorphically complete complex manifolds and complex spaces that have been known as Stein manifolds and Stein spaces since the 1950s. I remember the date and occasion so precisely because it occurred at a crucial moment in my professional life and at a very special place—the apartment of Friedrich and Inge Hirzebruch in Bonn during the traditional party for the participants of the famous *Arbeistagung*. I had just decided to take a leave of absence from the University of Erlangen to explore the possibility of becoming the editor for the mathematics program at Springer Verlag. Stein had heard about it and tried to persuade me to give up that crazy idea. "Didn't I understand the unmatchable pleasure of sitting in front of a blank sheet of paper for weeks and even months until suddenly you are struck by an inspiration that will yield a breakthrough in a mathematical problem? How could I give that up?" The conversation was brief as I had already accepted the invitation from Springer, but I remember the part of my response where I explained that I could do more for mathematics by representing the profession inside a publishing company than by the small chance that *I* would prove a theorem that would change mathematical history. I added that, in a few years, I hoped to prove that statement in a way that he, Karl Stein, would appreciate and acknowledge. Jumping ahead to 1969, I am very happy to report that Stein approached me with the suggestion to start a new journal that would allow young people to publish their first paper in a peer-reviewed journal without the often formidable hurdles set up by the established publications; he agreed to be the first chief editor, and *Manuscripta Mathematica* was born. I admit that I reminded him with pleasure of our earlier conversation.

This little story contains an answer to the question posed to me by the editors of this volume. At first I was worried that the question was too broad and the answer too obvious, because every human endeavor that can be communicated in words needs to be and has been published since the invention of script. For mathematics, as for many other intellectual achievements, it is vital that these achievements will be shared and archived. For me the question has a much more personal aspect that leads to an answer to the more specific question: *Why and how to publish mathematics?*

As a publisher of scientific literature, I have observed that the field where publications have above-average longevity is mathematics. Mathematicians, particularly the creative leaders in the field, will confirm the power of inspiration gained by studying classical or sometimes obscure papers that were published a long time ago. This is one reason why the archival character of publishing is so important to mathematics and why the effort to preserve published works and keep them accessible deserves attention and financial support. It goes beyond the scope of this discussion, but let me mention that the new technologies of the digital era offer such opportunities if used with care and some caution. The digitization of published material (respecting copyright restriction but also

Klaus Peters is publisher at A K Peters, Ltd. His email address is klaus@akpeters.com.

allowing generous inexpensive access by copyright holders) will be of tremendous benefit to the scientific community and to our ecology (for more information on this subject, see [1]).

When Karl Stein questioned me in 1964, he did not ask why anyone should publish mathematics; rather his question implied why a mathematician should be actively involved within a publishing company. I believe my response will go beyond the personal and will explain some of the important aspects that a publisher should consider when dealing with mathematical subjects.

The program of a scientific publishing company was mostly directed from the outside through scientific advisors who were hired by the publisher to develop the focus of the program and act as a bridge to the scientific community. That was entirely the case at Springer Verlag until 1964, when the main consultant for the mathematical program, Friedrich Karl Schmidt (1901–1977) in Heidelberg, resigned for health reasons. The business of publishing has been a very personal one as indicated by the fact that most publishing houses carry the names of their founders: Wiley, Springer, Teubner, McGraw-Hill, W. H. Freeman. However, these founders were not scientists or writers but businessmen with an interest in the dissemination of knowledge.

They had a keen sense and sensibility for subjects that were in need of outlets to communicate ideas and results. They turned to the leading representatives of fields of intellectual endeavor and solicited their advice. When F. K. Schmidt resigned, Springer realized that the times had changed and that it was no longer possible to find established scientists to run a publishing program "on the side". Not only was the growing specialization and competition among scientists an obstacle to a generalist approach, the competition among publishers, the beginning globalization, and the need to integrate editorial judgment in acquiring good manuscripts with the efficient presentation of the published products (books as well as journals) to the market required a new approach. Heinz Götze and Konrad Springer, the publishers at Springer, understood this challenge and looked for a mathematician who was willing to learn about the economic and marketing side of the business. I had the privilege to be offered that position and appreciate now, with hindsight, the unique opportunity to be the bridge between two *modus operandi*. With the support from the scientific community—my mentor Reinhold Remmert in Germany and Richard Courant[1] in the U.S. opened a world of contacts—I was able to represent the interests of mathematicians and create a viable program at the same time.

This experience forms the basis for my thesis that mathematicians, and scientists from other fields for that matter, should consider a career in publishing. Many have since then, and I believe the quality of scientific/technical publishing has benefited from their service.

As to the *how*, I would like to outline a few principles and explain in some detail the challenges posed by the ever-changing environment (*cultural, economic, technological*).

Within the mathematical *culture* I see two seemingly conflicting trends: on the one hand there is an undeniable move towards specialization, particularly on the level of solid but not necessarily spectacular research; on the other hand, great mathematical breakthroughs as they have occurred in the past decades are the result of the creative fusion of different areas of mathematics. The first trend is the result of the *publish or perish* climate that forces researchers to specialize in order to be able to produce an acceptable output. The second trend is based on the appreciation and understanding that the great outstanding problems require an interdisciplinary approach and the mastery of a broad range of techniques. Understanding these trends and the cultural climate is important for a publisher who wants to create material that is useful to both approaches. This is where the classic approach involving advisors who are respected leaders in the field *and* committed to the dissemination of knowledge is very important. An editor who has a broad knowledge of the science and of the rigor of scientific work is able to facilitate and benefit from the work of such advisors. He speaks their language and can evaluate variant opinions.

The *economic* model of a scientific/technical/medical (STM) publisher plays a major role in its relationship with and impact on the scientific community. The major factors are pricing and distribution. Observing the publishing landscape from the point of view of the scientific community, one is struck by the enormous difference in pricing between journals and books at the large conglomerates and at the smaller houses. A closer look reveals that prices at large publishing houses are often higher by a factor of 2 to 3. An even more detailed analysis shows that the higher pricing is directly related to smaller unit sales. The "chicken and egg" question comes to mind, and we believe that the answer lies in the economic model on which that publishing philosophy is based. Selling fewer copies at higher prices yields a higher profit margin, keeps warehousing costs down, and generally requires less marketing effort and expense; the larger house can rely on its core market—the libraries—all the while ignoring the crucial matter of expanding marginal sales. If one thinks of a publisher as an entity with an obligation to

[1] *Richard Courant had been instrumental in building the mathematics program at Springer in the 1920s when he was the head of the Mathematical Institute at the University of Göttingen. He was the director of the Courant Institute for the Mathematical Sciences at New York University when I met him.*

publicize and, therefore, to maximize the distribution of the ideas contained in its publications, such a publishing strategy certainly conflicts with the latter goal. This pattern has not gone unnoticed among scientists, and a growing and quite vocal group is raising questions. Publishers, I believe, have an obligation to maximize the distribution of the works they have been entrusted to publish. It also makes business sense because the best authors will support those publishers that guarantee or at least strive for maximum unit sales and hence the widest possible dissemination of authors' intellectual work.

The *technological* environment of publishing has changed and continues to change dramatically. I will list and briefly comment on two aspects:

1. Production: In my lifetime as a publisher two major innovations affected the production process.

a) Offset printing gained wide acceptance and led to major changes. Let me only mention the introduction of "Lecture Notes" (in Mathematics) and later in many other fields in the early 1960s. The quick publication of camera-ready manuscripts was made possible by the improved and more widely used offset printing technology, and it led to a revolution in speed and pricing of publishing research monographs. The facility of the new technology carried the danger of proliferation, and it required the watchful eye of an editor to negotiate the conflicting currents of profitability, usefulness, and quality.

b) A new method of typesetting, TEX, was developed, and it conquered the scientific community and soon the publishing industry by storm. This program allows authors to prepare manuscripts in a form that resembles classical typesetting and seemingly eliminates a whole step in the production process. The benefits are enormous, and, if used appropriately, TEX saves time and money to a degree that has probably not been fully studied and appreciated. However, as with offset printing, the use of TEX has encouraged a trend towards acceptance of manuscripts in a form that resembles finished products and seems to allow bypassing the editing and designing process that is essential for good book making. The uncritical analysis of the consequences of such technological innovations has led to misunderstandings that affect the valuation of the role of publishers. I will get back to this in my comments on electronic publishing.

2. Electronic publishing: I believe that we are in the infancy of this new format, but I want to offer some comments that fit into the framework of this paper (on this topic see [1] and [2]). While electronic publishing, i.e., access to the written word through electronic media, such as E-books, the World Wide Web, CDs/DVDs, etc., offers obvious advantages, in particular for journals and reference works, providing quick access at different locations and fast search facilities, the well-designed book offers other forms of convenience that make it still the medium of choice for many. As technology advances, as-yet unknown options will narrow the gap, but I believe that two elements of good book making, (a) thorough editing for organization, content, and style, and (b) formatting and design for easy reading, will be important. Unfortunately these two aspects are often overlooked or taken for granted, and their cost is not considered in the debate about pricing and propriety of electronic access publications. I close by presenting some thoughts of mine that were quoted in a web posting by the mathematician Alf van der Poorten [3]:

> However, I am much more concerned with the often-encountered misconception that the cost of books is largely a function of the bad old days, now past, when books "were rather expensive to produce and distribute." Not! At any rate, certainly not quite! A substantial portion of the cost in producing books arises from the editorial process of critical evaluation. While this is often done with invaluable help from the scientific community, it still requires substantial work from highly qualified in-house editors. Subsequently, there is developmental and copy editing, again, performed by experienced, well-educated, and well-paid specialists. That such effort is appreciated shows in the following quotes: "I am indebted to N. N. whose judicious and thoughtful editing of the manuscript greatly improved its readability" and "I would like to especially thank [the publishers] for encouraging me to write the first edition of this book, for their great skill in bringing a book to fruition and for their dedication to making their books the best they can be. In addition to finding many errors in formulas and language in the second edition, they put in many weeks of extremely long hours in the home stretch of the process." Further, books need to be designed to optimize their readability. This includes the treatment of illustrations and producing a reader-friendly layout. While I believe that everybody has the right to place books (and, for that matter, articles) on the Internet, I am concerned that the elimination of valuable filters (editorial) and value-added features (design and production) will erode the quality of available material (both for teaching and research). The argument that everybody is free to choose from the material made available is not con-

vincing considering the many criteria going into the selection of teaching material. As a publisher, I have argued with instructors who suggested reprinting outdated editions instead of using substantially revised editions that were longer and slightly higher priced.

The role of publishers has changed over the centuries, from medieval scribes to entrepreneurial owners of printing equipment to content-driven scientific societies and marketing-savvy distributors. The word for *publisher* (*éditeur, Verlag, Uitgever*) in different languages emphasizes these different roles, and, speaking as a scientific/technical publisher, I believe that all of these functions have to be balanced to allow the publisher to be a true servant of the scientific community.

With the growing sophistication of Information Technology, this balance will change, and at this point, we are rapidly moving toward electronic forms of distribution. I would like to caution everybody involved in this discussion to keep all functions of a publisher in mind lest we destroy the publishing enterprise as a whole. The most endangered because least visible part, in my mind, is the editorial function in which publishers and the scientific community work well together to ensure the quality and usefulness of the material being published.

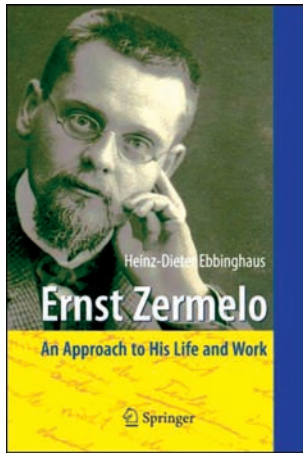
References

[1] Walter Kaufmann-Bühler, Alice Peters, and Klaus Peters, Mathematicians love books, in *Mathematics Tomorrow*, (Lynn Steen, ed.), Springer, New York, 1981, pp. 221–226.

[2] Jonathan Borwein, Eugénio A. M. Rocha, and José Francisco Rodrigues, editors, *Communicating Mathematics in the Digital Era*, A K Peters, Wellesley, MA, 2008.

[3] IMU on the Web: Communications and Information from the CEIC, `http://www.ceic.math.ca/News/IMUonWeb.shtml#CEIC19`, (February 25, 2008).

Ernst Zermelo: An Approach to His Life and Work



Reviewed by Gregory H. Moore

Ernst Zermelo: An Approach to His Life and Work
Heinz-Dieter Ebbinghaus in cooperation with Volker Peckhaus
Springer, Berlin, 2007
US$64.95, xiv + 356 pages
ISBN-13: 978-3-540-49551-2

Ernst Zermelo is familiar to mathematicians as the creator of the controversial Axiom of Choice in 1904 and the theorem, based on the Axiom of Choice, that every set can be well ordered. Many will be aware that in 1908 he axiomatized set theory—in a form later modified by Abraham Fraenkel (1922) and then by Zermelo himself (1930). Some will know of Zermelo's conflict with Ludwig Boltzmann over the Poincaré Recurrence Theorem and its role in understanding the Second Law of Thermodynamics.

Fewer will know of the following: Zermelo's work in the calculus of variations at the start of his career; his pioneering work in game theory before that of Emile Borel and John von Neumann; his conflict with Thoralf Skolem over whether axiomatic set theory should be formulated in first-order or second-order logic (and the resulting conflict over the Löwenheim–Skolem Theorem and the existence of a countable model of set theory); his contributions to infinitary logic; or finally his conflict with Gödel over the latter's Incompleteness Theorems and Zermelo's attempts to circumvent them.

The book under review is the first full-length biography of Zermelo. It is based on a great deal of archival research, on the cooperation of Zermelo's widow Gertrud (who outlived him by half a century), and on work by earlier historians of mathematics, including the reviewer. The best parts of the book are the previously unpublished letters. Yet relatively few of them from Zermelo appear in the book, even when they were available, such as his letters to Hilbert. Thanks largely to his widow, this book contains more photographs of Zermelo than any other source.

The biography begins with Zermelo's ancestors, then turns to his youth spent in Berlin, where his father died shortly before Zermelo finished high school and where Zermelo already experienced the poor health that would plague him through much of his life. Next the book discusses his university studies, which focused on mathematics, physics, and philosophy (a combination that was later shared by Paul Bernays and Kurt Gödel). Like many German students of the time, he studied at several universities—in his case Berlin, Freiburg, and Halle. At Halle he attended lectures by Georg Cantor on elliptic functions and number theory, but Cantor's work had no particular influence on him at the time. His interest in set theory was stimulated later, circa 1900, by David Hilbert.

Zermelo's 1894 doctoral dissertation under H. A. Schwarz was on the calculus of variations. Schwarz, who had been Weierstrass's student at Berlin, succeeded him there in 1892, and Zermelo was Schwarz's first doctoral student. After his dissertation, Zermelo worked for three years as assistant to Max Planck at the Berlin Institute for Theoretical Physics. It was during this period that Zermelo's polemical dispute with Boltzmann over the Second Law of Thermodynamics occurred.

In 1897 Zermelo wrote to Felix Klein at Göttingen, expressing the wish to come there to prepare a *Habilitation* in theoretical physics or mechanics. Although Klein's reply is not extant, apparently he encouraged Zermelo, for Zermelo

Gregory H. Moore is professor of mathematics and statistics at McMaster University. His email address is ghmoore@mcmaster.ca.

came, and his 1899 *Habilitationsschrift* at Göttingen was in theoretical hydrodynamics. (In the German academic system a *Habilitationsschrift*, which was like a second doctoral dissertation, was required before one was allowed to give a lecture course at a university.) At Göttingen, Zermelo then returned to researching the calculus of variations, on which he had many conversations with Constantin Carathéodory, who became a lifelong friend. In fact, they undertook a joint book on the calculus of variations, which, as Hermann Minkowski wrote to Wilhelm Wien in 1906, "promises to become the best in this field" (p. 33). Unfortunately the book was never finished.

One of the finest parts of the biography concerns Hilbert's repeated attempts to help Zermelo's career. In 1901 Zermelo, who as a *Privatdozent* (lecturer) at Göttingen had to subsist solely on fees from students attending his lectures, applied for a grant intended to help such young lecturers. His application was supported by Hilbert, who wrote:

> Dr. Zermelo is a gifted scholar with a sharp judgment and a quick intellectual grasp. He shows a lively interest and open understanding of the questions of our [mathematical] science and, moreover, has comprehensive theoretical knowledge in the domain of mathematical physics. I am in continual scientific exchange with him. (p. 34)

Thanks to Hilbert's support, Zermelo's application was successful.

Unfortunately, Hilbert's support did not get Zermelo a position in 1903 at the University of Breslau. That university asked Hilbert to rate candidates for the position there (among whom Zermelo was not listed). Hilbert replied to Breslau in May 1903 by rating them, and then added:

> Now, concerning further names, I immediately start with the one whom I consider the real candidate for the Breslau Faculty, namely Zermelo.
>
> Zermelo is a modern mathematician who combines versatility with depth in a rare way. He is an expert in the calculus of variations…. I regard the calculus of variations as a branch of mathematics which will belong to the most important ones in the future….
>
> You must not presume that I intend to praise Zermelo into leaving [Göttingen]. Before Minkowski came here and before Blumenthal matured, Zermelo was my main mathematical company. I have learned a lot from him, e.g., the Weierstrassian calculus of variations, and so I would miss him here most of all. (pp. 35–36)

Zermelo, as he wrote three decades later (in a passage first published in 1980 by the reviewer), was much influenced by Hilbert in starting to do research on set theory:

> Thirty years ago, when I was a *Privatdozent* in Göttingen, I began, under the influence of D. Hilbert, to whom I owe more than anyone else for my scientific development, to concern myself with questions about the foundations of mathematics, especially with the fundamental problems of Cantorian *set theory*, which only came to my full consciousness in the productive cooperation among Göttingen mathematicians. (p. 28)

Since 1981 it has been known that Zermelo discovered Russell's Paradox before Bertrand Russell did and that Zermelo's version of the paradox was discussed by mathematicians at Göttingen, including Hilbert, before Russell published his paradox in 1903.

But Zermelo's first immortal and yet controversial achievement in set theory was his proof, in a letter to Hilbert of September 1904, that every set can be well ordered. A month earlier, at the International Congress of Mathematicians in Heidelberg, Julius König had given a lecture purporting to disprove Cantor's Continuum Hypothesis and to show that the set of all real numbers cannot be well ordered. König's argument relied essentially on a "theorem" in Felix Bernstein's doctoral dissertation. Cantor, Hilbert, and Schoenflies contributed to the official discussion following the lecture.

What happened next has been the subject of dispute. Ebbinghaus tends to rely on the dubious account of Gerhard Kowalewski, written almost a half-century after the event. The reviewer published a letter from Felix Hausdorff to Hilbert of September 24, 1904, in Leipzig, where Hausdorff had checked in the library soon after his return home: "After the Continuum Problem had plagued me at Wengen almost like a monomania, naturally I looked first here at Bernstein's dissertation" [[6], 108]. Hausdorff informed Hilbert that the error lay where it had been suspected—in Bernstein's argument that if κ is an infinite cardinal with $\kappa < \lambda$ and if B is a set with cardinality λ, then *every* subset A of B (where A has cardinality κ) lies in an initial segment of λ. This is false when κ is $\aleph_0$ and λ is $\aleph_\omega$—precisely the case that König needed for his argument. The seminal concept hidden here, and waiting for Hausdorff to discover it, was cofinality.

Kowalewski [[4], 202] had claimed that Zermelo found the error the day after König's talk. Grattan-Guinness [[3], 334] asserted that Zermelo had not found the error. Ebbinghaus (p. 52) discovered a letter of October 27, 1904, from Zermelo to Max Dehn, which showed that Zermelo was one of those to suspect the error lay in Bernstein's "theorem", but was able to verify this only when, after the holidays, he returned to Göttingen and could visit the library. Consequently, Grattan-Guinness was mistaken. However, the clearest light on what happened is shed by a letter (not mentioned by Ebbinghaus) from Otto Blumenthal to Emile Borel on December 1, 1904. Blumenthal informed Borel that König himself was the first to realize that his proof was not valid, followed (independently of each other) by Cantor, Bernstein, and Zermelo [[1], 74].

In 1907 Zermelo had been teaching as a *Privatdozent* at Göttingen for eight years, and his grant for doing so was finished. He either had to find a salaried position somewhere or abandon academic life altogether. So Hilbert turned to the Ministry of Cultural Affairs in Berlin (responsible for all universities in Germany) and made a case for establishing a lectureship in mathematical logic at Göttingen and for Zermelo to hold this lectureship. Hilbert persuaded Friedrich Althoff, the all-powerful director of the First Educational Department at the ministry, to establish this lectureship—the first in mathematical logic in Germany or, to the best of my knowledge, anywhere else. However, lecture courses in mathematical logic had previously been given in Germany by Ernst Schröder and Gottlob Frege, and in England by Russell.

Zermelo held his first course in mathematical logic in 1908, but almost all that we know of this course comes from lecture notes taken by Kurt Grelling. Zermelo's own notes for the course were in Gabelsberger, a form of shorthand that Bernays and Gödel also used frequently. Almost no one knows Gabelsberger now, since it was superseded in Germany by a different form of shorthand. Further, Ebbinghaus does not inform the reader that Zermelo's lecture notes are in Gabelsberger and hence inaccessible even to Germans. By contrast, the Gödel Editorial Project trained someone in Gabelsberger in order to transcribe unpublished manuscripts by Gödel into German. Unfortunately, the manuscripts of Zermelo and of Bernays have not been transcribed.

Early in 1905 Zermelo fell seriously ill with an inflammation of the lungs, and had to abandon his teaching for several months. A year later, he again had an illness in his lungs, finally diagnosed as tuberculosis. Once again, he had to stop teaching. In 1906 Minkowski, who was asked to recommend candidates for a position at the University of Würzburg, gave a strong recommendation to Zermelo, whom he described as "a mathematician of the highest qualities, of the broadest knowledge, of quick and penetrating grasp, of rare critical gift" (p. 106). But Minkowski also commented on his personality:

> Above all, his conspicuous lack of good luck stems from his outer appearance, his nervous haste which shows in his speaking and conduct. Only very recently it is giving way to a more calm, serene nature. Because of the clarity of his intellect he is a first-class teacher for the more sophisticated students, for whom it is important to penetrate the depths of science. They, like all the younger lecturers here with whom he is a close friend, appreciate him extraordinarily. However, he is not a teacher for beginners…. (p. 107)

Zermelo did not obtain the professorship at Würzburg in 1906, nor again in 1909. In 1910, when Bernstein was being considered at Göttingen for an extraordinary professorship in actuarial mathematics, the mathematics department urged the Minister to offer an extraordinary professorship there to Zermelo as well. In the end it was not offered because of news from Switzerland—in 1910 Zermelo obtained a full professorship at the University of Zurich. At that time, Zermelo's friend Erhard Schmidt was still professor at Zurich and was on the committee to select his replacement. Schmidt vigorously supported Zermelo's application, which included a very strong recommendation from Hilbert.

Zermelo held this professorship at Zurich only until 1916. It was ended at the request of the university because of his tuberculosis. He had undergone surgery for the disease and had missed several terms of teaching due to ill health. However Fraenkel, who began working on axiomatic set theory around 1919 and whose relations with Zermelo were strained, published in his autobiography a claim that Zermelo lost his professorship because, when a guest at a hotel in Germany he wrote under his nationality "Thank God, not Swiss!", a comment unfortunately read in the hotel register by the head of Zurich's education department. Ebbinghaus made thorough use of documents from Zermelo's official file at the University of Zurich to show that his illness, by making him unable to teach for several semesters, was the reason for his involuntary retirement. He was given a generous pension.

In 1921 Zermelo left Switzerland permanently and settled at Freiburg in Germany, where he remained until his death in 1953. In Freiburg

Zermelo became friends with Reinhold Baer and Arnold Scholz (both algebraists), who were successively assistants there. In 1926 the two professors of mathematics at Freiburg, Lothar Heffter and Alfred Loewy, applied to the Ministry of Education to make Zermelo a full honorary professor. This permitted Zermelo to teach (which he did for seven years without salary). During this period his mathematical research and publications resumed, both in the foundations of mathematics and in applied mathematics. Then, early in 1935, he was dismissed from his position because he refused to give the Hitler salute. In 1946 he wrote to the rector of the university, asking to be rehabilitated: "As an *honorary professor* I gave regular lectures in pure and applied mathematics for a number of years until I was forced under the Hitler government by political intrigues to give up this activity. Circumstances having now changed,…I therefore request the University…to look favorably on my reappointment as an honorary professor" (p. 251). His request was granted.

Even after his dismissal, Zermelo maintained some scientific contacts. In 1941 Scholz organized a colloquium at Göttingen for Zermelo's seventieth birthday, and among the speakers was Bartel van der Waerden. Zermelo gave three talks at the colloquium, all on applied mathematics.

As the review has mentioned, this biography has many positive features. However, there are certain matters where a more critical approach is necessary. We leave to one side various minor errors, due to its author writing in English, which is not his mother tongue: "inconstructive character of the axiom of choice" (p. vii) rather than "nonconstructive character", "*n*th derivation" (p. 12) for "*n*th derivative", etc. Nor do we wish to emphasize his misleading claim (p. 40) that Frege took a logicist position on the foundations of geometry, i.e., that geometrical objects are built on the basis of logic alone (p. 40). This was not Frege's view at all, since he was very much a traditionalist in regard to geometry (unlike his treatment of the real numbers, where he was a logicist). Likewise, we pass over Ebbinghaus's failure (pp. 136–8), when discussing at length the Axiom of Replacement and its invention by Fraenkel and Skolem, to point out that this axiom had actually been published years before them by Dmitri Mirimanoff in 1917 [[5], 262].

But on one matter Ebbinghaus leaves a serious misimpression that must be corrected: namely Zermelo's 1929 dispute with Skolem on the foundations of set theory and the role of first-order (or second-order) logic in set theory. Ebbinghaus implies that Skolem was right, and Zermelo wrong (and wrongheaded), in this dispute, since first-order logic (with its Completeness Theorem) is now the dominant form of mathematical logic. Yet that Completeness Theorem (every valid first-order sentence is provable) was published only after this dispute. Even now, many mathematicians do not understand what is meant by "first-order logic" and, consequently, the import of the Löwenheim-Skolem Theorem and the Compactness Theorem for this logic. Because the chief question at issue between Zermelo and Skolem was the latter's formulation of set theory within first-order logic, we must be clear (as almost all those at the time were not) about what was involved: the difference between first-order and second-order logic.

The essential difference between these two logics (relative to axiomatizing set theory) is in how to interpret a quantifier ranging over the subsets of a given set within a given model A. In second-order logic, the expression "for every subset of a given set x" is interpreted in the way natural to mathematicians who are not logicians, i.e., that expression means what it says: "every subset" means "every subset", whether or not a given subset happens to be in A. But in first-order logic, "for every subset of a given set x" in a model A means only those subsets of x that are members of A. Thus, within second-order logic, "the set S of all subsets of $\mathbb{N}$", where $\mathbb{N}$ is the set of all natural numbers, is uncountable, whether looked at from inside a model A or from outside A. By contrast, in first-order logic, "the set S of all subsets of $\mathbb{N}$" can be uncountable if looked at from inside the model A but countable if looked at from outside the model A. From outside, the apparent uncountability of S is seen to be an artifact caused by the lack of a certain bijection inside A, a bijection between S and $\mathbb{N}$ that is present outside A. This is the so-called "Skolem paradox", which was precisely the point at issue between Zermelo and Skolem.

The extremely limited expressive power of first-order logic can be made clearer as follows: First-order logic does not permit a theory of finite groups. That is, there is no first-order axiomatization whose models are all and only the finite groups. This is not accidental but essential since, by the Compactness Theorem, any collection of first-order sentences that has arbitrarily large finite models also has an infinite model. In this sense, the models of first-order logic cannot distinguish the finite from the infinite. Nor can first-order logic distinguish between different infinite cardinalities; for any first-order theory that has countably many primitive symbols (and these were the only first-order theories considered before 1936), if the theory has an infinite model, then it has a model of *every* infinite cardinality. The Löwenheim-Skolem Theorem is the special case that if a first-order theory has an infinite model, it has a model in the set of natural numbers. Thus, in first-order logic, the "set" of all real numbers has a model that is a subset of the natural numbers, and the set of all natural numbers also has uncountable models.

Moreover, the set of all first-order sentences true of the natural numbers has a countable model that is not isomorphic with the set of all natural numbers. All of these aspects of first-order logic are common knowledge to logicians, although usually unfamiliar to mathematicians who are not logicians.

Given all of the above, why would logicians formulate set theory within first-order logic? (The dominance of first-order logic only began in the 1950s when Alfred Tarski developed model theory.) In December 1938 at a conference in Zurich on the foundations of mathematics—a conference to which Zermelo regretted not being invited—Skolem returned again to the existence of countable models for set theory and to the Skolem paradox [[2], 37]. On this occasion he chose to emphasize the relativism, not only of set theory, but of mathematics as a whole. The discussion that followed Skolem's lecture revealed both interest in and ambivalence about the Löwenheim-Skolem Theorem. Bernays commented at length on this matter:

> The axiomatic restriction of the notion of set [to first-order logic] does not prevent one from obtaining all the usual theorems…of Cantorian set theory…. Nevertheless,…this way of making the notion of set (or that of predicate) precise has a consequence of another kind: the interpretation of the system is no longer necessarily unique…. It is to be observed that the impossibility of characterizing the finite with respect to the infinite comes from the restrictiveness of the [first-order] formalism. The impossibility of characterizing the countable with respect to the uncountable in a sense that is in some way unconditional—does this reveal, one might wonder, a certain inadequacy of the method under discussion here [first-order logic] for making axiomatizations precise? [Bernays in [2], 49–50]

Skolem objected vigorously to Bernays' suggestion and insisted that a first-order axiomatization is surely the most appropriate.

In 1958, at a colloquium held in Paris, Skolem reiterated his views on the relativism of fundamental mathematical notions and criticized Tarski's contributions:

> It is self-evident that the dubious character of the notion of set renders other notions dubious as well. For example, the semantic definition of mathematical truth proposed by A. Tarski and other logicians presupposes the general notion of set. [Skolem in [7], 13]

In the discussion following Skolem's lecture, Tarski responded to this criticism:

> [I] object to the desire shown by Mr. Skolem to reduce every theory to a denumerable model…. Because of a well-known generalization of the Löwenheim-Skolem Theorem, every formal system that has an infinite model has a model whose power is any transfinite cardinal given in advance. From this, one can just as well argue for excluding denumerable models from consideration in favor of uncountable models. [Tarski in [2], 17]

Skolem aimed to cripple set theory. But Tarski's view, allowing models of all infinite cardinalities within first-order logic, has dominated later developments and is a partial vindication of Zermelo's views. It is only partial, since today almost all set theorists formulate set theory within first-order logic with its rich theory of models.

References

[1] PIERRE DUGAC, Sur la correspondance de Borel et le théorème de Dirichlet-Heine-Weierstrass-Borel-Schoenflies-Lebesgue, *Archives internationales d'histoire des sciences* **39** (1989), 69–110.

[2] FERDINAND GONSETH (ed.), *Les Entretiens de Zurich sur les Fondements et la Méthode des Sciences Mathématiques. 6–9 Décembre 1938*, Leemann, Zurich, 1941.

[3] IVOR GRATTAN-GUINNESS, *The Search for Mathematical Roots: 1870–1940. Logics, Set Theories, and the Foundations of Mathematics from Cantor through Russell to Gödel*, Princeton University Press, Princeton, 2000.

[4] GERHARD KOWALEWSKI, *Bestand und Wandel. Meine Lebenserinnerungen zugleich ein Beitrag zur neueren Geschichte der Mathematik*, Oldenbourg, Munich, 1950.

[5] GREGORY H. MOORE, *Zermelo's Axiom of Choice: Its Origins, Development and Influence*, Springer, New York, 1982.

[6] _____, Towards a History of Cantor's Continuum Problem, in *The History of Modern Mathematics*, volume 1, pp. 78–121, as edited by David E. Rowe and John McCleary, Academic Press, Boston, 1989.

[7] THORALF SKOLEM, Une relativisation des notions mathématiques fondamentales, *Colloques Internationaux du Centre National de la Recherche Scientifique*, Paris, 1958, pp. 13–18.

2008 Annual Survey of the Mathematical Sciences in the United States

(Second Report)

Updated Report on the 2007–2008 Doctoral Recipients
Starting Salary Survey of the 2007–2008 Doctoral Recipients

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

Update on the 2007–2008 Doctoral Recipients

This Second Report of the 2008 Annual Survey gives an update of the 2007–2008 new doctoral recipients from the First Report, which appeared in the *Notices of the AMS* in February 2009, pages 257–67. The First Report contains a section on new doctoral recipients in statistics that is not updated here.

The 2008 Annual Survey represents the fifty-second in an annual series begun in 1957 by the American Mathematical Society. The 2008 Survey is under the direction of the Data Committee, a joint committee of the American Mathematical Society, the American Statistical Association, the Institute of Mathematical Statistics, the Mathematical Association of America, and the Society of Industrial and Applied Mathematics. The current members of this committee are Richard Cleary, Richard M. Dudley, John W. Hagood, Abbe H. Herzig, Ellen Kirkman, David J. Lutzer, Joanna Mitro, James W. Maxwell (ex officio), Bart Ng, Polly Phipps (chair), Douglas Ravanel, Jianguo (Tony) Sun, and Marie Vitulli. The committee is assisted by AMS survey analyst Colleen A. Rose. Comments or suggestions regarding this Survey Report may be directed to the committee.

Introduction

The Annual Survey of the Mathematical Sciences collects information each year about degree recipients, departments, faculties, and students in the mathematical sciences at four-year colleges and universities in the United States. Information about recipients of doctoral degrees awarded between July 1, 2007, and June 30, 2008, was collected from doctorate-granting departments beginning in late spring 2008. The "2008 Annual Survey First Report" (*Notices*, February 2009, pages 257–67) presented survey results about 1,235 new doctoral recipients based on the data provided by the departments. Here we update this information using data obtained from 557 new doctoral recipients who responded to a questionnaire, "Employment Experiences of New Doctoral Recipients" (EENDR), sent in early October 2008 to all new doctoral recipients. In addition, this report incorporates information on an additional 143 doctoral recipients from departments that responded too late to have the information included in the First Report. Finally, we present the starting salaries and other employment information from the new doctoral recipients that responded to the EENDR questionnaire.

The names and thesis titles of the 2007–2008 doctoral recipients reported on in the First Report were published in "Doctoral Degrees Conferred" (Notices, February 2009, pages 281–301). A supplemental listing of the 143 additional new

Doctorates Granted Departmental Response Rates (updated April 2008)

Group I (Pu)[1]	25 of 25 including	0 with no degrees
Group I (Pr)	23 of 23 including	0 with no degrees
Group II	56 of 56 including	3 with no degrees
Group III	73 of 73 including	18 with no degrees
Group IV	65 of 89 including	4 with no degrees
Group Va	21 of 21 including	1 with no degrees

[1] For definitions of groups see page 839.

Polly Phipps is a senior research statistician with the Bureau of Labor Statistics. James W. Maxwell is AMS associate executive director for special projects. Colleen A. Rose is AMS survey analyst.

Highlights

There were 1,378 doctoral recipients from U.S. institutions for 2007–2008, up 45 (3%) from the previous year, continuing an upward trend that began in 2002–2003. This is the highest number of new Ph.D.'s ever reported. An increase in response rate for the second report is partly responsible for the increase.

The final unemployment rate was 3.8% for all 2007–2008 doctoral recipients and 2.3% for females. Both percentages reflect increases over last year's percentages (2.4% and 1.5%, respectively) which where the lowest reported since the early 1990s.

The number of new doctoral recipients who are U.S. citizens is 622, up 46 (8%) from last year's number and 163 (36%) from 2003–2004. This is the highest number of U.S. citizens reported over the past eleven surveys. The percentage of U.S. citizens among all doctoral recipients is 44%, up from 43% last year. The number of new doctoral recipients who are not U.S. citizens remains stable at 756, but up 134 (22%) from 2003–2004.

Females totaled 435 (32%) of all new doctoral recipients, down in number and percentage from 446 (33%) last year. The highest percentage of females among the annual counts of doctoral recipients was 34%, reported for 1998–1999. Of the 540 U.S. citizen new doctoral recipients, 191 are female (31%).

Of the 576 U.S. citizen new doctoral recipients this year, 9% are underrepresented minorities compared to 6% last year.

Of the 1,221 new doctoral recipients whose employment status is known, 1,166 reported having employment in fall 2008, with 88% (1,026) finding employment in the U.S., the same as last year. Non-U.S. citizens accounted for 50% of those employed in the U.S. (last year this percentage was 52%). The percentage of non-U.S. citizens employed in the U.S. has declined three consecutive years.

The number of new doctoral recipients hired into U.S. academic positions in fall 2008 remains stable at 756. Although this year's number remains stable, it is still the highest such number reported over the past twenty-six years. Indeed, each of the numbers reported for the past four falls exceeds any number reported during the period from fall 1982 through fall 2004.

The number of new doctoral recipients taking positions in U.S. business/industry and government was 270 in fall 2008, a 5% increase from last year's numbers. This group constitutes 26% of all the new doctoral recipients employed in the U.S. (up from 25% last year).

There were 557 new doctoral recipients responding to the EENDR survey; of the 496 who found employment in the U.S., 49% reported obtaining a permanent position (down from 53% in fall 2006).

The percentage of temporarily employed respondents who reported taking a postdoctoral position in the U.S. increased from 76% in fall 2007 to 77% in fall 2008, but the number remained unchanged at 172.

Table 1A: Doctoral Recipients: Preliminary and Final Counts

Year	Preliminary	Final
1998–1999	1133	1135
1999–2000	1119	1127
2000–2001	1008	1065
2001–2002	948	960
2002–2003	1017	1037
2003–2004	1041	1081
2004–2005	1116	1222
2005–2006	1245	1311
2006–2007	1157	1333
2007–2008	1235	1378

Table 1B: Doctoral Recipients: Citizenship

Year	U.S.	Non-U.S.	TOTAL
2003-2004	459	622	**1081**
2004-2005	496	726	**1222**
2005-2006	552	759	**1311**
2006-2007	576	757	**1333**
2007-2008	622	756	**1378**

Table 1C: 2007–2008 Doctoral Recipients by Type of Degree-Granting Department

	Department Group[1]					
	I (Pu)	I (Pr)	II	III	IV	Va
Number	315	176	301	152	317	117
Percent	23%	13%	22%	11%	23%	8%

[1] For definitions of groups see page 839.

Table 1D: Doctoral Recipients: U.S. Citizens—Percent Female and Percent Underrepresented Minorities

Year	U.S.	% Female	% URM*
1998-1999	560	34%	5%
1999-2000	566	29%	5%
2000-2001	532	31%	7%
2001-2002	428	30%	6%
2002-2003	499	32%	6%
2003-2004	459	33%	7%
2004-2005	496	28%	7%
2005-2006	552	28%	8%
2006-2007	576	31%	6%
2007-2008	622	31%	9%

* Percentage of underrepresented minorities calculated using Gender, Race/Ethnicity and Citizenship data gathered from granting departments.

Table 2A: Fall 2008 Employment Status of 2007–2008 Doctoral Recipients by Field of Thesis (updated April 2009)

TYPE OF EMPLOYER		FIELD OF THESIS												TOTAL
		Algebra Number Theory	Real, Comp., Funct., & Harmonic Analysis	Geometry/ Topology	Discr. Math./ Combin./ Logic/ Comp. Sci.	Probability	Statistics/ Biostat.	Applied Math.	Numerical Analysis/ Approxi-mations	Linear Nonlinear Optim./ Control	Differential, Integral, & Difference Equations	Math. Educ.	Other/ Unknown	
Group I (Public)[1]		33	7	15	4	4	0	6	7	3	10	0	1	**90**
Group I (Private)		22	3	17	5	6	3	10	1	0	8	0	0	**75**
Group II		15	14	9	7	2	3	9	5	2	13	2	1	**82**
Group III		16	2	2	1	2	9	4	3	2	1	5	0	**47**
Group IV		0	0	0	0	2	39	2	0	0	0	0	0	**43**
Group Va		0	0	0	2	0	0	8	3	0	1	0	0	**14**
Master's		10	4	5	11	1	13	3	7	2	6	6	0	**68**
Bachelor's		37	11	18	20	3	13	22	3	4	17	4	0	**152**
Two-Year College		3	4	4	3	0	1	5	1	0	4	1	0	**26**
Other Academic Dept.[2]		9	2	1	6	2	64	27	5	0	5	3	0	**124**
Research Institute/ Other Nonprofit		2	0	1	3	2	16	6	2	0	2	0	1	**35**
Government		0	0	2	2	1	24	8	1	1	2	0	0	**41**
Business and Industry		17	7	10	12	21	111	26	12	5	6	0	2	**229**
Non-U.S. Academic		19	8	17	11	5	17	24	1	3	14	0	0	**119**
Non-U.S. Nonacademic		4	0	1	1	2	8	0	4	0	1	0	0	**21**
Not Seeking Employment		2	0	0	0	0	4	1	0	0	2	0	0	**9**
Still Seeking Employment		10	4	5	4	2	6	6	1	0	7	0	1	**46**
Unknown (U.S.)		12	4	5	5	3	25	16	9	2	10	0	1	**92**
Unknown (non-U.S.)[3]		8	2	9	7	3	17	8	5	0	5	0	1	**65**
TOTAL		**219**	**72**	**121**	**104**	**61**	**373**	**191**	**70**	**24**	**114**	**21**	**8**	**1378**
Column Subtotals	Male	172	55	95	76	54	182	136	56	20	79	10	8	**943**
	Female	47	17	26	28	7	191	55	14	4	35	11	0	**435**

[1] For definitions of groups see page 839.
[2] These are departments outside the mathematical sciences.
[3] Includes those whose status is reported as "unknown" or "still seeking employment".

Table 2B: Fall 2008 Employment Status of 2007–2008 Doctoral Recipients by Type of Degree-Granting Department (updated April 2009)

TYPE OF EMPLOYER		TYPE OF DOCTORAL DEGREE-GRANTING DEPARTMENT						TOTAL	Row Subtotals	
		Group I (Public)	Group I (Private)	Group II Math.	Group III Math.	Group IV Statistics	Group Va Applied Math.		Male	Female
Group I (Public)[1]		40	21	16	8	0	5	**90**	70	20
Group I (Private)		21	40	5	1	4	4	**75**	60	15
Group II		27	10	30	10	3	2	**82**	62	20
Group III		10	1	15	14	6	1	**47**	32	15
Group IV		0	0	2	1	39	1	**43**	24	19
Group Va		2	3	4	0	0	5	**14**	14	0
Master's		18	3	24	10	12	1	**68**	50	18
Bachelor's		39	9	64	24	9	7	**152**	86	66
Two-Year College		6	1	11	5	1	2	**26**	21	5
Other Academic Dept.[2]		13	5	15	18	55	18	**124**	73	51
Research Institute/ Other Nonprofit		4	4	6	1	16	4	**35**	14	21
Government		9	4	5	1	19	3	**41**	20	21
Business and Industry		35	20	35	23	90	26	**229**	152	77
Non-U.S. Academic		42	27	18	8	16	8	**119**	97	22
Non-U.S. Nonacademic		5	3	3	1	6	3	**21**	18	3
Not Seeking Employment		1	0	1	3	3	1	**9**	1	8
Still Seeking Employment		17	5	11	7	3	3	**46**	37	9
Unknown (U.S.)		10	12	22	12	21	15	**92**	71	21
Unknown (non-U.S.)[3]		16	8	14	5	14	8	**65**	41	24
TOTAL		**315**	**176**	**301**	**152**	**317**	**117**	**1378**	**943**	**435**
Column Subtotals	Male	248	145	215	101	151	83	**943**		
	Female	67	31	86	51	166	34	**435**		

[1] For definitions of groups see page 839.
[2] These are departments outside the mathematical sciences.
[3] Includes those whose status is reported as "unknown" or "still seeking employment".

Table 2C: Degree-Granting Department of 2007–2008 Doctoral Recipients by Field of Thesis (updated April 2009)

TYPE OF DOCTORAL DEGREE-GRANTING DEPARTMENT	FIELD OF THESIS												TOTAL
	Algebra Number Theory	Real, Comp., Funct., & Harmonic Analysis	Geometry/ Topology	Discr. Math./ Combin./ Logic/ Comp. Sci.	Probability	Statistics/ Biostat.	Applied Math.	Numerical Analysis/ Approxi-mations	Linear Nonlinear Optim./ Control	Differential, Integral, & Difference Equations	Math. Educ.	Other/ Unknown	
Group I (Public)[1]	80	22	41	43	16	10	42	15	7	35	0	4	315
Group I (Private)	57	12	32	13	11	0	30	1	1	18	0	1	176
Group II	66	24	34	21	14	15	56	29	5	29	7	1	301
Group III	16	13	9	14	6	21	16	17	5	19	14	2	152
Group IV	0	0	0	0	6	305	6	0	0	0	0	0	317
Group Va	0	1	5	13	8	22	41	8	6	13	0	0	117
TOTAL	219	72	121	104	61	373	191	70	24	114	21	8	1378

[1] For definitions of groups see page 839.

Table 2D: Percentage of Employed New Doctoral Recipients by Type of Employer

	Employed in U.S.		Employed outside. U.S.		NUMBER EMPLOYED
	Academic[1]	Nonacademic	Academic	Nonacademic	
Fall 2004	72%	15%	12%	1%	**910**
Fall 2005	69%	17%	12%	2%	**1018**
Fall 2006	65%	22%	11%	2%	**1099**
Fall 2007	66%	22%	11%	1%	**1151**
Fall 2008	65%	23%	10%	2%	**1166**

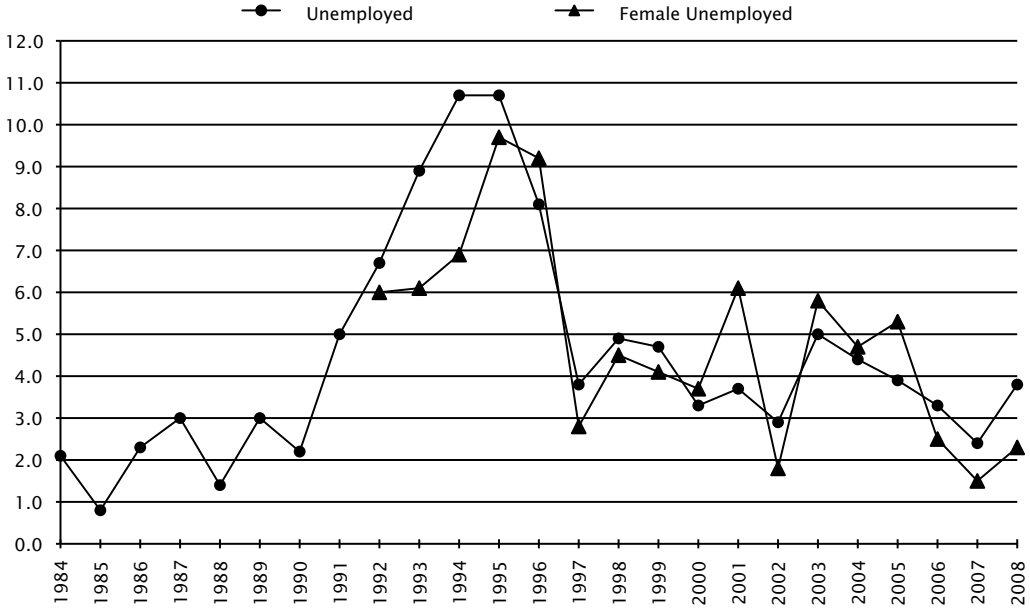
[1] Includes research institutes and other non-profits.

doctoral recipients appears at the end of this report on pages 840–843.

Updated Employment Status of 2007–2008 Doctoral Recipients

The updated response rates for the 2008 Survey of New Doctoral Recipients appear on page 828. The total number of departments responding in time for inclusion in this Second Report was 263, 29 more than were included in the 2008 First Report and 11 more than the total number responding for inclusion in the 2007 Second Report. Groups I, II, III, and Va achieved a 100% response rate by the second report; the Data Committee thanks all departments for their efforts. No adjustments were made in this report for nonresponding departments. Definitions of the various groups surveyed in the Annual Survey can be found on page 839 of this report.

Figure 1: Percentage of New Doctoral Recipients Unemployed[1]



[1] As reported in the respective Annual Survey Second Reports.

Table 3A: New Doctoral Recipients Employed in the U.S.

	Degree-Granting Department Group[1]													
	I (Pu)		I (Pr)		II		III		IV		Va		TOTAL	
	Academic[2]	Business/ Industry & Government	Academic	Business/ Industry & Government	Academic	Business/ Industry & Government	Academic	Business/ Industry & Government	Academic	Business/ Industry & Government	Academic	Business/ Industry & Government	Academic	Business/ Industry & Government
Fall 2004	118	18	118	18	144	17	73	11	150	61	52	11	655	137
Fall 2005	152	21	104	17	152	23	97	18	149	79	45	18	699	176
Fall 2006	171	41	109	21	128	32	93	15	155	104	59	30	715	243
Fall 2007	191	50	91	12	181	20	95	27	151	123	47	24	756	256
Fall 2008	180	44	97	24	192	40	92	24	145	109	50	29	756	270

[1] For definitions of groups see page 839.
[2] Includes research institutes and other non-profits.

Table 1A shows the fall and final counts of doctoral recipients in the mathematical sciences awarded by U.S. institutions in each year from 1998 through 2008. This year the total number of new doctoral recipients is 1,378, up from the previous year by 45. The response rates for Groups I (Pr), II, and III all increased in 2008, thus caution should be taken in interpreting change between 2007 and 2008 for these groups.

Table 1B shows trends in the number of new doctoral recipients for the past five years broken down by U.S. citizens and non-U.S. citizens. This year the number of new doctoral recipients who are U.S. citizens is 622, an increase of 46 (8%) over last year. The number of non-U.S. citizen new doctoral recipients dropped by 1 to 756.

Table 1C gives a breakdown of the 1,378 doctoral degrees awarded in the mathematical sciences between July 1, 2007, and June 30, 2008, by type of degree-granting department.

Table 1D shows the number of U.S. citizens, receiving degrees, the percentage of U.S. citizen females and the percentage of U.S. citizen underrepresented minorities for the years 1998–1999 through 2007–2008. Underrepresented minorities include any person having origins in the categories American Indian or Alaska Native, Black or African American, Hispanic or Latino, and Native Hawaiian or Other Pacific Islander.

Tables 2A, 2B, and 2C display updates of these same numbered tables in the First Report to include the 143 additional doctoral recipients reported too late for inclusion in the First Report. New doctoral recipients are grouped by field of thesis using the Mathematical Reviews 2000 Mathematics Subject Classification list. A complete list of these groups is available on the AMS website at www.ams.org/employment/Thesis_groupings.pdf. At the time of this Second Report, the fall 2008 employment status of 1,221 of the 1,378 doctoral recipients was known.

The fall 2008 unemployment rate for new doctoral recipients, based on information gathered by the time of the Second Report, was 3.8%. Figure 1 presents the fall 1984 through fall 2008 trend

Table 3B: New Doctoral Recipients Employed in U.S. Academic Positions

	Hiring Department Group[1]					
	I–III	IV	Va	M&B	Other[2]	**TOTAL**
Fall 2004	220	66	19	172	178	**655**
Fall 2005	249	53	12	212	173	**699**
Fall 2006	263	73	14	198	167	**715**
Fall 2007	286	44	15	229	182	**756**
Fall 2008	294	43	14	220	185	**756**

[1] For definitions of groups see page 839.
[2] Includes two-year colleges, other academic departments, and research institutes/other nonprofits.

Table 3C: Females as a Percentage of 2007–2008 New Doctoral Recipients

	Department Group[1]							
	I (Pu)	I(Pr)	II	III	IV	Va	M&B	**TOTAL**
% Female								
Produced	21%	18%	29%	34%	52%	29%	-	**32%**
Hired	22%	20%	24%	32%	44%	0%	38%	**30%**

[1] For definitions of groups see page 839.

in the final unemployment rate of new doctoral recipients. The counts on which these rates are determined do not include those new doctoral recipients whose fall employment status was still unknown at the time of the Second Report. This year the number of recipients whose employment status was reported as unknown increased to 157 from 143 last year.

Of the 1,221 new doctoral recipients whose employment is known, 1,026 were employed in the U.S., 140 were employed outside the U.S., 46 were still seeking employment, and 9 were not seeking employment.

Table 2D presents the trend in the percentage of employed new doctoral recipients by type of employer for the last five years. Academic employment includes those employed by research institutes and other nonprofits. Among new doctoral recipients who are employed in the U.S., the percentage taking nonacademic employment

Table 3D: Citizenship of 2007–2008 Male Doctoral Recipients by Fall 2008 Employment Status

TYPE OF EMPLOYER	CITIZENSHIP				TOTAL MALE DOCTORAL RECIPIENTS
	U.S. CITIZENS	NON-U.S. CITIZENS			
		Permanent Visa	Temporary Visa	Unknown Visa	
U.S. Employer	341	38	292	7	**678**
U.S. Academic	270	24	209	3	**506**
Groups[1] I, II, III, and Va	115	7	113	3	**238**
Group IV	10	0	14	0	**24**
Non-Ph.D. Department	138	16	76	0	**230**
Research Institute/Other Nonprofit	7	1	6	0	**14**
U.S. Nonacademic	71	14	83	4	**172**
Non-U.S. Employer	26	1	87	1	**115**
Non-U.S. Academic	25	0	71	1	**97**
Non-U.S. Nonacademic	1	1	16	0	**18**
Not Seeking Employment	0	0	1	0	**1**
Still Seeking Employment	21	2	14	0	**37**
Subtotal	388	41	394	8	**831**
Unknown (U.S.)	42	4	24	1	**71**
Unknown (non-U.S.)[2]	1	0	40	0	**41**
TOTAL	**431**	**45**	**458**	**9**	**943**

[1] For definitions of groups see page 839.
[2] Includes those whose status is reported as "unknown" or "still seeking employment".

Table 3E: Citizenship of 2007–2008 Female Doctoral Recipients by Fall 2008 Employment Status

TYPE OF EMPLOYER	CITIZENSHIP				TOTAL FEMALE DOCTORAL RECIPIENTS
	U.S. CITIZENS	NON-U.S. CITIZENS			
		Permanent Visa	Temporary Visa	Unknown Visa	
U.S. Employer	168	22	152	6	**348**
U.S. Academic	139	11	96	4	**250**
Groups[1] I, II, III, and Va	39	2	28	1	**70**
Group IV	8	0	10	1	**19**
Non-Ph.D. Department	83	8	48	1	**140**
Research Institute/Other Nonprofit	9	1	10	1	**21**
U.S. Nonacademic	29	11	56	2	**98**
Non-U.S. Employer	8	0	15	2	**25**
Non-U.S. Academic	7	0	13	2	**22**
Non-U.S. Nonacademic	1	0	2	0	**3**
Not Seeking Employment	6	1	1	0	**8**
Still Seeking Employment	1	1	7	0	**9**
Subtotal	183	24	175	8	**390**
Unknown (U.S.)	8	2	8	3	**21**
Unknown (non-U.S.)[2]	0	1	22	1	**24**
TOTAL	**191**	**27**	**205**	**12**	**435**

[1] For definitions of groups see page 839.
[2] Includes those whose status is reported as "unknown" or "still seeking employment".

varied significantly by field of thesis. For those whose field of thesis is in the first three columns in Table 2A, the percentage is 12% (up from 7% last year), while the percentage for those with theses in probability or statistics is the highest at 45% (up from 44% last year).

Table 3A shows that the fall 2008 total number of doctoral recipients taking positions in business/industry and government is 270. This number reflects an increase of 5% over last year. Groups I Pr and II increased 100% from last year from 12 to 24 and from 20 to 40, respectively. Table 3B shows that the number of new doctoral recipients taking U.S. academic positions remains unchanged from last year at 756. Doctoral hires into U.S. academic

Table 3F: Number of 2007–2008 New Doctoral Recipients Employed in the U.S. by Citizenship and Type of Employer

U.S. EMPLOYER	CITIZENSHIP		TOTAL
	U.S.	Non-U.S.	
Academic: Groups I–Va	172	179	**351**
Academic: M&B, Other	237	168	**405**
Nonacademic	100	170	**270**
TOTAL	**509**	**517**	**1026**

positions are down slightly in all groups except Groups I-III (up to 294 from 286 last year) and Other (up to 185 from 182 last year). The biggest percentage decrease is in Group M&B (4%).

Table 3C gives information about the production of female new doctoral recipients in the doctoral-granting departments and the hiring of females by all department groups. From Table 3C we see that the percentage of females hired ranges from a high of 44% in Group IV, followed by Group M&B at 38% to zero in Group Va. The percentage of female new doctoral recipients produced is highest in Group IV (52%).

Updated Information about 2007–2008 Doctoral Recipients by Gender and Citizenship

Tables 3D and 3E show the gender and citizenship of the 1,378 new doctoral recipients and the fact that 1,026 new doctoral recipients found jobs in the U.S. this year. This is 84% of the 1,221 new doctoral recipients whose employment status was known and 88% of the 1,166 known to have jobs in fall 2008. Last year these percentages were 85% and 88%, respectively.

Gender and citizenship are known for all of the 1,378 new doctoral recipients. The final count of new doctoral recipients who are U.S. citizens is 622 (45%) (up from 43% last year). Pages 262–65 of the First Report present further information related to the citizenship of the 2007–2008 new doctoral recipients.

Of the 622 U.S. citizen new doctoral recipients reported for 2007–2008, 191 are female and 431 are male. Females accounted for 31% of the U.S. citizen total (the same as last year). The number of female U.S. citizens has increased by 11 from last year's count of 180, and the number of male U.S. citizens increased by 35 from last year's count of 396.

Table 3F shows that U.S. citizens accounted for 50% of those employed in the U.S. (up from 48 % last year). Groups I through Va hired 49% U.S. citizens, while groups M, B, and all other academic departments hired 59% U.S. citizens (last year these percentages were 49% and 55%, respectively). U.S. citizens represented 37% of those hired into nonacademic positions (last year 36%). Among all the 1,026 new 2007–2008 doctoral recipients employed in the U.S., 26% took nonacademic employment (government or business and industry) up from 25% last year.

Table 4A: Number (and Percentage) of Annual EENDR Respondents Employed in the U.S. by Job Status

	Employed in U.S.					
	Permanent Total	Temporary Total	Temporary			Unknown
			Permanent not available	Postdoctoral		
				Total	Permanent not available	
Fall 2004	220(49%)	229(51%)	81(35%)	176(77%)	49(28%)	--
Fall 2005	291(56%)	232(44%)	92(40%)	172(74%)	55(32%)	--
Fall 2006	289(51%)	274(49%)	98(36%)	209(76%)	57(27%)	--
Fall 2007	259(53%)	227(47%)	88(39%)	172(76%)	57(33%)	--
Fall 2008	245(49%)	222(45%)	74(33%)	172(77%)	47(27%)	--

Table 4B: Percentage of Annual EENDR Respondents Employed in the U.S. by Employment Sector within Job Status

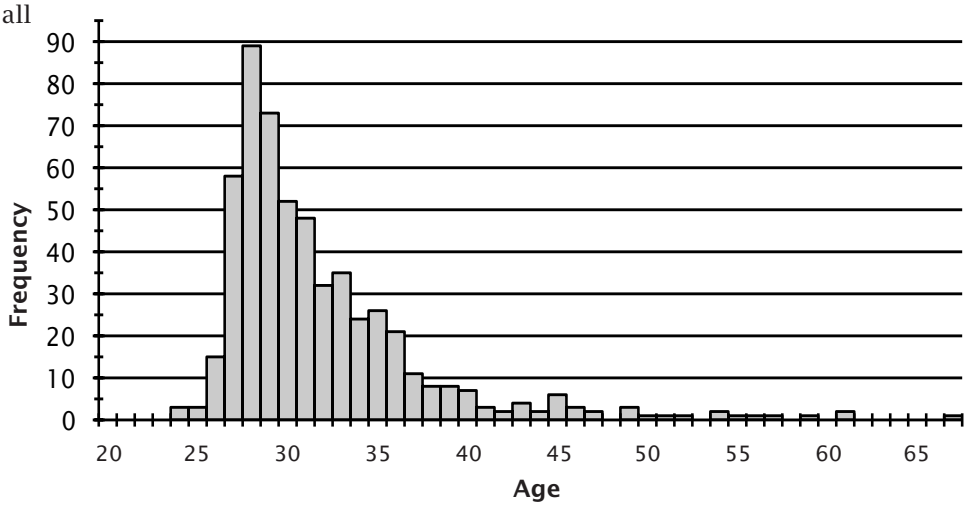
	Employed in U.S.					
	Permanent			Temporary		
	Academic[1]	Government	Business/ Industry	Academic	Government	Business/ Industry
Fall 2004	72%	5%	23%	97%	3%	0%
Fall 2005	68%	5%	27%	96%	4%	0%
Fall 2006	66%	4%	30%	93%	5%	2%
Fall 2007	68%	3%	29%	93%	4%	3%
Fall 2008	63%	6%	31%	95%	4%	1%

[1] Includes research institutes and other non-profits.

New Information from the EENDR Survey

The 1,235 new doctoral recipients reported in the First Report were sent the "Employment Experiences of New Doctoral Recipients" (EENDR) survey in October 2008, and 557 (45%) responded. The response rates varied considerably among the various subgroups of new doctoral recipients defined by their employment status as reported by

Figure 2: Age Distribution of 2007–2008 EENDR Respondents



departments. Among those who were employed the highest response rate, 57%, was from those employed in the U.S. academic, while the lowest, 20%, was from those in non-U.S. academic.

The EENDR gathered details on employment experiences not available through departments. The remainder of this section presents additional information available on this subset of the 2007–2008 doctoral recipients.

Table 4A gives the numbers and percentages of EENDR respondents taking permanent and temporary positions in the U.S for fall 2004 through fall 2008.

This year we see that among the 496 employed in the U.S., 245 reported obtaining a permanent position and 222 a temporary position. (Twenty-nine individuals did not classify their position.) While these numbers both reflect a decrease, the percentage of individuals taking permanent positions in 2008 has decreased to 49% from 53% in 2007, and the percentage of those taking temporary positions has decreased to 45% from 47%. Of the 222 in temporary positions, 74 (33%) reported taking temporary employment because a suitable permanent position was not available, down from 39% in 2007. Most respondents classified their temporary position as postdoctoral (77%). Of the 172 respondents taking postdoctal positions, 47 (27%) reported that a suitable permanent position was not available, down from 33% in 2007.

Table 4B shows the employment trends of permanent and temporary positions broken down by sector for the last five years. Among the 245 who reported obtaining a permanent position in the U.S. in fall 2008, 63% were employed in academia (including 2% in research institutes and other nonprofits), 6% in government, and 31% in business or industry. Women held 37% of the permanent positions.

Among the 222 individuals with temporary employment in the U.S. this year, 95% were employed in academia (including 7% in research institutes and other nonprofits), 4% in government, and 1% in business or industry.

Figure 2 gives the age distribution of the 550 new doctoral recipients who responded to this question. The median age of new doctoral recipients was 30 years, while the mean age was 32 years. The first and third quartiles were 28 and 31 years, respectively. This distribution is consistent with those of the recent past.

Previous Annual Survey Reports

The 2008 First Report was published in the Notices in the February 2009 issue. For the last full year of reports, the 2007 First, Second, and Third Reports were published in the Notices in the February, August, and December 2008 issues respectively. These reports and earlier reports, as well as a wealth of other information from these surveys, are available on the AMS website at www.ams.org/employment/surveyreports.html.

Starting Salary Survey of the 2007–2008 Doctoral Recipients

The starting salary figures for 2008 were compiled from information gathered on the EENDR questionnaires sent to individuals who received doctoral degrees in the mathematical sciences during the 2007–2008 academic year from universities in the United States (see previous section for more details).

The questionnaires were distributed to 1,235 recipients of degrees using addresses provided by the departments granting the degrees; 557 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 population.

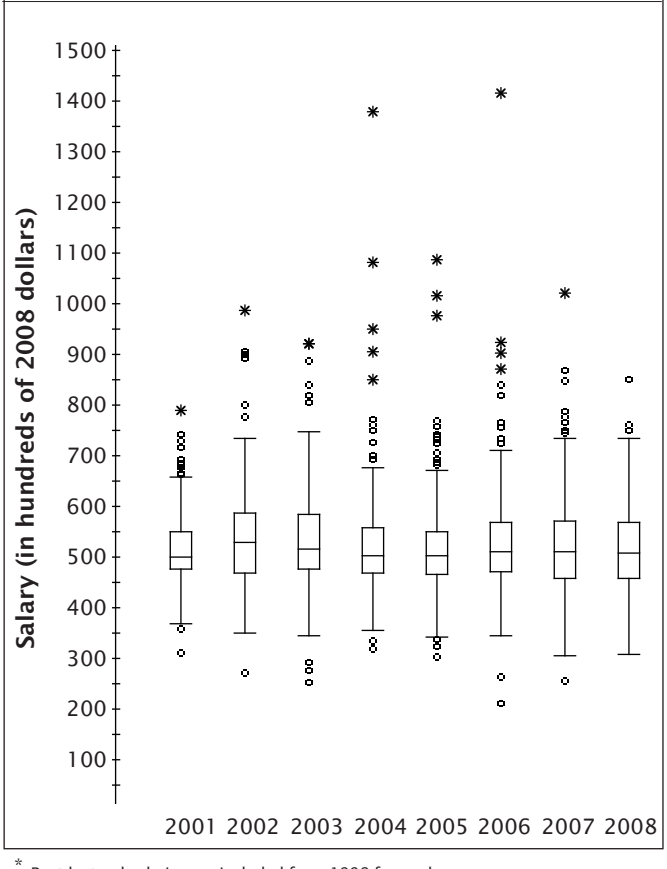
Key to Tables and Graphs. Salaries are those reported for the fall immediately following the survey cycle. Years listed denote the survey cycle in which the doctorate was received—for example, survey cycle July 1, 2007–June 30, 2008, is designated as 2008. Salaries reported as 9–10 months exclude stipends 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 2001 through 2008. Values plotted for 2001 through 2007 are converted to 2008 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

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

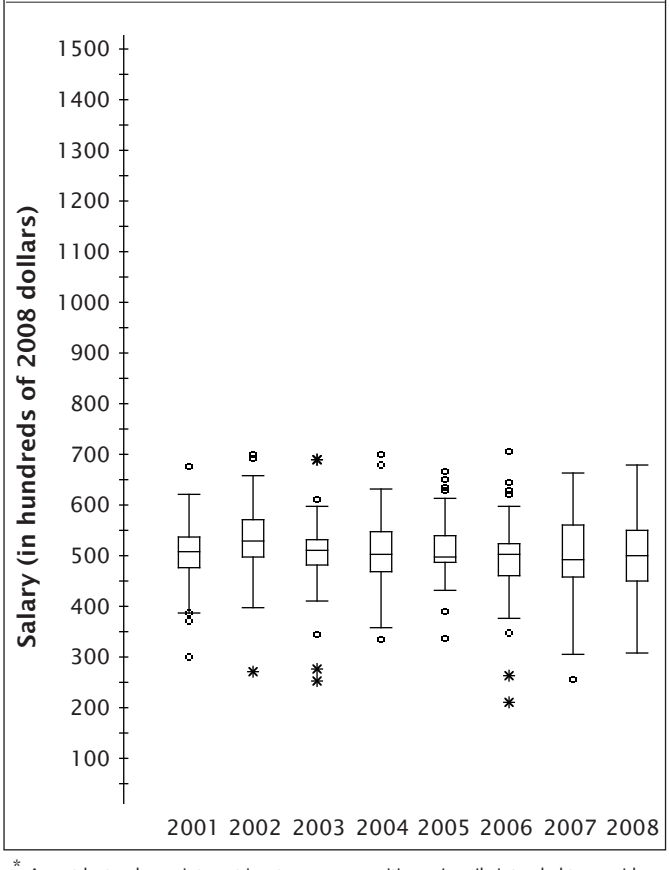
Ph.D. Year	Min	Q_1	Median	Q_3	Max	Reported Median in 2008 $
1980	105	155	171	185	250	387
1985	170	230	250	270	380	439
1990	230	305	320	350	710	480
1995	220	320	350	382	640	465
1998*	140	340	370	410	700	469
2000	250	380	415	450	650	508
2002	230	400	450	500	840	529
2003	220	415	450	510	920	518
2004	285	420	450	500	1234	503
2005	280	430	465	506	1002	504
2006	200	450	490	550	1350	515
2007	250	450	500	560	1000	511
2008	310	460	510	569	850	510
2004 M	285	420	450	490	850	
2004 F	300	421	450	500	1234	
2005 M	300	430	465	510	710	
2005 F	280	430	467	501	1002	
2006 M	200	450	499	550	880	
2006 F	270	450	480	520	1350	
2007 M	320	450	500	558	1000	
2007 F	250	438	490	560	830	
Total (163 male/79 female)						
2008 M	310	460	515	573	850	
2008 F	380	455	500	550	760	
One year or less experience (138 male/60 female)						
2008 M	316	453	508	570	850	
2008 F	380	458	500	550	680	



* Postdoctoral salaries are included from 1998 forward.

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

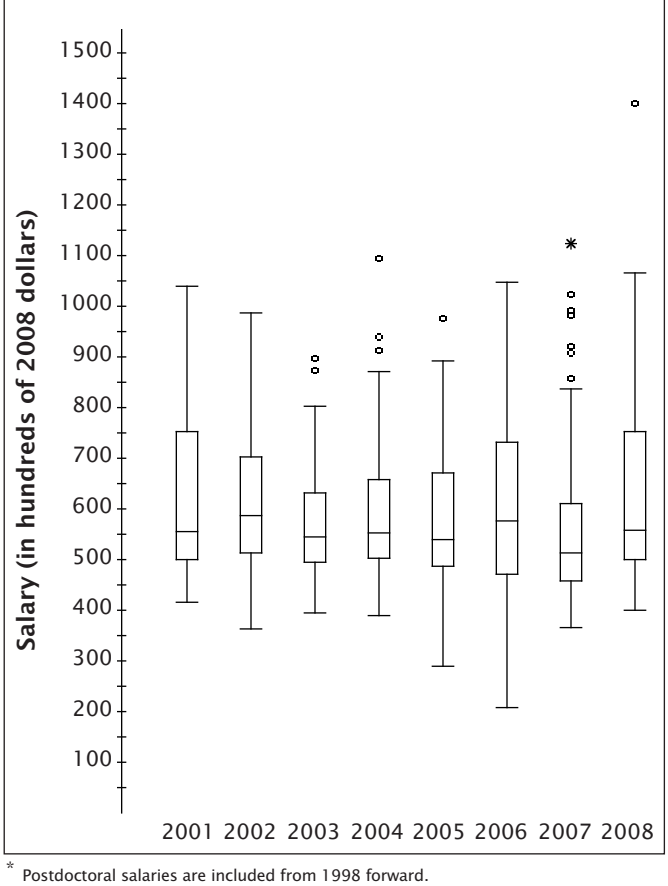
Ph.D. Year	Min	Q_1	Median	Q_3	Max	Reported Median in 2008 $
1997	180	350	385	410	450	494
1998	290	350	390	420	500	495
1999	130	365	400	418	540	450
2000	300	385	420	450	550	514
2001	250	400	425	450	566	508
2002	230	425	450	487	595	529
2003	240	420	450	480	600	518
2004	300	420	450	490	625	503
2005	310	450	460	500	615	498
2006	200	441	480	500	670	504
2007	250	450	483	550	650	494
2008	310	450	500	550	680	500
2004 M	300	420	450	480	625	
2004 F	400	440	470	500	606	
2005 M	310	450	470	500	615	
2005 F	400	437	450	471	500	
2006 M	200	450	483	523	670	
2006 F	330	413	464	500	590	
2007 M	360	450	490	575	650	
2007 F	250	425	470	515	650	
Total (67 male/18 female)						
2008 M	310	450	500	553	655	
2008 F	400	460	505	542	680	
One year or less experience (64 male/18 female)						
2008 M	354	450	505	555	655	
2008 F	400	460	505	542	680	



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

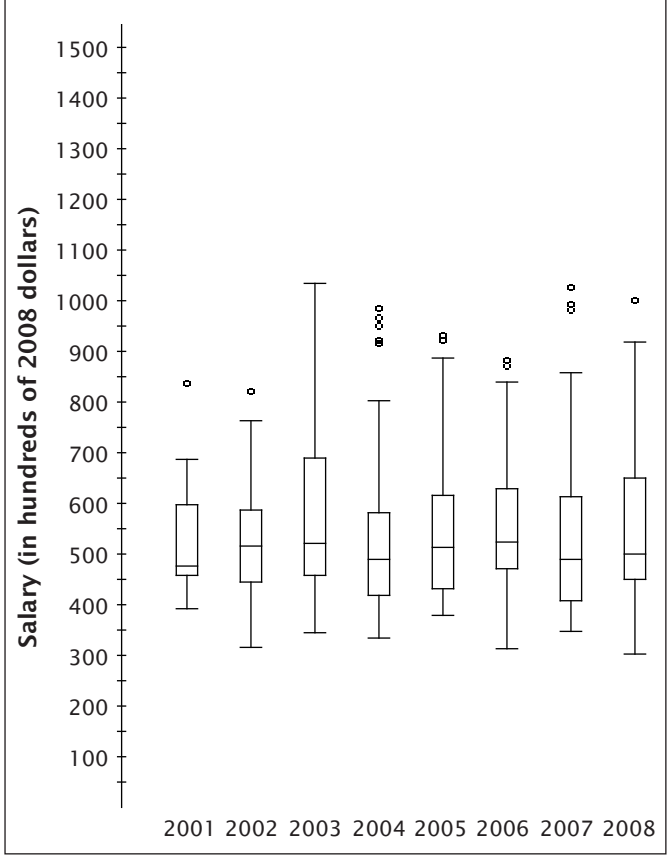
Academic Teaching/Teaching and Research 11–12-Month Starting Salaries* (in hundreds of dollars)

Ph.D. Year	Min	Q_1	Median	Q_3	Max	Reported Median in 2008 $
1985	220	230	273	300	470	479
1990	225	318	365	404	670	548
1995	300	354	410	478	600	545
1998*	275	405	480	575	700	609
2000	300	400	485	600	1170	594
2002	310	439	500	597	840	587
2003	345	438	475	550	780	546
2004	350	450	495	583	980	554
2005	270	450	500	615	900	542
2006	200	450	550	700	1000	578
2007	340	450	504	600	1100	515
2008	400	500	560	753	1400	560
2004 M	350	448	487	533	980	
2004 F	380	465	545	605	650	
2005 M	270	455	490	549	900	
2005 F	420	450	570	753	824	
2006 M	300	450	535	685	900	
2006 F	200	520	600	850	1000	
2007 M	360	440	500	600	1100	
2007 F	340	480	529	703	1003	
Total (33 male/16 female)						
2008 M	419	530	560	750	1400	
2008 F	400	498	540	757	1067	
One year or less experience (28 male/10 female)						
2008 M	435	523	560	638	985	
2008 F	400	475	500	530	752	



Academic Research Only 11–12-Month Starting Salaries (in hundreds of dollars)

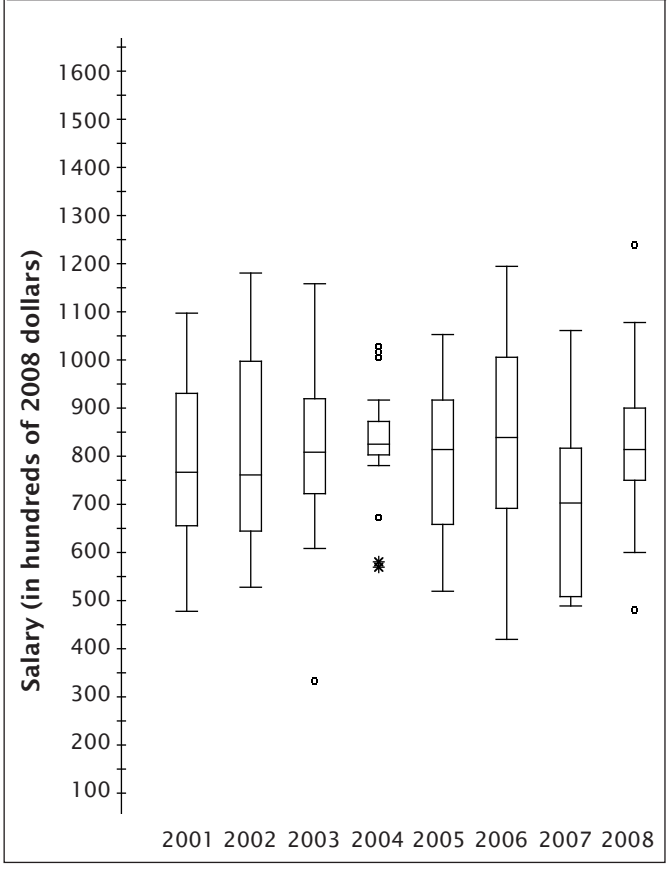
Ph.D. Year	Min	Q_1	Median	Q_3	Max	Reported Median in 2008 $
1997	190	300	350	400	600	449
1998	200	333	360	428	617	457
1999	270	380	400	480	720	500
2000	300	365	400	529	1000	490
2001	300	350	400	575	796	478
2002	270	380	440	500	700	517
2003	300	405	455	600	900	523
2004	300	378	440	510	880	492
2005	350	400	475	570	860	515
2006	300	450	500	600	840	525
2007	340	415	480	540	1003	491
2008	305	450	500	577	1000	500
2004 M	300	380	440	560	880	
2004 F	350	378	430	493	820	
2005 M	350	420	480	580	860	
2005 F	350	400	475	529	850	
2006 M	350	450	500	600	830	
2006 F	300	455	540	680	840	
2007 M	360	400	470	600	970	
2007 F	340	465	480	504	1003	
Total (29 male/11 female)						
2008 M	305	450	500	550	1000	
2008 F	370	465	500	675	920	
One year or less experience (27 male/8 female)						
2008 M	305	450	500	550	1000	
2008 F	420	478	500	739	920	



* Postdoctoral salaries are included from 1998 forward.

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

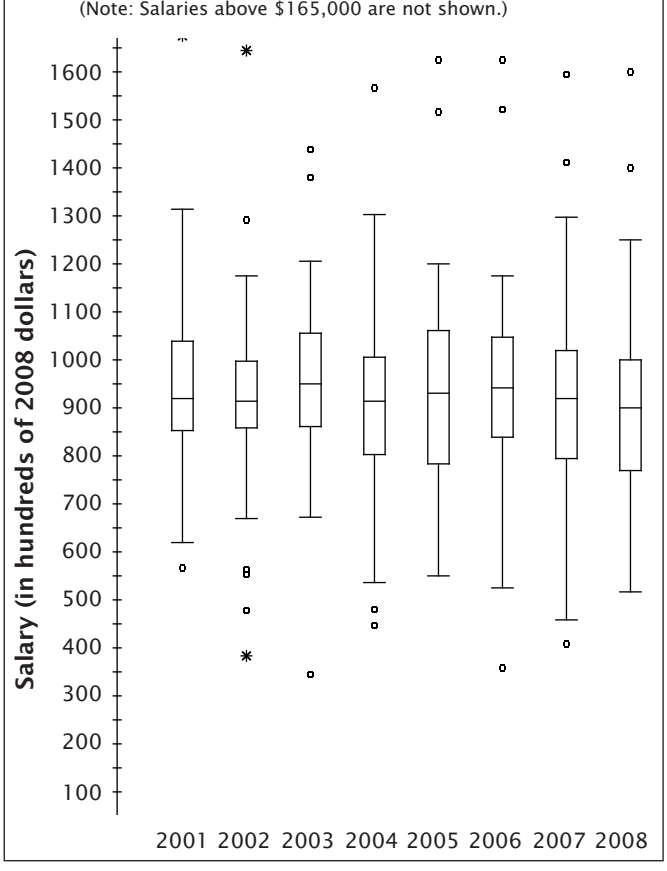
Ph.D. Year	Min	Q_1	Median	Q_3	Max	Reported Median in 2008 $
1985	263	294	325	381	440	571
1990	320	345	378	430	587	567
1995	370	440	494	507	650	657
2000	440	540	600	640	830	734
2001	400	580	644	758	920	770
2002	450	551	650	775	1005	764
2003	290	668	705	763	1008	811
2004	510	720	738	780	920	825
2005	480	610	752	848	972	815
2006	400	678	800	961	1140	840
2007	480	500	690	800	1040	706
2008	480	750	815	900	1240	815
2004 M	520	700	730	740	910	
2004 F	510	733	749	790	920	
2005 M	500	668	790	902	955	
2005 F	480	540	750	770	972	
2006 M	500	660	800	960	1000	
2006 F	400	775	790	1043	1140	
2007 M	480	500	695	813	1040	
2007 F	To few women to report separately.					
Total (9 male/12 female)						
2008 M	600	790	830	982	1240	
2008 F	480	720	810	863	930	
One year or less experience (7 male/9 female)						
2008 M	600	784	810	921	1080	
2008 F	700	720	837	900	930	



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

Ph.D. Year	Min	Q_1	Median	Q_3	Max	Reported Median in 2008 $
1985	260	360	400	420	493	702
1990	320	438	495	533	700	743
1995	288	480	568	690	1250	755
2000	200	640	720	800	1500	881
2001	475	716	770	865	1850	920
2002	325	734	780	850	1400	916
2003	300	700	800	900	1250	920
2004	400	728	817	900	1800	914
2005	510	755	870	978	2000	942
2006	340	800	900	1000	1550	945
2007	400	780	900	1000	2500	921
2008	518	780	900	1000	1700	900
2004 M	400	710	813	900	1800	
2004 F	480	789	850	900	1100	
2005 M	510	760	930	1005	2000	
2005 F	600	745	860	890	1100	
2006 M	340	750	890	1000	1450	
2006 F	500	850	900	960	1550	
2007 M	400	760	920	1000	2500	
2007 F	710	800	855	950	1270	
Total (56 male/19 female)						
2008 M	518	768	910	1013	1700	
2008 F	700	800	900	955	1250	
One year or less experience (40 male/14 female)						
2008 M	518	768	900	1000	1600	
2008 F	700	800	900	958	1250	

(Note: Salaries above $165,000 are not shown.)



Definitions of the Groups

As has been the case for a number of years, much of the data in these reports is presented for departments divided into groups according to several characteristics, the principal one being the highest degree offered in the mathematical sciences. Doctoral-granting departments of mathematics are further subdivided according to their ranking of "scholarly quality of program faculty" as reported in the 1995 publication *Research-Doctorate Programs in the United States: Continuity and Change*.[1] These rankings update those reported in a previous study published in 1982.[2] Consequently, the departments which now comprise Groups I, II, and III differ significantly from those used prior to the 1996 survey.

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

Brief descriptions of the groupings are as follows:

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

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

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

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

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

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

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

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

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

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

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

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.

Acknowledgments

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

Other Data Sources

American Association of University Professors, Financial *Inequality in Higher Education: The Annual Report on the Economic Status of the Profession 2007–2008*, Academe: Bull. AAUP (March/April 2008), Washington, DC.

American Statistical Association, *2008–2009 Salaries of Academic Statisticians*. (Published in *AMSTATNEWS*, December 2008, Issue #378.)

_____, *Salary Survey Results of Biostatistics and other Biomedical Statistics Departments and Units*, AmStat News (January 2009, Issue #379), Alexandria, VA.

Commission on Professionals in Science and Technology, *Professional Women and Minorities,* 17th ed., CPST, Washington, DC, 2008.

_____, *Salaries of Scientists, Engineers, and Technicians: A Summary of Salary Surveys*, 22nd ed., CPST (November 2007), Washington, DC.

Conference Board of the Mathematical Sciences, *Statistical Abstract of Undergraduate Programs in the Mathematical Sciences in the United States: Fall 2005 CBMS Survey*, American Mathematical Society, Providence, RI, 2007.

_____, *Statistical Abstract of Undergraduate Programs in the Mathematical Sciences in the United States: Fall 2000 CBMS Survey*, American Mathematical Society, Providence, RI, 2002.

National Opinion Research Center, *Doctorate Recipients from United States Universities: Summary Report 2006*, Survey of Earned Doctorates, Chicago, IL, 2007. (`http://www.norc.org/SED`)

National Research Council, *Gender Differences at Critical Transitions in the Careers of Science, Engineering and Mathematics Faculty*, National Academy Press, Washington, DC, 2009.

_____ , *Policy Implications of International Graduate Students and Postdoctoral Scholars in the United States*, National Academy Press, Washington, DC, 2005.

_____, *Strengthening the Linkages between the Sciences and the Mathematical Sciences*, National Academy Press, Washington, DC, 2000.

_____, *U.S. Research Institutes in the Mathematical Sciences: Assessment and Perspectives*, National Academy Press, Washington, DC, 1999.

National Science Board, *Science and Engineering Indicators—2008*. Two Volumes (NSB 08-01; NSB 08-1A), National Science Foundation, Arlington, VA, 2008.

National Science Foundation, *U.S. Doctorates in the 20th Century*, (NSF 06-319), Arlington, VA, 2006.

_____, *Graduate Students and Postdoctorates in Science and Engineering: Fall 2006* (NSF 08-306), Arlington, VA, 2008. (http://www.nsf.gov/statistics/nsf08306)

_____, *Science and Engineering Degrees: 1966–2006* (NSF 08-321), Detailed Statistical Tables, Arlington, VA, 2008. (http://www.nsf.gov/statistics/nsf08321)

_____, *Science and Engineering Degrees, by Race/Ethnicity of Recipients: 1995–2004* (NSF 07-308), Detailed Statistical Tables, Arlington, VA, 2007.

_____, *Science and Engineering Doctorate Awards: 2006* (NSF 09-311), Detailed Statistical Tables, Arlington, VA, 2006. (http://www.nsf.gov/statistics/nsf09311)

_____, *Women, Minorities, and Persons with Disabilities in Science and Engineering: 2009* (NSF 09-305), Arlington, VA. (http://www.nsf.gov/statistics/wmpd)

Doctoral Degrees Conferred 2007–2008

Supplementary List

The following list supplements the list of thesis titles published in the February 2009 *Notices*, pages 281–301.

ALABAMA

University of Alabama at Birmingham (3)

BIOSTATISTICS

Ayanlowo, Ayanbola, Design of Phase II & III clinical trials.

Jones, Tamekia, A statistical approach identifying and limiting the effect of influential observations.

Sawrie, David, Preemptive power for the consulting statistician: novel application of internal pilot design and information based monitoring systems.

CALIFORNIA

Naval Postgraduate School (1)

APPLIED MATHEMATICS

Phillips, Donovan, Mathematical modeling and optimal control of battlefield information flow.

University of California, Berkeley (24)

MATHEMATICS

Al-Aidroos, Jameel, Perfect pairings in the tautological rings of the moduli spaces of stable curves.

Berg, Jennifer Danae, On the center of the lie superalgebra $q(n)^{(2)}$.

Burstein, Richard David, Hadamard subfactors of Bisch-Haagerup type.

Chen, Tianbing, Piecewise polynomial discretization and Krylov-accelerated multigrid for elliptic interface problems.

Clayton, Aubrey, Mutation-selection balance for polynomial selection costs and matrix-valued orthogonal polynomial.

Closson, Erik, The solovay sequence in derived models associated to mice.

Courtney, Dennis, Asymptotic lifts of UCP semigroups.

Dan-Cohen, Elizabeth, Structure of root-reductive lie algebras.

Fern, Jesse, Calculations of quantum error correction and fault tolerance thresholds.

Freeman, David Stephen, Constructing Abelian varieties for pairing-based cryptography.

Gray, Aaron, Functoriality of the logarithmic Riemann-Hilbert.

Han, Fei, Supersymmetric QFTS, super loop spaces and Bismut-Chern character.

Huggins, Peter, Polytopes in computational biology.

Jetchev, Dimitar, CM points, selmer groups, component groups and Euler systems.

Kirkpatrick, Kay, Rigorous derivation of the Landau equation in the weak coupling limit.

Lebow, Eli, Embedded contact homology of 2-torus bundles over the circle.

Levine, Lionel, Limit theorems for internal aggregation models.

Mihaescu, Radu, Distance methods in phylogeny.

Morton, Jason, Geometry of conditional independence.

Nachmias, Asaf, Percolation on finite groups.

Schlutenberg, Farmer, Measures in mice.

Tingley, Peter, Some results on the crystal commutor and affine sl(n) crystals.

Yao, Jiangang, Codimension one embedding of manifolds.

Zywina, David, The large sieve and Galois representations.

University of California, Riverside (4)

MATHEMATICS

McLoughlin, Peter, When is the adjoint of a finite-rank minimal projection also minimal.

Troutman, Tiffany, Infinity-harmonic functions, maps and morphisms of Riemannian manifolds.

Wrkich, James, Solvability of some inhomogeneous parabolic.

Yao, Chui Zhi, Discrete logarithm and related problems in cryptography.

University of California, Santa Barbara (10)

MATHEMATICS

Barbaro, Alethea, An interacting particle model for the migrations of pelagic fish.

Haynal, Heidi, PI degree parity in q-skew polynomial rings.

Kolpas, Allison, Coarse-grained analysis of collective motion in animal groups.

Learned, John, Graphical methods in representation theory.

Levitt, Rena, Biautomaticity and nonpositively curved spaces.

Macauley, Matthew, Coexter theory and discrete dynamical systems.

Rehkopf, Edward, Reduction of quadratic forms over polynomial rings.

Sentinella, Robert, Multi-scale modeling of liquid crystalline polymers.

Trethewey, Peterson, Conformal curvature and one-relator group theory.

Wiley, Chad, Nugatory crossings in closed 3-braid diagrams.

COLORADO

University of Colorado, Boulder (10)

APPLIED MATHEMATICS

Kurcz, Christopher, Fast convolutions with Helmholtz Green's functions and radially symmetric band-limited kernels.

Lim, Jisun, The qualitative study of a chemical reaction diffusion system and some integral equations.

Mao, Wenjin, Dimension jumping and auxiliary variable techniques for Markov chain Monte Carlo algorithms.

Nolting, Joshua, Efficiency-based local adaptive refinement for FOSLS finite elements.

Pietarila-Graham, Jonathan, Regularizations as subgrid models for turbulent flows.

Piret, Cecile, Analytical and numerical advances in radial basis functions.

Rojsiraphisal, Thaned, A study of the variability of the North Indian ocean.

Wang, Jian, Recovering Bayesian networks with applications to gene regulary networks.

Watson, Michael, A study of rotationally constrained convection in tall annular geometries.

Zuev, Julia, Recent advances in numerical PDEs.

University of Denver (1)

MATHEMATICS

Nagrath, Aditya, Properties of scattered lattices, and the introduction of a meet semilattice duality.

CONNECTICUT

Wesleyan University (1)

MATHEMATICS AND COMPUTER SCIENCE

Babichev, Andrey, Speedups of ergodic group extensions.

Yale University (4)

MATHEMATICS

Liu, Qihou, On the colored Jones polynomials of certain links.

Maitra, Rachel, Mathematically rigorous quantum field theories with a non-linear normal ordering of the Hamiltonian operator.

Patnaik, Manish, Geometry of loop Einstein series.

Zhu, Minxian, Vertex operator algebras arising from affine lie algebras.

IDAHO

Idaho State University (1)

MATHEMATICS

Lundeen, Suzanne, The finite reflection group H_4.

ILLINOIS

Illinois State University (5)

MATHEMATICS

Hofbauer, Pamela, Characterizing high school students' understanding of the purpose of graphical representations.

Knapp, Andrea, Prompting mathematics teacher development through dynamic discourse.

Naresh, Nirmala, Workplace mathematics of the bus conductors in Chennai, India.

Simmons, Eugene, The effects of using a QAR reading strategy to improve students' conceptual understanding.

Thompson, Kevin, Students' understanding of trigonometry enhanced through the use of a real word problem: improving the instructional sequence.

KENTUCKY

University of Kentucky (5)

STATISTICS

Hersh, Matt, Indentification of multiple functional peaks resulting from a common peak shape function.

Li, Hao, Identifying gene expression patterns in oligonucleotide microarray experiments.

McClintock, Scott, Stochastic securities market model with no short selling.

Vandyke, Rhonda, Classification of self-modeling regressions.

Zhu, Hua, Smoothed empirical likelihood for quantiles and some variations/extention of empirical likelihood for Buckley-James estimator.

MARYLAND

John Hopkins University (1)

APPLIED MATHEMATICS AND STATISTICS

Tan, Liang, Numerical methods for multi-dimensional American options.

University of Maryland (23)

APPLIED MATHEMATICS AND COMPUTER SCIENCE

Bard, George, Algorithms for solving linear and polynomial systems over finite fields with applications to cryptoanalysis.

Chakraborty, Purnendu, Molecular dynamic studies of organic coated nano aerosols.

Cheng, Bin, On the rotational shallow water and Euler equations.

Finkbiner, Amy, Global phenomena from local rules: Peer-to-peer networks and discrete crystal steps.

Ganesh, Nadarajasundaram, Small area estimation and prediction problems.

Heath, Jeffery, Global optimization of finite mixture models.

Johnson, Hunter, Definable families of finite VC dimension.

Li, Huilin, Small area estimation: an empirical best linear unbiased prediction approach.

Long, Nicholas, Involutions of shift of finite type: fixed point shifts, orbit quotients, and the dimension representation.

Lu, Guanhua, Asymptotic theory in multiple-sample semiparametric density ratio models and its applications to mortality forecasting.

Mai, Yabing, Comparing survival distributions in the presence of dependent censoring: asymptotic validity and bias corrections of the Logrank test.

Min, Min, Asymptotic normality in generalized linear mixed models.

O'Hara, Michael, Adiabatic quantum computation: noise in the adiabatic theorem and using the Jordan-Wigner transform to find effective Hamiltonians.

Oktay, Onur, Frame quantization theory and equiangular tight frames.

Smetaniouk, Taras, Pricing variance derivatives using hybrid models with stochastic interest rates.

Tate, Calandra, An investigation of the relationship between automated machine evaluation metrics and user performance on an information extraction task.

Truman, Kathryn, Analysis and extension of non-communative NTRU.

Wei, Dongming, Critical thresholds in Eulerian dynamics.

Wen, Shihua, Semi-paramatric cluster detection.

Widemann, David, Dimensionality reduction for hyperspectral data.

Yu, Tinghui, Estimation theory of a location parameter in small samples.

Zhang, Chensong, Adaptive finite element methods for variational inequalities: theory and applications in finance.

Zhong, Weigang, Entropy stable approximations of nonlinear conservation laws and related fluid equations.

MASSACHUSETTS

Harvard University (1)

MATHEMATICS

Paur, Katherine, Modeling the effects of population structure and vaccination strategy on infectious diseases.

MINNESOTA

University of Minnesota (13)

SCHOOL OF MATHEMATICS

Bemis, Christopher, Modeling and optimization of mortgage loan portfolios.

Chen, Yanlai, An adaptive high order discontinuous Galerkin method with error control for the Hamilton-Jacobi equations.

Chung, Kuerak, Based Cacti.

Jung, Yoon Mo, Variational modeling, analysis, and computing of image and visual segmentation problems.

Kim, Sangwook, Topology of diagonal arrangements and flag enumerations of matroid base polytopes.

Kontovourkis, Michalis, On elliptic equations with low-regularity divergence-free drift terms and the steady-state Navier-Stokes equation in higher dimenions.

Kurkcu, Harun, High-frequency scattering by infinite rough surfaces.

Mahajan, Deepa, Boundary-conforming discontinuous Galerkin methods via extension form subdomains.

Maxwell, Molly, Enumerating self-dual spanning trees and self-dual matroid bases.

Phan, Tuoc Van, On global existence of solutions to a cross-diffusion system.

Weimerskirch, Michael, On infinite indistinguishability quotient monoids in misere impartial combinatorial games.

Zhang, Hang, Static and dynamical problems of hydrogel swelling: modeling and analysis.

Zuniga, Jose Javier, Compactifications of moduli spaces.

NEW HAMPSHIRE

Dartmouth College (6)

MATHEMATICS

Andersen, Brooke, Distinguishing complete sets with respect to strong notions of reducibility.

Bayless, Jonathan, Carmichael's conjecture and the unit group function.

Bourke, John, Results of off-branch numbers.

Henrich, Allison, A sequence of degree one Vassiliev invariants for virtual knots.

Malandro, Martin, Fast Fourier transforms for inverse semigroups.

Pollack, Paul, Prime numbers and prime polynomials.

NEW JERSEY

Rutgers University - Newark (2)

MATHEMATICS AND COMPUTER SCIENCE

McDonald, Keith Tim, On *p*-adic zeta functions and their derivatives at *s*=0.

Min, Honglin, Hyperbolic graphs of surface groups.

Rutgers The State University of New Jersey (11)

MATHEMATICS

Bao, ShiTing, Gradient estimates for the conductivity problems.

Coskey, Samuel, Descriptive aspects of torsion-free abelian groups.

Costello, Kevin, Ranks of random matrices and graphs.

Duffy, Colleen, Graded traces and irreducible representations of Aut (A(Gamma)) acting on graded A(Gamma) and A(Gamma) dual.

Guo, Ren, Parameterizations of Teichmüller spaces of surfaces with boundary.

Hansen, Derek, Asymptotic perturbation formulas for the effect of scattering by small objects: an analysis over a broad band of frequencies.

Kennedy, Benjamin, Differential delay equations with several fixed delays.

Lins, Brian, Asymptotic behavior and Denjoywolff theorems for Hilbert metric nonexpansive maps.

Pudwell, Lara, Enumerative schemes for pattern - avoiding words and permutations.

Speck, Jared, On the questions of local and global existence for the hyperbolic PDEs occuring in some relativistic theories of gravity and electromagnetism.

Stucchio, Christopher, Selected problems in quantum mechanics.

NEW YORK

Columbia University (3)

BIOSTATISTICS

Chang, Chung, Statistical analysis for neuroimaging data.

Xu, Qiang, Existing approaches and a new weighted method for cox regression in the presence of missing covariates.

Zhang, Hui, Handling missing data without specifying auxiliary models.

PENNSYLVANNIA

University of Pennsylvania (2)

STATISTICS

Ghia, Kartikeya, Statistical applications in finance: permutation tests, regression trees, and normality tests.

Shirley, Kenneth, Hidden Markov models for alcoholism treatment trial data.

University of Pittsburgh (3)

STATISTICS

Iosif, Ana-Maria, Analysis of longitudinal random length data.

Lopez, Adriana, Markov models for longitudinal course of youth bipolar disorder.

Wu, Qiang, Clustering methodologies with applications to integrative analyses of post-mortem tissue studies in schizophrenia.

UTAH

Utah State University (1)

MATHEMATICS AND STATISTICS

Cook, Lawrence, Small sample methods for the analysis of clustered binary data.

Mathematics People

Rouquier Awarded Adams Prize

RAPHAËL ROUQUIER of the Mathematical Institute, University of Oxford, has been awarded the 2009 Adams Prize by the University of Cambridge. The selected topic was representation theory. According to the prize citation, "the quality, depth and influence of Professor Rouquier's work is already highly impressive. He has a long list of fundamental results, extending back to the late 1990s, on both the two main areas of representation theory: representations of general finite-dimensional algebras and derived categories and representations of Lie groups in various forms."

The Adams Prize is awarded each year by the Faculty of Mathematics and St. John's College to a young researcher based in the United Kingdom who is doing first-class international research in the mathematical sciences. The prize is named after the mathematician John Couch Adams and was endowed by members of St. John's College. It is currently worth approximately £13,000 (about US$19,700), of which one-third is awarded to the prizewinner on announcement of the prize, one-third is provided to the prizewinner's institution (for research expenses of the prizewinner), and one-third is awarded to the prizewinner when a substantial (normally at least twenty-five printed pages) original survey article of which the prizewinner is an author has been accepted for publication in an internationally recognized journal.

—From a University of Cambridge announcement

Mueller-Gronbach Awarded 2009 Information-Based Complexity Prize

THOMAS MUELLER-GRONBACH of Université Passau, Germany, has been awarded the 2009 Information-Based Complexity Prize. The prize consists of US$3,000 and a plaque. The award will be presented at the Seminar on Algorithms and Complexity for Continuous Problems, Schloss Dagstuhl, Germany, in September 2009.

This annual prize is given for outstanding contributions to information-based complexity.

—Joseph Traub, Columbia University

National Academy of Sciences Elections

The National Academy of Sciences (NAS) has announced the election of seventy-two new members and eighteen foreign associates. The new members who work in the mathematical sciences are SUN-YUNG ALICE CHANG, Princeton University; PERCY DEIFT, Courant Institute of Mathematical Sciences, New York University; JOHN E. HOPCROFT, Cornell University; THOMAS J. R. HUGHES, University of Texas, Austin; JOHN W. MORGAN, Columbia University; CHRISTOS C. PAPADIMITRIOU, University of California, Berkeley; GILBERT STRANG, Massachusetts Institute of Technology; CUMRUN VAFA, Harvard University; and WING H. WONG, Stanford University.

—From an NAS annoucement

American Academy Elections

Ten mathematical scientists have been elected to membership in the American Academy of Arts and Sciences. They are: SPENCER J. BLOCH, University of Chicago; ROBERT A. FEFFERMAN, University of Chicago; DORIAN GOLDFELD, Columbia University; DOUGLAS R. HOFSTADTER, Indiana University; MARIA KLAWE, Harvey Mudd College; STANLEY J. OSHER, University of California, Los Angeles; MICHAEL SIPSER, Massachusetts Institute of Technology; TERENCE TAO, University of California, Los Angeles; GUNTHER UHLMANN, University of Washington; and RUTH J. WILLIAMS, University of California, San Diego.

The American Academy of Arts and Sciences was founded in 1780 to foster the development of knowledge as a means of promoting the public interest and social

progress. The membership of the academy is elected and represents distinction and achievement in a range of intellectual disciplines—mathematical and physical sciences, biological sciences, social arts and sciences, and humanities and fine arts.

—From an AAAS announcement

Cortes and Vapnik Receive ACM Award

CORINNA CORTES of Google Research and VLADIMIR VAPNIK of the University of London and NEC Laboratories have been awarded the Paris Kanellakis Theory and Practice Award of the Association for Computing Machinery (ACM). They were recognized "for their revolutionary development of a highly effective algorithm known as Support Vector Machines (SVM), a set of related supervised learning methods used for data classification and regression common in the field of artificial intelligence." Because of their work, "SVM is one of the most frequently used algorithms in machine learning, which is used in medical diagnosis, weather forecasting, and intrusion detection, among many other practical applications."

The Paris Kanellakis Theory and Practice Award honors specific theoretical accomplishments that have had a significant and demonstrable effect on the practice of computing. This award is endowed by contributions from the Kanellakis family, with additional financial support provided by ACM's Special Interest Groups on Algorithms and Computational Theory, on Design Automation, on Management of Data, and on Programming Languages, the ACM SIG Project Fund, and individual contributions.

—From an ACM announcement

USA Mathematical Olympiad

The 2009 USA Mathematical Olympiad (USAMO) was held April 28 and 29, 2009. The students who participated in the Olympiad were selected on the basis of their performances on the American High School and American Invitational Mathematics Examinations. The twelve highest scorers in the USAMO, listed in alphabetical order, were: JOHN BERMAN, Wilmington, North Carolina; SERGEI BERNSTEIN, Belmont, Massachusetts; WENYU CAO, Andover, Massachusetts; ROBIN CHENG, Coquitlam, British Columbia, Canada; VLAD FIROIU, Westford, Massachusetts; ERIC LARSON, Eugene, Oregon; DELONG MENG, Baton Rouge, Louisiana; QINXUAN PAN, Rockville, Maryland; PANUPONG PASUPAT, Deerfield, Massachusetts; TOAN PHAN, Watertown, Connecticut; DAVID RUSH, Exeter, New Hampshire; and DAVID YANG, Walnut, California.

In June the twelve USAMO winners will take the team selection test to qualify for the U.S. team. The six students with the highest combined scores from the test and the USAMO will attend the Mathematical Olympiad Summer Program (MOSP) at the University of Nebraska, Lincoln, to train to compete in the International Mathematical Olympiad (IMO) to be held in Bremen, Germany, July 10– 22, 2009.

—Elaine Kehoe

Moody's Mega Math Challenge Winners Announced

The winners of the 2009 Mega Math Challenge for high school students have been announced. The topic for this year's competition was "$787 Billion: Will the Stimulus Act Stimulate the U.S. Economy?". A team from High Technology High School in Lincroft, New Jersey, was awarded the Summa Cum Laude Team Prize of US$20,000 in scholarship money. The members of the team were STEVE CASTELLANO, ETHAN DALE, JAY FELDMAN, DAN MANE, and MATTHEW WARSHAUER. Their coach was Ellen LeBlanc.

The Magna Cum Laude Team Prize of US$15,000 was awarded to a team from Elk County Catholic High School in St. Marys, Pennsylvania. The team members were JOSHUA CASMIR CATALANO, ERIC HIGGINS, DONALD ANTHONY MEIER, CHARLES HAROLD O'LEARY, and WILLIAM FRANCIES YOST. Their coach was Theodore Hanes.

The Cum Laude Team Prize of US$10,000 was awarded to the Wheeler School in Providence, Rhode Island. The team members were MATT HALPERN, BRETT MUSCO, CHRIS SHAW, KARAN TAKHAR, and ALEX WHEELOCK. They were coached by George Lewis.

A team from Bergen County Academies in Hackensack, New Jersey, won the Meritorious Team Prize of US$7,500. The team members were JOSHUA EISEMAN, PETER HUMANIK, ELAN PAZ KUGELMASS, TAESUP LEE, and JORDAN MOLDOW. They were coached by Elizabeth Casarico.

The Exemplary Team Prize of US$5,000 was awarded to a team from West Windsor-Plainsboro High School North in Plainsboro, New Jersey. The team members were SHIR AHARON, CHRIS BERGMAN, MOYA CHIN, TRACIE KONG, and YUN HUI LIN, and they were coached by John Cornell.

The First Honorable Mention Team Prize of US$2,500 went to a team from Staples High School in Westport, Connecticut. The team members were KYLE BEATTY, JONATHAN CHOI, JASON GANDELMAN, NAVEEN MURALI, and JUSTIN SHERMAN. Their coach was Gertrude Denton.

The Mega Math Challenge invites teams of high school juniors and seniors to solve an open-ended, realistic, challenging modeling problem focused on real-world issues. The top five teams receive awards ranging from US$5,000 to US$20,000 in scholarship money. The competition is sponsored by the Moody's Foundation, a charitable foundation established by Moody's Corporation, and organized by the Society for Industrial and Applied Mathematics (SIAM).

—Elaine Kehoe

Mathematics Opportunities

NSF Focused Research Groups

The Focused Research Groups (FRG) activity of the Division of Mathematical Sciences (DMS) of the National Science Foundation (NSF) supports small groups of researchers in the mathematical sciences.

The DMS has announced deadline dates for the fiscal year 2009 competition for FRG grants. The deadline for receipt of the required letters of intent to submit FRG proposals is **August 21, 2009**. The deadline date for full proposals is **September 18, 2009**. The FRG solicitation may be found on the Web at `http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5671`.

—From an NSF announcement

NSF Mathematical Sciences Postdoctoral Research Fellowships

The Mathematical Sciences Postdoctoral Research Fellowship program of the Division of Mathematical Sciences (DMS) of the National Science Foundation (NSF) awards fellowships each year that are designed to permit awardees to choose research environments that will have maximal impact on their future scientific development. Awards of these fellowships are made for appropriate research in areas of the mathematical sciences, including applications to other disciplines. Fellows may opt to choose either a research fellowship or a research instructorship. The deadline for this year's applications is **October 21, 2009**. Applications must be submitted via FastLane on the World Wide Web. For more information see the website `http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5301`.

—From an NSF announcement

NSF CAREER Program Guidelines Available

The guidelines for the Faculty Early Career Development (CAREER) Program of the National Science Foundation (NSF) are now available on the World Wide Web. The program solicitation number is 08-557. Information is available at `http://nsf.gov/pubs/2008/nsf08557/nsf08557.htm`. The deadline for submission of proposals is **July 23, 2009**.

—From an NSF announcement

Call for Nominations for Sloan Fellowships

Nominations for candidates for Sloan Research Fellowships, sponsored by the Alfred P. Sloan Foundation, are due by **September 15, 2009**. A candidate must be a member of the regular faculty at a college or university in the United States or Canada and must have received the Ph.D. or equivalent within the six years previous to the nomination. For information write to: Sloan Research Fellowships, Alfred P. Sloan Foundation, 630 Fifth Avenue, Suite 2550, New York, NY 10111-0242; or consult the foundation's website: `http://www.sloan.org/programs/fellowship_brochure.shtml`.

—From a Sloan Foundation announcement

NSA Mathematical Sciences Grants and Sabbaticals Program

As the nation's largest employer of mathematicians, the National Security Agency (NSA) is a strong supporter of the academic mathematics community in the United States. Through the Mathematical Sciences Program, the NSA provides research funding and sabbatical opportunities for eligible faculty members in the mathematical sciences.

Grants for Research in Mathematics. The Mathematical Sciences Program (MSP) supports self-directed, unclassified research in the following areas of mathematics: algebra, number theory, discrete mathematics, probability, and statistics. The program also supports conferences and workshops (typically in the range of US$15,000–US$20,000) in these five mathematical areas. The program does not entertain research or conference proposals that involve cryptology. Research support may include summer salary for faculty members, a modest amount for graduate student support, travel assistance, and other miscellaneous expenses. Proposals that involve participation by women and other individuals from underrepresented backgrounds are encouraged.

Principal investigators, graduate students, consultants, and all other personnel supported by NSA grants must be U.S. citizens or permanent residents of the United States at the time of proposal submission. Proposals should be submitted **electronically** by **October 15, 2009**, via the program website: `http://www.nsa.gov/research/math_research/index.shtml`.

Sabbatical Program. NSA's Mathematics Sabbatical Program offers mathematicians, statisticians, and computer

scientists the unique opportunity to develop skills in directions that would be nearly impossible anywhere else. Sabbatical employees work side by side with other NSA scientists on projects that involve cryptanalysis, coding theory, number theory, discrete mathematics, statistics and probability, and many other subjects. Visitors spend 9–24 months at NSA, and most find that within a very short period of time they are able to make significant contributions.

NSA pays 50 percent of salary and benefits during academic months and 100 percent of salary and benefits during summer months of the sabbatical detail. A monthly housing supplement is available to help offset the cost of local lodging. On average, three sabbatical positions are available per year.

Applicants must be U.S. citizens and must be able to obtain a security clearance. A complete application includes a cover letter and curriculum vitae with list of significant publications. The cover letter should describe the applicant's research interests, programming experience and level of fluency, and how an NSA sabbatical would affect teaching and research upon a return to academia. Additional information about the Sabbatical Program is available at http://www.nsa.gov/research/math_research/sabbaticals/index.shtml.

For more information about the Grants or Sabbaticals Program, please contact the program office at 301-688-0400. You may also write to the program director, Heather Garten (hlgarte@nsa.gov), or to the program administrator, Barbara Johnson (bajohn1@nsa.gov).

—Mathematical Sciences Program announcement

Travel Grants for ICM 2010

The American Mathematical Society has applied to the National Science Foundation (NSF) for funds to permit partial travel support for U.S. mathematicians attending the 2010 International Congress of Mathematicians (ICM 2010), August 19–27, 2010, in Hyderabad, India. Subject to the award decision by the NSF, the Society is preparing to administer the selection process, which would be similar to previous programs funded in 1990, 1994, 1998, 2002, and 2006.

Instructions on how to apply for support will be available on the AMS website at http://www.ams.org/employment/icm2010.html. The application period will be **September 1–November 15, 2009**. This travel grants program, if funded, will be administered by the Membership and Programs Department, AMS, 201 Charles Street, Providence, RI 02904-2294. You can contact us at ICM2010@ams.org; 800-321-4267, ext. 4170; or 401-455-4170.

This program is open to U.S. mathematicians (those who are currently affiliated with a U.S. institution). 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. ICM 2010 Invited Speakers from U.S. institutions 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 by the Society.

Should the proposal to the NSF be funded, the following conditions will apply: mathematicians accepting grants for partial support for travel to ICM 2010 may not supplement the grants with any other NSF funds. Currently, it is the intention of the NSF's Division of Mathematical Sciences (DMS) to provide no additional funds in its other regular research grants for travel to ICM in 2010. 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 ICM 2010 program, organization, and registration procedure is located on the ICM 2010 website, http://www.icm2010.org.in.

—AMS Memberships and Programs Department

Call for Entries for Ferran Sunyer i Balaguer Prize

The Ferran Sunyer i Balaguer Foundation invites entries for the 2009 Ferran Sunyer i Balaguer Prize. The prize is awarded for a mathematical monograph of an expository nature presenting the latest developments in an active area of research in mathematics. The prize consists of 15,000 euros (approximately US$20,400) and publication of the winning monograph in Birkhäuser-Verlag's series Progress in Mathematics. The deadline for submission is **December 4, 2009**. For more information see the website http://ffsb.iec.cat.

—From a Ferran Sunyer i Balaguer Foundation announcement

Call for Nominations for 2009 Sacks Prize

The Association for Symbolic Logic (ASL) invites nominations for the 2009 Sacks Prize for the most outstanding doctoral dissertation in mathematical logic. The Sacks Prize consists of a cash award and five years' free membership in the ASL. The deadline for nominations is **September 30, 2009**.

General information about the prize is available at http://www.aslonline.org/info-prizes.html. For details about nomination procedures, see http://www.aslonline.org/Sacks_nominations.html.

—From an ASL announcement

For Your Information

Mathematics Subject Classification 2010

Mathematical Reviews (MR) and *Zentralblatt für Mathematik* (Zbl) collaborate in maintaining the Mathematics Subject Classification (MSC), which is used by these reviewing services and many others to categorize items in the mathematical sciences literature. The current version, MSC2000, consists of 63 areas classified with two digits refined into over 5,000 three- and five-digit classifications. The MSC has undergone a general revision, with some additions, changes, and corrections, to create MSC2010, the successor to the present MSC2000. As anticipated, there are no changes at the two-digit level, but refinements have been made at the three- and five-digit levels. MR and Zbl are now using MSC2010 as their classification scheme.

MR and Zbl carefully considered input received from the community in recent years, especially since the announcement of the projected revision in December 2006, and used it in the preparation of their joint MSC revision. The final MSC2010, the result of four working drafts, can be viewed at `http://msc2010.org`. These drafts were publicly developed using the MSCwiki at this site, which will remain open for public view and to document any corrections to MSC2010 that may be made. Various PDF forms and an interactive TiddlyWiki version of MSC2010 are also there.

MR and Zbl welcome and encourage community adoption of MSC2010. Comments can be submitted through the Web form found at `http://msc2010.org/feedback` or by email to `feedback@msc2010.org`. All information about MSC2010 is jointly shared by MR and Zbl.

The editors and their staffs wish to express their gratitude to the numerous members of the community for their assistance in this lengthy revision process.

—Graeme Fairweather, executive editor, MR, and Bernd Wegner, editor-in-chief, Zbl

NSF Math Institutes Create New Jobs

The seven National Science Foundation (NSF) Mathematical Sciences Research Institutes announced in May 2009 the creation of 45 new one- and two-year positions for young, highly trained mathematical scientists across the country. In addition to furthering research in all areas of the mathematical sciences, these positions will allow recent Ph.D.'s to teach at community colleges and other higher-education institutions or to participate in projects tied to business and industry. This new initiative is a result of a partnership among the NSF-supported mathematics institutes.

The impact of the economic downturn is being felt everywhere, including academia. This year has seen widespread hiring freezes and canceled job searches at universities across the country. For the mathematical science community, this has meant almost 400 positions lost for recent Ph.D.'s. The severity of the situation became apparent earlier this year when many graduates, even of top-tier programs, were facing unemployment. The NSF, through its mathematics institutes, responded by creating these new postdoctoral fellowships.

The training of these young scientists represents a long-term investment. The postdocs typically spent five years in graduate education, often with some level of support from state or federal funds.

"These new researchers are primed to make significant contributions to their fields," said Peter March, director of NSF's Division of Mathematical Sciences. The newly created positions will place highly trained people as teachers at two- and four-year colleges and universities, as well as in business and industry.

"These positions not only refine the research skills of new Ph.D.'s but provide them with opportunities to apply their training in other settings," said Russ Caflisch, director of the Institute for Pure and Applied Mathematics (IPAM). "The role of research along with teaching or industry mentors and professional development workshops reinforces the institutes' commitment to ensuring the continued success of these young people in the workforce."

Exactly one month elapsed between the first meeting of the seven mathematics institute directors and the close of applications. More than 750 applications were received for the 45 positions. Typically, academic job searches begin in the fall and take several months to complete.

"The timing was perfect," said Eddie Herman, one of the newly hired mathematicians. "Most academic positions are decided by the middle of March, so the institutes began advertising at exactly the time when many of us were losing hope of finding a research position and were ready to look for other jobs." Herman received his Ph.D. from UCLA this year.

The economic downturn is being felt by everyone, including the research and academic community. Universities are canceling job searches, which limits the number of positions for new Ph.D.'s and people completing postdoctoral training. Additionally, many U.S. graduate programs have reduced the size of their incoming classes. In fact, some programs will not be admitting any students in the next academic year. This will have the effect of diminishing the size of our next generation of scientists, those who would be graduating at a time when our economy is recovering and in need of a highly trained workforce.

Currently, many workers are seeking retraining in response to the needs of the changing economy just as colleges and universities face cutbacks.

"There are problems all along the pipeline," said Marty Golubitsky, director of the Mathematical Biosciences Institute (MBI). "New Ph.D.'s are not finding jobs that make use of their extensive training, and consequently graduate programs are admitting fewer students. This stifling of scientific training in our next generation will make it more difficult for the U.S. to remain competitive in the future."

"We knew that the job market for young Ph.D.'s in mathematics was extremely tight this year, but we were astonished by the number and quality of the applicants for these new positions," said Robert Bryant, director of the Mathematical Sciences Research Institute (MSRI) in Berkeley, California. Of the more than 750 applications submitted for the institutes' postdocs, 400 came from people who received their Ph.D. just this year.

"Being able to offer these positions allows us to keep these highly trained people in the workforce and is a great boon for mathematics and for our society," said Bryant.

The impact of this program is widespread, with postdocs working in a dozen states across the country, and in all areas of the mathematical sciences. While continuing their research, the institute postdocs will also apply their training through teaching or industrial partnerships. The following highlights an example from each institute.

Postdocs at the American Institute of Mathematics (AIM) will help to fill a desperate need for math instructors by teaching at De Anza Community College in Cupertino, California, and at San Francisco State University. "I have more than 1,000 students on a waiting list for math classes, and no faculty to teach them," said Jerry Rosenberg, Dean of Physical Sciences, Mathematics, and Engineering at De Anza. Thanks to this initiative, approximately 250 of those students will be able to take a math class from one of the new postdocs at AIM. According to Brian Conrey, executive director of AIM, "We were aware of the dire need for math instructors at California colleges, and we saw the institute postdocs as a way to help address that need. This will bring enthusiastic young instructors into the classroom and allow the postdocs to further develop their teaching skills." Their teaching duties will be in addition to the research they will do under the direction of Stanford University faculty.

Through the Institute for Mathematics and its Applications (IMA) in Minneapolis, Mustafa Tural, who trained in statistics and operations research at the University of North Carolina, will intern at Telcordia Technologies in Piscataway, NJ. He will apply his knowledge to the development of statistical learning methods for creating more efficient algorithms and protocols for communication networks. The project is supervised by Eric van den Berg, who leads a research effort on the analysis of cognitive networks. "We are excited to have Dr. Tural with us. The work he will do here will have an impact on how large mobile ad hoc networks are managed," says van den Berg.

Prashant Athavale, a postdoc from the Institute of Pure and Applied Mathematics (IPAM), will collaborate with scientists at Placental Analytics, a company that studies the effect of placenta structure on fetal development. The placenta can be used to track fetal development, faithfully retaining information about possible prenatal problems and acting as a predictor of adult health risks. The postdoc will apply his training in image processing to study irregularities of placenta structure and develop models of placental vascular branching.

Among the ten postdoctoral NSF fellowships awarded through the Mathematical Sciences Research Institute (MSRI) in Berkeley, California, is Sikimeti Ma'u, originally from Tonga and now a permanent U.S. resident. Sikimeti will pursue research in geometry and topology as a postdoctoral fellow at MSRI in 2009–10. Then her NSF fellowship award will take her to Barnard, which has historic legacy as a college for women, to be mentored by the distinguished topologist Dusa McDuff. "It's a really exciting opportunity," remarked Ma'u, "to be at the MSRI while so many leading mathematicians in the field will be there and to be mentored by one of them. I'm very grateful to the NSF and MSRI."

At the Statistical and Applied Mathematical Sciences Institute (SAMSI), the new postdoctoral fellows will be joining the existing postdoctoral program, as this ensures that the fellows will become involved in highly interdisciplinary research, a potential key for their future employment. The postdoctoral appointments will typically be for two years. For those interested in an eventual academic position, the appointments will involve teaching at one of the partner universities of SAMSI (Duke University, North Carolina State University, and the University of North Carolina at Chapel Hill) to ensure that they will enhance their teaching skills.

Jean-Philippe Lessard, currently a postdoc at Rutgers, The State University of New Jersey, has been selected by the School of Mathematics at the Institute for Advanced Study (IAS) for an appointment at Rutgers beginning in September of 2009. Lessard is developing new techniques to deal with large amounts of data. Complicated problems, such as those arising in biology or engineering, can be modeled on a computer, but the result is often too much data and too little understanding of the essential qualitative behavior of the system. One solution to this problem of data overload comes from algebraic topology, which is traditionally a very pure branch of mathematics. This project concerns an abstract and notoriously difficult-to-calculate notion of algebraic topology—Morse homology, as developed by Morse, Conley, Witten, and Floer. The goal is to make it computable.

Julia Chifman, a postdoc at the Mathematical Biosciences Institute (MBI), will be exploring the genetic relationship between species. Phylogenetics studies the evolutionary history of a group of organisms, for example, the evolution of different forms of the flu virus. These histories can be illustrated through graphs called phylogenetic trees, and Chifman will use her training in algebraic methods to work on the mathematical structure of these trees. Ultimately such studies can lead to more efficient reconstruction algorithms and to new hypotheses for evolutionary biologists to study.

—NSF Mathematical Sciences Institutes news release

Inside the AMS

Fan China Exchange Program Names Awardees

The Society's Fan China Exchange Program awards grants to support collaborations between Chinese and U.S. or Canadian researchers. Institutions in the United States or Canada apply for the funds to support a visitor from China or vice versa. This funding is made possible through a generous gift made to the AMS by Ky and Yu-Fen Fan in 1999. The total amount available for grants this year was US$18,000. The awardees for 2009 follow.

RUTGERS UNIVERSITY received a grant of US$4,000 to support a visit by Wanke Yin of Wuhan University.

The UNIVERSITY OF KENTUCKY was awarded a grant of US$2,500 to support a visit by Shijin Ding of South China Normal University.

NORTH CAROLINA STATE UNIVERSITY received a US$5,000 grant to support a visit by Honglian Zhang of Shanghai University.

OKLAHOMA STATE UNIVERSITY received a grant of US$3,000 to support a visit by Baoquan Yuan of Henan Polytechnic University.

INNER MONGOLIA UNIVERSITY was awarded a grant of US$3,500 to support a visit by Anton Zettl of Northern Illinois University.

For information about the Fan China Exchange Program, visit the website `http://www.ams.org/employment/chinaexchange.html` or contact the AMS Membership and Programs Department, email: `chinaexchange@ams.org`, telephone 401-455-4170 (within the U.S. call 800-321-4267, ext. 4170).

—Elaine Kehoe

Math in Moscow Scholarships Awarded

The AMS has made awards to six mathematics students to attend the Math in Moscow program in the fall of 2009. The names of the undergraduate students and their institutions are NATE BOTTMAN, University of Washington; MICHAEL DONATZ, Oregon State University; LEONARD FORET, Florida International University; NATALIE SHEILS, Seattle University; DAVID SHOR, Florida International University; and MICHAEL WEISS, New York University.

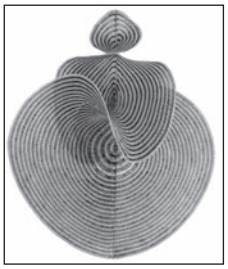
Math in Moscow is a program of the Independent University of Moscow that offers foreign students (undergraduate or graduate students specializing in mathematics and/or computer science) the opportunity to spend a semester in Moscow studying mathematics. All instruction is given in English. The fifteen-week program is similar to the Research Experiences for Undergraduates programs that are held each summer across the United States.

Since 2001 each semester the AMS has awarded several scholarships for U.S. students to attend the Math in Moscow program. The scholarships are made possible through a grant from the National Science Foundation. For more information about Math in Moscow, consult `http://www.mccme.ru/mathinmoscow` and the article "Bringing Eastern European mathematical traditions to North American students", *Notices*, November 2003, pages 1250–4.

—Elaine Kehoe

From the AMS Public Awareness Office

Mathematical Imagery. Two albums, *Crocheted Lorenz Manifolds* (`http://www.ams.org/mathimagery/thumbnails.php?album=24`) and *Simulated Snowflakes* (`http://www.ams.org/mathimagery/thumbnails.php?album=25`), were recently added to Mathematical Imagery. All of the albums, including nearly 200 images that can be sent as e-postcards, may be viewed at `http://www.ams.org/mathimagery/`.



Images: "Crocheted Lorenz manifold, white background" (top, right), by Hinke Osinga, in collaboration with Bernd Krauskopf, Department of Engineering Mathematics, University of Bristol; and "Snowflake Model 12" (bottom, right), by David Griffeath, University of Wisconsin-Madison, and Janko Gravner, University of California, Davis.

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

Discussion on "The Mathematics behind Tom Stoppard's *Arcadia*"

The American Mathematical Society (AMS) and the Mathematical Association of America (MAA) hosted a discussion on mathematics and the theatre on May 18, 2009, in Washington, DC. The event was held in conjunction with the production of Tom Stoppard's acclaimed play *Arcadia*, performed at Washington's Folger Theatre May 5–June 14, 2009.

Arcadia juxtaposes the past with the present to illustrate the connections between people, their ideas, and scientific understanding. The play references such mathematical topics as iterated algorithms, fractals, chaos, and Fermat's Last Theorem in its portrayal of our search for knowledge.

Cast member Erin Weaver, playing the child prodigy in *Arcadia*, and the Folger's Dramaturg, Michele Osherow, joined Production Mathematics Consultant Manil Suri (novelist and professor of mathematics at the University of Maryland, Baltimore County) in leading attendees in a discussion of the challenges of representing mathematics—and mathematicians—on stage. "m(Arcadia)", a video prepared by Suri to explain the mathematics behind the play, may be viewed at `http://www.YouTube.com`.

Editor's Note: A review of the Lincoln Center production of *Arcadia* appeared in the November 1995 issue of the *Notices*.

—Anita Benjamin, AMS Washington Office

AMS Lecturers for Cambodian Master's Degree Program

In 2008 and again in 2009, the AMS has supported the teaching of a 3-week intensive course in Real Analysis at the Royal University of Phnom Penh in Cambodia. The course was given in spring 2008 by John Lamperti of Dartmouth College and in spring 2009 by Eduardo Cattani of the University of Massachusetts at Amherst. The AMS support of these courses is part of the Visiting Lecturer Program of the U.S. National Committee for Mathematics (USNCM). The AMS donation of approximately US$5,000 each year covers the lecturer's travel and living expenses.

The USNCM, a committee of the U.S. National Academy of Sciences, is the United States's adhering organization to the International Mathematical Union. The USNCM developed the Visiting Lecturer Program to foster productive interaction between the mathematical community of the developed world and the vast, mostly untapped reservoir of talent in the developing world. The series provides intensive courses at the advanced undergraduate level. Courses must be part of a recognized degree program in advanced mathematics at the host university.

The series was created in response to an appeal from French and Cambodian mathematicians for U.S. assistance in teaching short intensive courses at the advanced undergraduate level in a Master's degree program organized by the Centre International de Mathématiques Pures et Appliquées (CIMPA) at the Royal University of Phnom Penh. To date, support for lecturers has been provided by the AMS, the Society for Industrial and Applied Mathematics, and USNCM itself.

Although the devastation of Cambodian mathematical infrastructure during the late 1970s, down through even the elementary school level, is well known and perhaps particularly tragic, there are many cases of comparable needs at other universities in the developing world. As a response, the International Mathematical Union is partnering with CIMPA and USNCM to expand the Volunteer Lecturer Program to reach other countries.

In 2009 the Visiting Lecturer Series enabled four U.S. mathematicians to teach courses at the Royal University of Phnom Penh. In addition to Cattani, the other lecturers in the series in 2009 are William Murray (California State University), Jan Hannig (University of North Carolina), and Angel Piñeda (California State University).

The 2008 lecturers supported in Cambodia were, in addition to Lamperti, Jan Hannig (Colorado State University), and Yontha Ath (Aerospace Corporation).

The outpouring of interest in volunteering by AMS membership to give short courses in the developing world, much of it in response to an AMS appeal for the Cambodia program, has been overwhelming. The program size and scope is only limited at the moment by USNCM's limited ability to raise the US$5,000 increments, each one necessary to fund the participation of one more lecturer in the program.

For more information about the USNCM and the Visiting Lecturer Program, visit the website `http://sites.nationalacademies.org/pga/biso/IMU/index.htm`.

—Herb Clemens, Ohio State University, USNCM Chair

"Stipends for Study and Travel" to Appear Only on Web

The "Stipends for Study and Travel", which lists a wide variety of fellowship and postdoctoral opportunities, has for many years appeared annually in the September issue of the *Notices*. The AMS Membership and Programs Department, which prepares the "Stipends" section, identified this service as one that would be more useful to offer on the Web than in print. Starting in 2009, the "Stipends" list will appear only on the Web and not in print in the *Notices*. The Web presentation will allow for continual updates to the "Stipends" information, rather than the once-a-year updates that were possible in the *Notices*.

A preliminary version of the "Stipends" list is available at `http://www.ams.org/employment/stipends-list.html`.

—AMS Membership and Programs Department

Corrections

Due to technical problems, characters were missing in some math expressions in two of the articles in the June/July issue of the *Notices*.

On page 698 in the "Remembering Atle Selberg" article, in Peter Sarnak's essay, the following sentences were missing characters and should be corrected (adding missing parentheses, a comma, plus signs, and a period) to read:

It was before the days of computers, and Chowla had noted that $L(\frac{1}{2}, \chi)$ must be nonnegative for a quadratic Dirichlet character, for otherwise the Riemann Hypothesis is false for this Dirichlet L-function. He wanted to compute these numbers for various χ's, such as the one corresponding to $\mathbb{Q}(\sqrt{-163})$, where he expected the value was small.

In describing his method, Selberg used Dirichlet's notation for binary quadratic forms, $ax^2 + bxy + cy^2$ (as most of us do today), but Chowla was old-fashioned and used Gauss's notation, $ax^2 + 2bxy + cy^2$. Once this inconsistency was clarified, the value turned up positive (it is 0.0685…).

In the same article, in Brian Conrey's essay, on page 706, the following sentence should be corrected (adding a slash between the 1 and the 2) to:

What is striking about Selberg's formulation is that he got exactly the right set of axioms (down to the—at first sight mysterious—$\theta < 1/2$) to provide an analytic framework for future work.

Several instances of missing characters occurred in the book review by Chelluri C. A. Sastri on pages 726–728. In the first instance, on page 727, the following sentence should be corrected (adding parentheses) to read:

In this connection, he mentions two examples, the first of which trips people up because they don't know or understand the monotonic nature of probability (if $A \subset B$, then $P(A) \leq P(B)$), while the second one causes trouble because in it a single event is described in two different ways, leading to the misperception that two distinct events are being referred to.

On page 728, equal signs should have appeared in the following sentence so it would correctly read:

For example, on page 68 he refers to what is called the Weber-Fechner Principle, which says $S = k \log R$, where S = Sensory Response and R = Stimulus; k is presumably a constant.

The *Notices* regrets these errors.

Deaths of AMS Members

MICHAEL O. ALBERTSON, professor, Smith College, died on March 21, 2009. Born on June 24, 1946, he was a member of the Society for 40 years.

C. D. ALIPRANTIS, professor, Purdue University, died on February 27, 2009. Born on May 12, 1946, he was a member of the Society for 37 years.

ALLAN G. ANDERSON, from Basking Ridge, NJ, died on November 5, 2008. Born on October 30, 1923, he was a member of the Society for 56 years.

CHARLES S. BALLANTINE, professor emeritus, Oregon State University, died on December 23, 2008. Born on August 27, 1929, he was a member of the Society for 54 years.

ROBERT D. BARNARD, retired professor, Wayne State University, College of Engineering, died on April 2, 2008. Born on March 17, 1929, he was a member of the Society for 43 years.

CLAUDE W. BURRILL, professor, University of Iowa, died on October 20, 2008. Born on February 19, 1925, he was a member of the Society for 55 years.

ELVY L. FREDRICKSON, professor emeritus, Lewis and Clark College, died on December 11, 2008. Born on July 11, 1921, he was a member of the Society for 54 years.

EDWARD D. GAUGHAN, from Mesilla Park, NM, died on March 6, 2009. Born on January 30, 1931, he was a member of the Society for 50 years.

IRVING JOHN GOOD, professor, Virginia Polytechnic Institute and State University, died on April 5, 2009. Born on December 9, 1916, he was a member of the Society for 40 years.

RICHARD A. GOOD, from McLean, VA, died on November 24, 2008. Born on September 24, 1917, he was a member of the Society for 67 years.

EDMUND HLAWKA, retired, Vienna University of Technology, died on February 19, 2009. Born on November 5, 1916, he was a member of the Society for 49 years.

HARRY HOCHSTADT, retired professor, Polytech University, Brooklyn, died on May 4, 2009. Born on September 7, 1925, he was a member of the Society for 55 years.

RICHARD A. HUNT, professor, Purdue University, died on March 22, 2009. Born on June 16, 1937, he was a member of the Society for 42 years.

KI HANG KIM, professor, Alabama State University, died on January 15, 2009. Born on August 5, 1936, he was a member of the Society for 40 years.

JOHN R. KNUDSEN, from Austin, TX, died on February 6, 2009. Born on July 12, 1916, he was a member of the Society for 50 years.

BRUCE E. MESERVE, from Green Valley, AZ, died on November 14, 2008. Born on February 2, 1917, he was a member of the Society for 66 years.

F. VIRGINIA ROHDE, retired professor, Mississippi State University, died on December 5, 2008. Born on May 15, 1918, she was a member of the Society for 58 years.

PAUL T. ROTTER, from San Diego, CA, died on February 24, 2009. Born on February 21, 1918, he was a member of the Society for 60 years.

DOMINICK A. RUSSO, from Chappaqua, NY, died on August 2, 2008. Born on October 21, 1928, he was a member of the Society for 51 years.

JOSEPH A. SCHATZ, professor emeritus, University of Houston, died on August 10, 2007. Born on June 23, 1924, he was a member of the Society for 58 years.

JACOB T. SCHWARTZ, professor, New York University, died on March 2, 2009. Born on January 9, 1930, he was a member of the Society for 62 years.

JOHN J. SWEENEY, retired professor, Indiana University of Pennsylvania, died on September 19, 2008. Born on April 10, 1928, he was a member of the Society for 2 years.

Reference and Book List

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

Contacting the *Notices*

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

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

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

Upcoming Deadlines

July 23, 2009: Proposals for NSF Faculty Early Career Development (CAREER) Program. See "Mathematics Opportunities" in this issue.

July 31, 2009: Nominations for ICTP Ramanujan Prize. See http://prizes.ictp.it/Ramanujan/.

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

August 4, 2009: Full proposals (by invitation only) for NSF Partnerships for International Research and

Where to Find It

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

AMS Bylaws—*November 2007, p. 1366*

AMS Email Addresses—*February 2009, p. 278*

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

AMS Officers 2008 and 2009 Updates—*May 2009, p. 651*

AMS Officers and Committee Members—*October 2008, p. 1122*

Conference Board of the Mathematical Sciences—*September 2008, p. 980*

IMU Executive Committee—*December 2008, p. 1441*

Information for *Notices* Authors—*June/July 2009, p. 749*

Mathematics Research Institutes Contact Information—*August 2009, p. 854*

National Science Board—*January 2009, p. 67*

New Journals for 2008—*June/July 2009, p. 751*

NRC Board on Mathematical Sciences and Their Applications—*March 2009, p. 404*

NRC Mathematical Sciences Education Board—*April 2009, p. 511*

NSF Mathematical and Physical Sciences Advisory Committee—*February 2009, p. 278*

Program Officers for Federal Funding Agencies—*October 2008, p. 1116 (DoD, DoE); December 2007, p. 1359 (NSF); December 2008, p. 1440 (NSF Mathematics Education)*

Program Officers for NSF Division of Mathematical Sciences—*November 2008, p. 1297*

Stipends for Study and Travel—*September 2008, p. 983*

Education (PIRE). See http://www.nsf.gov/pubs/2009/nsf09505/nsf09505.htm.

August 15, 2009: Nominations for SASTRA Ramanujan Prize. See http://www.math.ufl.edu/sastra-prize/nominations-2008.html.

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

August 21, 2009: Letters of intent for NSF Focused Research Groups (FRG). See "Mathematics Opportunities" in this issue.

September 1–November 15, 2009: Applications for travel grants to ICM 2010. See "Mathematics Opportunities" in this issue.

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

September 15, 2009: Nominations for Alfred P. Sloan Foundation Fellowships. See "Mathematics Opportunities" in this issue.

September 18, 2009: Full proposals NSF Focused Research Groups (FRG). See "Mathematics Opportunities" in this issue.

September 30, 2009: Nominations for 2009 Sacks Prize. See "Mathematics Opportunities" in this issue.

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

October 15, 2009: Proposals for NSA Grants for Research in Mathematics. See "Mathematics Opportunities" in this issue.

October 15, 2009: Nominations for Emanuel and Carol Parzen Prize for Statistical Innovation. See http://www.stat.tamu.edu/events/parzenprize/nominations.pdf.

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

November 1, 2009: Nominations for Vasil Popov Prize. See http://www.math.sc.edu/~popov/.

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

November 12, 2009: Full proposals for NSF Project ADVANCE Institutional Transformation (IT) and Institutional Transformation Catalyst (IT-Catalyst) awards. See http://www.nsf.gov/pubs/2009/nsf09504/nsf09504.htm.

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

December 4, 2009: Entries for 2009 Ferran Sunyer i Balaguer Prize. See "Mathematics Opportunities" in this issue.

Contact Information for Mathematics Institutes

American Institute of Mathematics
360 Portage Avenue
Palo Alto, CA 94306-2244
Telephone: 650-845-2071
Fax: 650-845-2074
email: conrey@aimath.org
http://www.aimath.org

Stefan Banach International Mathematical Center
8 Śniadeckich str., Room 426
P.O. Box 21
00-956 Warszawa, Poland
Telephone: 48 22 522-82-32
Fax: 48 22 622-57-50
email: Banach.Center.Office@impan.pl
http://www.impan.gov.pl/BC

Banff International Research Station
c/o PIMS Central Office
University of British Columbia
200-1933 West Mall
Vancouver, BC V6T 1Z2, Canada
Telephone: 604-822-1649
Fax: 604-822-0883
email: birs-director@birs.ca
http://www.birs.ca

Center for Discrete Mathematics and Theoretical Computer Science (DIMACS)
CoRE Building, 4th Floor
Rutgers University
96 Frelinghuysen Road
Piscataway, NJ 08854-8018
Telephone: 732-445-5930
Fax: 732-445-5932
email: center-admin@dimacs.rutgers.edu
http://dimacs.rutgers.edu

Center for Scientific Computation and Mathematical Modeling (CSCAMM)
University of Maryland
4146 CSIC Building #406
Paint Branch Drive
College Park, MD 20742-3289
Telephone: 301-405-0662
Fax: 301-314-6674
email: info@cscamm.umd.edu
http://www.cscamm.umd.edu/

Center for the Topology and Quantization of Moduli Spaces
Department of Mathematical Sciences
Faculty of Science
University of Aarhus
Ny Munkegade, Building 1530
8000 Aarhus C, Denmark
Telephone: 45 8942 3432
email: ctqm@imf.au.dk
http://www.ctqm.au.dk/

Centre International de Rencontres Mathématiques (CIRM)
163, avenue de Luminy Case 916
F-13288 Marseille Cedex 09, France
Telephone: 33 04 91 83 30 00
Fax: 33 04 91 83 30 05
email: colloque@cirm.univ-mrs.fr

http://www.cirm.univ-mrs.fr

Centre de Recerca Matemática (CRM)
Apartat 50
E 08193 Bellaterra
Barcelona, Spain
Telephone: 34 93 581 1081
Fax: 34 93 581 2202
email: crm@crm.cat
http://www.crm.cat

Centre for Mathematics and Its Applications
Building 27
Australian National University
Canberra ACT 0200, Australia
Telephone: 61 2 6125 2897
Fax: 61 2 6125 5549
email: MathsAdmin@maths.anu.edu.au
http://www.maths.anu.edu.au/CMA/

Centre de Recherches Mathématiques (CRM)
Université de Montréal
C.P. 6128, Succ. Centre-ville
Montréal, Quebec, Canada H3C 3J7
Telephone: 514 343 7501
Fax: 514 343 2254
email: CRM@CRM.UMontreal.ca
http://www.crm.umontreal.ca

Centro de Investigación en Matemáticas (CIMAT)
Jalisco S/N, Col. Valenciana
CP: 36240
Guanajuato, Gto, México
Telephone: +52 473 732 7155/735 0800
Fax: +52 473 732 5749
email: jcarlos@cimat.mx
http://www.cimat.mx

Centro di Ricerca Matematica Ennio de Giorgi
Collegio Puteano
Scuola Normale Superiore
Piazza dei Cavalieri, 3
I-56100 Pisa, Italy
Telephone: 39 (050) 509256
email: crm@crm.sns.it
http://www.crm.sns.it/index_02.html

Centro Internazionale per la Ricerca Matematica
Fondazione Bruno Kessler
Via Sommarive, 14 Povo
38100 Trento, Italy
Telephone: 39-0461-881628
Fax: 39-0461-810629
email: michelet@science.unitn.it
http://www.science.unitn.it/cirm/

Chennai Mathematical Institute
Plot H1, SIPCOT IT Park
Padur PO, Siruseri 603103
India
Telephone: 91-44-3298-3441, 91-44-3298-3442
Fax: 91-44-2747-0225
email: office@cmi.ac.in
http://www.cmi.ac.in

Chern Institute of Mathematics
Nankai University
Tianjin 300071, China
Telephone: 86-22-2350-8228
Fax: 86-22-2350-1532
email: cim@nankai.edu.cn
http://www.nim.nankai.edu.cn/nim_e/index.htm

Euler International Mathematical Institute
nab. Fontanki, 27
St. Petersburg 191023, Russia
Telephone: 7 812 312-40-58
Fax: 7 812 310-53-77
email: admin@euler.pdmi.ras.ru
http://www.pdmi.ras.ru/EIMI/index.html

Fields Institute for Research in Mathematical Sciences
222 College Street, 2nd Floor
Toronto, Ontario M5T 3J1 Canada
Telephone: 416 348 9710
Fax: 416 348 9714
email: geninfo@fields.utoronto.ca
http://www.fields.utoronto.ca/

Forschungsinstitut für Mathematik (FIM)
Eidgenössische Technische Hochschule Zentrum
Rämistrasse 101
8092 Zurich, Switzerland
Telephone: 41-44-632-3475
email: marcela.kraemer@fim.math.ethz.ch
http://www.fim.math.ethz.ch/

Institut des Hautes Études Scientifiques (IHÉS)
Le Bois Marie 35, route de Chartres
F 91440 Bures sur Yvette, France
Telephone: 33 1 60 92 66 00
Fax: 33 1 60 92 66 69
http://www.ihes.fr

Institut Henri Poincaré
11, rue Pierre et Marie Curie
75231 Paris Cedex 05, France
Telephone : 01 44 27 67 89
Fax : 01 44 07 09 37
http://www.ihp.jussieu.fr/

Institut Mittag-Leffler
Auravägen 17
SE-182 60 Djursholm, Sweden
Telephone: 46-8-622 05 60
Fax: 46-8-622 05 89
email: info@mittag-leffler.se
http://www.mittag-leffler.se/

Institute for Advanced Study (IAS)
School of Mathematics
Einstein Drive
Princeton, NJ 08540
Telephone: 609 734 8100
Fax: 609 951-4459
email: math@math.ias.edu
http://www.math.ias.edu/

Institute for Mathematical Sciences
National University of Singapore
3 Prince George's Park
Singapore 118402, Republic of Singapore
Telephone: 65 6516 1897
Fax: 65 6873 8292
email: ims@nus.edu.sg
http://www.ims.nus.edu.sg

Institute of Mathematical Sciences
Chinese University of Hong Kong
Unit 601
Academic Building No. 1
Shatin, N. T., Hong Kong
Telephone: 852 2609 8038
Fax: 852 2603 7636
email: ims@ims.cuhk.edu.hk
http://www.ims.cuhk.edu.hk

Institute for Mathematics and its Applications (IMA)
University of Minnesota
114 Lind Hall
207 Church Street, SE
Minneapolis, MN 55455-0134
Telephone: 612-624-6066
Fax: 612-626-7370

email: staff@ima.umn.edu
http://www.ima.umn.edu/

Institute for Pure and Applied Mathematics (IPAM)
IPAM Building
460 Portola Plaza
Box 957121
Los Angeles, CA 90095-7121
Telephone: 310 825 4755
Fax: 310 825-4756
email: ipam@ucla.edu
http://www.ipam.ucla.edu

Institute for Research in Fundamental Sciences
School of Mathematics
P. O. Box 19395-5746
Tehran, Iran
Telephone: 98-21-22290928
Fax: 98-21-22290648
email: ipmmath@ipm.ir
http://math.ipm.ac.ir

Instituto Nacional de Matemática Pura e Aplicada (IMPA)
Estrada Dona Castorina, 110
Rio de Janeiro, RJ, Brazil 22460-320
Telephone: 55 21 2529 5000
Fax: 55 21 2512 4115
email: diretor@impa.br
http://www.impa.br

International Center for Theoretical Physics (ICTP)
Strada Costiera 11
34151 Trieste, Italy
Telephone: 39 040 2240111
Fax: 39 040 224163
email: sci_info@ictp.it
http://www.ictp.it

International Centre for Mathematical Sciences (ICMS)
14 India Street
Edinburgh EH3 6EZ
United Kingdom
Telephone: 44 (0)131 220 1777
Fax: 44 (0)131 220 1053
email: enquiries@icms.org.uk
http://www.icms.org.uk/index.php

Isaac Newton Institute for Mathematical Sciences
20 Clarkson Road
Cambridge CB3 0EH
United Kingdom
Telephone: 44 1223 335999
Fax: 44 1223 330508
email: info@newton.cam.ac.uk
http://www.newton.cam.ac.uk/

Korea Institute for Advanced Study (KIAS)
207-43 Cheongnyangni 2-dong
Dongdaemun-gu
Seoul 130-722, Korea
Telephone: 82-2-958-3711
Fax: 82-2-958-3770
http://www.kias.re.kr/en/index.jsp

Mathematical Biosciences Institute
The Ohio State University
Jennings Hall, 3rd Floor
1735 Neil Avenue
Columbus, Ohio 43210
Telephone: 614-292-3648
Fax: 614-247-6643
email: rebecca@mbi.osu.edu
http://www.mbi.osu.edu

Mathematical Sciences Research Institute (MSRI)
17 Gauss Way
Berkeley, CA 94720 5070
Telephone: 510 642 0143
Fax: 510 642 8609
email: msri-inquiries@msri.org
http://www.msri.org/

Mathematisches Forschungs Institut (Oberwolfach)
Schwarzwaldstr. 9-11 (Lorenzenhof)
D 77709 Oberwolfach Walke
Germany
Telephone: 49 7834 979 0
Fax: 49 7834 979 38
email: admin@mfo.de
http://www.mfo.de

Max Planck Institut für Mathematik
P.O. Box 7280
53072 Bonn, Germany
Telephone: 49 228 402 0
Fax: 49 228 402277
email: admin@mpim-bonn.mpg.de
http://www.mpim-bonn.mpg.de

Max Planck Institut für Mathematik in den Naturwissenschaften
Inselstrasse 22
04103 Leipzig, Germany
Telephone: 49 (0) 341 99 59 50
Fax: 49 (0) 341 99 59 65 8
email: vah@mis.mpg.de
http://www.mis.mpg.de/

New Zealand Institute of Mathematics and Its Applications (NZIMA)
University of Auckland
Private Bag 92019
Auckland, New Zealand
Telephone: 64 (0)9 373 7599 ext. 82025
Fax: 64 (0)9 373 7457
email: nzima-admin@nzima.auckland.ac.nz
http://www.nzima.org

Pacific Institute for the Mathematical Sciences (PIMS)
University of British Columbia
1933 West Mall, Room 200
Vancouver, BC, V6T 1Z2, Canada
Telephone: 604-822-3922
Fax: 604-822-0883
email: reception@pims.math.ca
http://www.pims.math.ca

Alfréd Rényi Institute of Mathematics
Hungarian Academy of Sciences
POB 127
H-1364 Budapest, Hungary
Telephone: 36 1-483-8302
Fax: 36 1-483-8333
email: math@renyi.hu
http://www.renyi.hu

Research Institute for Mathematical Sciences (RIMS)
Kyoto University
Kyoto, 606 8502, Japan
Telephone: 81-75-753-7251
Fax: 81-75-753-7266
http://www.kurims.kyoto-u.ac.jp/

Erwin Schrödinger International Institute for Mathematical Physics
Boltzmanngasse 9
A-1090 Vienna, Austria
Telephone 43 1 4277 28282
Fax: 43 1 4277 28299
email: secr@esi.ac.at
http://www.esi.ac.at/

Sobolev Institute of Mathematics
Russian Academy of Sciences
Siberian Branch
4 Acad. Koptyug Avenue
630090 Novosibirsk, Russia
Telephone: 383 333 28 92
Fax: 383 333 25 98
email: im@math.nsc.ru
http://math.nsc.ru

Statistical and Applied Mathematical Sciences Institute (SAMSI)
19 T. W. Alexander Drive
P.O. Box 14006
Research Triangle Park, NC 27709-4006
Telephone: 919-685-9350
Fax: 919-685-9360
email: info@samsi.info
http://www.samsi.info/

Steklov Institute of Mathematics
Russian Academy of Sciences
Gubkina str. 8
119991, Moscow, Russia
Telephone: 7 499 135-22-91
Fax: 7 499 135-05-55
email: steklov@mi.ras.ru
http://www.mi.ras.ru

Steklov Institute of Mathematics
27, Fontanka
St. Petersburg 191023, Russia
Telephone: 7 812 312-40-58
Fax: 7 812 310-53-77
email: admin@pdmi.ras.ru
http://www.pdmi.ras.ru

Tata Institute of Fundamental Research
School of Mathematics
Dr. Homi Bhabha Road
Mumbai 400 005, India
Telephone: 91 22 22782000
Fax: 91 22 22804610; 91 22 22804611
http://www.math.tifr.res.in

T. N. Thiele Centre for Applied Mathematics in Natural Science
University of Aarhus
Department of Mathematical Sciences
Ny Munkegade 118, Building 1530
DK-8000 Aarhus C, Denmark
Telephone: 45 8942 3515
Fax: 45 8613 1769
email: thiele@imf.au.dk
http://www.thiele.au.dk

Warwick Mathematics Research Centre
University of Warwick
Coventry CV4 7AL, United Kingdom
Telephone: +44 (0)24 7652 8317
Fax: +44 (0)24 7652 3548
email: mrc@maths.warwick.ac.uk
http://www.maths.warwick.ac.uk/mrc/index.html

Weierstrass Institute for Applied Analysis and Stochastics
Mohrenstrasse 39
10117 Berlin, Germany
Telephone: 49-30-203720
Fax: 49-30-2044975
email: contact@wias-berlin.de
http://www.wias-berlin.de/

Book List

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

*Added to "Book List" since the list's last appearance.

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

The Annotated Turing: A Guided Tour Through Alan Turing's Historic Paper on Computability and the Turing Machine, by Charles Petzold. Wiley, June 2008. ISBN-13: 978-04702-290-57.

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

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

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

**The Calculus of Friendship: What a Teacher and Student Learned about Life While Corresponding about Math*, by Steven Strogatz. Princeton University Press, August 2009. ISBN-13: 978-06911-349-32.

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

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

**Chez les Weils (French)*, by Sylvie Weil. Buchet-Chastel, January 2009. ISBN-13: 978-22830-236-93.

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

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

**Decoding the Heavens: A 2,000-Year-Old Computer—and the Century-Long Search to Discover Its Secrets*, by Jo Marchant. Da Capo Press, February 2009. ISBN-13: 978-03068-174-27.

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

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

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

Einstein's Mistakes: The Human Failings of Genius, by Hans C. Ohanian. W. W. Norton, September 2008. ISBN-13: 978-0393062939.

Embracing the Wide Sky: A Tour Across the Horizons of the Human Mind, by Daniel Tammet. Free Press, January 2009. ISBN-13: 978-14165-696-95.

Emmy Noether: The Mother of Modern Algebra, by M. B. W. Tent. A K Peters, October 2008. ISBN-13: 978-15688-143-08.

**Ernst Zermelo: An Approach to His Life and Work*, by Heinz-Dieter Ebbinghaus. Springer, April 2007. ISBN-13 978-3-540-49551-2. (Reviewed this issue.)

Euler's Gem: The Polyhedron Formula and the Birth of Topology, by David S. Richeson. Princeton University Press, September 2008. ISBN-13: 97-80691-1267-77.

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

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

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

**Gaming the Vote (Why Elections Aren't Fair and What We Can Do About It)*, by William Poundstone. Hill and Wang, February 2009. ISBN-13: 978-08090-489-22.

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

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

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

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

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

Hexaflexagons, Probability Paradoxes, and the Tower of Hanoi: Martin Gardner's First Book of Mathematical Puzzles and Games, by Martin Gardner. Cambridge University Press, September 2008. ISBN-13: 978-0-521-73525-4.

The Housekeeper and the Professor, by Yoko Ogawa. Picador, February 2009. ISBN-13: 978-03124-278-01.

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

How to Think Like a Mathematician: A Companion to Undergraduate Mathematics, by Kevin Houston Cambridge University Press, March 2009. ISBN-13: 978-05217-197-80.

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

Is God a Mathematician? by Mario Livio. Simon & Schuster, January 2009. ISBN-13: 978-07432-940-58.

Kiss My Math: Showing Pre-Algebra Who's Boss, by Danica McKellar. Hudson Street Press, August 2008. ISBN-13: 978-1594630491.

The Last Theorem, by Arthur C. Clarke and Frederik Pohl. Del Rey, August 2008. ISBN-13: 978-0345470218.

Leonhard Euler and His Friends: Switzerland's Great Scientific Expatriate, by Luis-Gustave du Pasquier (translated by John S. D. Glaus). CreateSpace, July 2008. ISBN: 978-14348-332-73.

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

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

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

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

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

Mathematicians of the World, Unite!: The International Congress of Mathematicians: A Human Endeavor, by Guillermo P. Curbera. A K Peters, March 2009. ISBN-13: 978-15688-133-01.

Mathematics and the Aesthetic: New Approaches to an Ancient Affinity, edited by Nathalie Sinclair, David Pimm, and William Higginson. Springer, November 2006. ISBN-13: 978-03873-052-64. (Reviewed February 2009.)

Mathematics and Common Sense: A Case of Creative Tension, by Philip J. Davis. A K Peters, October 2006. ISBN 1-568-81270-1. (Reviewed June/July 2009.)

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

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

Mathematics Emerging: A Sourcebook 1540–1900, by Jacqueline Stedall. Oxford University Press, November 2008. ISBN-13: 978-01992-269-00.

Mathematics in Ancient Iraq: A Social History, by Eleanor Robson. Princeton University Press, August 2008. ISBN13: 978-06910-918-22.

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

**Mathematics in 10 Lessons: The Grand Tour*, by Jerry P. King. Prometheus Books, May 2009. ISBN: 978-1-59102-686-0.

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

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

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

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

The Numbers Game: The Commonsense Guide to Understanding Numbers in the News, in Politics, and in Life, by Michael Blastland and Andrew Dilnot. Gotham, December 2008. ISBN-13: 978-15924-042-30.

The Numerati, by Stephen Baker. Houghton Mifflin, August 2008. ISBN-13: 978-06187-846-08.

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

Origami, Eleusis, and the Soma Cube: Martin Gardner's Mathematical Diversions, by Martin Gardner. Cambridge University Press,

September 2008. ISBN-13: 978-0-521-73524-7.

Our Days Are Numbered: How Mathematics Orders Our Lives, by Jason Brown. McClelland and Stewart, to appear April 2009. ISBN-13: 978-07710-169-67.

Out of the Labyrinth: Setting Mathematics Free, by Robert Kaplan and Ellen Kaplan. Oxford University Press, January 2007. ISBN-13: 978-0-19514-744-5. (Reviewed June/July 2009.)

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

**Picturing the Uncertain World: How to Understand, Communicate, and Control Uncertainty through Graphical Display*, by Howard Wainer, Princeton University Press, April 2009. ISBN-13: 978-06911-375-99.

Plato's Ghost: The Modernist Transformation of Mathematics, by Jeremy Gray. Princeton University Press, September 2008. ISBN-13: 978-06911-361-03.

The Princeton Companion of Mathematics, edited by Timothy Gowers (June Barrow-Green and Imre Leader, associate editors). Princeton University Press, November 2008. ISBN-13: 978-06911-188-02.

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

**Pythagoras' Revenge: A Mathematical Mystery*, by Arturo Sangalli. Princeton University Press, May 2009. ISBN-13: 978-06910-495-57.

Pythagorean Crimes, by Tefcros Michalides. Parmenides Publishing, September 2008. ISBN-13: 978-19309-722-78. (Reviewed January 2009.)

Recountings: Conversations with MIT Mathematicians, edited by Joel Segel. A K Peters, January 2009. ISBN-13: 978-15688-144-90.

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

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

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

Sacred Mathematics: Japanese Temple Geometry, by Fukagawa Hidetoshi and Tony Rothman. Princeton University Press, July 2008. ISBN-13: 978-0-6911-2745-3.

The Shape of Content: An Anthology of Creative Writing in Mathematics and Science, edited by Chandler Davis, Marjorie Wikler Senechal, and Jan Zwicky. A K Peters, November 2008. ISBN-13: 978-15688-144-45.

Souvenirs sur Sofia Kovalevskaya (French), by Michèle Audin. Calvage et Mounet, October 2008. ISBN-13: 978-29163-520-53.

Strange Attractors: Poems of Love and Mathematics, edited by Sarah Glaz and JoAnne Growney. A K Peters, November 2008. ISBN-13: 978-15688-134-17.

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

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

Tools of American Math Teaching, 1800–2000, by Peggy Aldrich Kidwell, Amy Ackerberg-Hastings, and David Lindsay Roberts. Johns Hopkins University Press, July 2008. ISBN-13: 978-0801888144.

The Unfinished Game: Pascal, Fermat, and the Seventeenth-Century Letter That Made the World Modern, by Keith Devlin. Basic Books, September 2008. ISBN-13: 978-0-4650-0910-7.

The Unimaginable Mathematics of Borges' Library of Babel, by William Goldbloom Bloch. Oxford University Press, August 2008. ISBN-13: 978-01953-345-79.

What Is a Number?: Mathematical Concepts and Their Origins, by Robert Tubbs. Johns Hopkins University Press, December 2008. ISBN-13: 978-08018-901-85.

What's Happening in the Mathematical Sciences, by Dana Mackenzie. AMS, 2009. ISBN-13: 978-08218-447-86.

**Why Does E=mc²? (And Why Should We Care?)*, by Brian Cox and Jeff Forshaw. Da Capo Press, July 2009. ISBN-13: 978-03068-175-88.

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

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

Treasurer

The American Mathematical Society is seeking applications and nominations of candidates for the post of Treasurer. The Treasurer is an officer of the Society and is appointed by the Council for a two-year term. In this case the first term of the new Treasurer will begin 01 February 2011 and end 31 January 2013, so the new Treasurer can track the actions and activity in the position for a full year before assuming the post. Reappointments are possible and desirable. All necessary expenses incurred by the Treasurer in performance of duties for the Society are reimbursed, including travel and communications.

Duties

The primary responsibilities of the Treasurer are to administer or supervise the administration of fiscal policies laid down by the Trustees, to monitor the receipt and expenditure of funds and the care of investments, to monitor budgets and trends of finance over periods of years, and to review salary policy and its applications to individuals. The Treasurer has all the duties of the Trustees in general.

Applications

The Treasurer is appointed by the AMS Council upon recommendation by the Executive Committee and Board of Trustees. Applications, consisting of a letter expressing interest and a brief CV, should be sent to:

AMS Treasurer Search Committee
c/o Sandy Golden
Office of the AMS Secretary
Department of Mathematics
University of Tennessee
Knoxville, TN 37996-0612

email: golden@math.utk.edu

Applications received by 15 September 2009 will be assured full consideration.

AMS
American Mathematical Society
www.ams.org

The American Mathematical Society is an Equal Opportunity Employer.

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/ .

August 2009

* 14–15 **MSRI Upcoming Workshops: Connections for Women: Symplectic and Contact Geometry and Topology**, Mathematical Sciences Research Institute, Berkeley, California.
Organizers: Eleny Ionel (Stanford University), Dusa McDuff (Barnard College, Columbia University).
Parent Program(s): Symplectic and Contact Geometry and Topology.
Information: http://www.msri.org.

* 17–21 **MSRI Upcoming Workshops: Introductory Workshop: Symplectic and Contact Geometry and Topology**, Mathematical Sciences Research Institute, Berkeley, California.
Organizers: John Etnyre (Georgia Institute of Technology), Dusa McDuff (Barnard College, Columbia University), and Lisa Traynor (Bryn Mawr).
Parent Program(s): Symplectic and Contact Geometry and Topology.
Information: http://www.msri.org.

* 22–23 **MSRI Upcoming Workshops: Connections for Women: Tropical Geometry**, Mathematical Sciences Research Institute, Berkeley, California.
Organizers: Alicia Dickenstein (U. Buenos Aires), Eva Maria Feichtner (U. Bremen).
Parent Program(s): Tropical Geometry.
Information: http://www.msri.org.

* 24–26 **13th Workshop on Elliptic Curve Cryptography (ECC 2009)**, University of Calgary, Alberta, Canada.
Description: The aim of ECC is to bring together leading experts in the field as well as young researchers and graduate students for the purpose of exchanging ideas and presenting their work. The conference is accompanied by a one-week "summer school" on elliptic curves aimed at getting graduate students involved in the area. One of the main goals of the summer school is to give graduate students that are relatively new to the field a crash course in the core research areas that will be presented at the conference. This allows graduate students who are beginning their academic careers a chance to develop research topics and be able to benefit more from the conference.
Information: http://ecc.math.ucalgary.ca/.

* 24–26 **The 34th Sapporo Symposium on Partial Differential Equations**, Department of Mathematics, Hokkaido University, Sapporo, Japan.
Description: The Sapporo Symposium on Partial Differential Equations has been held annually to present the latest developments on PDE with a broad spectrum of interests not limited to the methods of a particular school.
Financial Support: Limited amount of financial support for local expenses is available to non-resident visitors who are interested in the meeting. Please make inquiry to cri@math.sci.hokudai.ac.jp by April 30, 2009.
Information: http://www.math.sci.hokudai.ac.jp/sympo/sapporo/program_en.html.

* 24–28 **MSRI Upcoming Workshops: Introductory Workshop: Tropical Geometry**, Mathematical Sciences Research Institute, Berkeley, California.
Organizers: Eva Maria Feichtner (U. Bremen), Ilia Itenberg (U. Strasbourg), Grigory Mikhalkin (U. Genève), Bernd Sturmfels (UC Berkeley).
Parent Program(s): Tropical Geometry.
Information: http://www.msri.org.

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/.

September 2009

* 8–10 **International Conference on Mathematics and Informatics ICMI 2 (2009)**, Faculty of Science (Department of Mathematics and Computer Science), University of Bacau, Bacau, Romania.
Description: The aim of the conference is to bring together mathematicians and computer scientists from all over the world and to attract original papers on the following topics: Algebra, Analysis and Complex Analysis, Topology and Geometry, Differential Equations, Probability and Statistics, Applied Mathematics, Theoretical Computer Science, Artificial Intelligence, Software Systems, Knowledge Engineering, E-Education. The Scientific Programme of the conference will consist of invited 30-minute plenary lectures and contributed 15-minute papers on the related topics.
Information: http://www.stiinte.ub.ro/cercetare/c-conferinte/103; email: mihaitalmaciu@yahoo.com.

* 14–18 **MSRI Upcoming Workshops: Black Holes in Relativity**, Mathematical Sciences Research Institute, Berkeley, California.
Organizers: Mihalis Dafermos (University of Cambridge) and Igor Rodnianski (Princeton).
Information: http://www.msri.org.

* 17–19 **The 5th William Rowan Hamilton Geometry and Topology Workshop on Computational and Algorithmic Geometry**, The Hamilton Mathematics Institute, Trinity College, Dublin, Ireland.
Description: A workshop on Computational and Algorithmic Geometry.
Information: Sponsored by Boston College, and the HMI; http://www.hamilton.tcd.ie/events/gt/gt2009.htm.

* 24–25 **4th International Workshop on Data Privacy Management (DPM09)**, Co-located with ESORICS 2009, Saint Malo, Britany, France.
Description: DPM 2009 Workshop aims at discussing and exchanging ideas related to privacy data management. We invite papers from researchers and practitioners working in privacy, security, trustworthy data systems and related areas to submit their original papers in this workshop.
Information: For more information, please see: http://dpm09.dyndns.org/.

October 2009

* 5–9 **Frobenius Lifts**, Lorentz Center, Leiden, The Netherlands.
Description: A workshop on the role of commuting Frobenius lifts in arithmetic algebraic geometry. Important roles are played by schemes of Witt vectors, arithmetic jet spaces, and the spectra of lambda-rings. There will be four expository lecture series: Pierre Cartier (IHES): Lambda-rings and Witt vectors; Lars Hesselholt (Nagoya): The de Rham-Witt complex; Alexandru Buium (Albuquerque): Arithmetic differential equations; James Borger (Canberra): Lambda-algebraic geometry. There will also be a number of individual talks about relations with nearby fields. We welcome workers and students in all fields of number theory and algebraic geometry. Some monetary support is available to Ph.D. students and postdocs.
Information: http://www.lorentzcenter.nl/lc/web/2009/342/info.php3?wsid=342.

* 12–16 **MSRI Upcoming Workshops: Tropical Geometry in Combinatorics and Algebra**, Mathematical Sciences Research Institute, Berkeley, California.
Organizers: Federico Ardila (San Francisco State University), David Speyer (MIT), Jenia Tevelev (U. Mass Amherst), Lauren Williams (Harvard).
Parent Program(s): Tropical Geometry.
Information: http://www.msri.org.

* 28–29 **The 5th Central and Eastern European Software Engineering Conference in Russia 2009 (CEE-SECR 2009)**, Moscow, Russia.
Description: This conference is aimed to consolidate the local software professional community and to integrate it into the international software society. The Software Engineering Conference in Russia attracts speakers from 15+ countries, over 500 participants from all over the world. The list of keynote speakers from previous SEC(R) conferences includes Michael Cusumano, Larry Constantine, Claudia Dent, Michael Fagan, Bill Hefley, Ivar Jacobson, Rick Kazman, Steve Masters, Mark Paulk and Michel Speranski, Erich Gamma, Stephen Mellor and many others. This conference is targeted at software professionals, such as Project Managers, Software Architects, Process Engineers, Software Engineering Process Group Directors, HR Specialists, Business Analysts, Team Leaders, IT Managers, CIO/CTO, QA Managers, Senior Developers, etc. from Russia, Ukraine, Belarus, Kazakhstan, Armenia, the Baltic, other CIS countries, Europe, and the U.S.
Information: http://cee-secr.org/.

* 29–31 **The 9th Red Raider Mini-Symposium: Non-linear Analysis, PDEs and Applications**, Texas Tech University, Lubbock, Texas.
Description: This is the 9th edition of the Annual Red Raider Mini-Symposium organized by the Department of Mathematics and Statistics, Texas Tech University. The Red Raider Mini-Symposium now has an established tradition of bringing in a range of distinguished scientists and promising early-career researchers in a particular area of modern mathematical importance. The theme for this year's mini-symposium is the mathematical analysis of non-linear problems in physics, engineering, and technology. This multidisciplinary research area spans nonlinear PDE, analysis, geometry, and scientific computing. The selection of conference speakers will emphasize interactions among these subject areas, applications of mathematics to other sciences, and important open problems. Additionally, the mutual interaction among speakers and attendees will lead to new opportunities for multi-disciplinary collaborations.
Information: http://www.math.ttu.edu/redraider2009/.

November 2009

* 2–7 **DNA Topology Course-Workshop 2009**, Okinawa Institute of Science and Technology, Okinawa, Japan.
Organizers: Robert Sinclair, OIST, Japan Nafaa Chbili, UAE University, United Arab Emirates.
Confirmed Speakers: De Witt Sumners, Patrick Forterre, Jun O'Hara, Javier Arsuaga, Dorothy Buck, Isabel Darcy, Christian Laing, Jennifer K. Mann, Koya Shimokawa, Andrzej Stasiak, Mariel Vazquez, and Lynn Zechiedrich.
Information: http://web.me.com/oist_mbu/DNA_Topology_Course/Home.html.

* 16–20 **MSRI Upcoming Workshops: Algebraic Structures in the Theory of Holomorphic Curves**, Mathematical Sciences Research Institute, Berkeley, California.
Organizers: Mohammed Abouzaid (Clay Mathematics Institute), Yakov Eliashberg (Stanford University), Kenji Fukaya (Kyoto University), Eleny Ionel (Stanford University), Lenny Ng (Duke University), Paul Seidel (MIT).
Parent Program(s): Symplectic and Contact Geometry and Topology.
Information: http://www.msri.org.

* 30–December 4 **International Conference on Elliptic and Parabolic Equations**, Weierstrass Institute for Applied Analysis and Stochastics (WIAS), Berlin, Germany.
Description: Elliptic and parabolic PDE's have been powerful models of problems in science and engineering for more than a quarter millennium. The classical solution theory of these equations assumes "perfect" spatial domains and coefficients. However, to deal with real world problems today, one has to take into account vertices and edges of three-dimensional spatial domains, discontinuous coefficient functions, and various mixed boundary conditions. Suitable regularity for such linear elliptic problems is crucial for the solution theory of corresponding nonlinear elliptic and parabolic equations. This conference will examine the progress in this direction, and elliptic and

parabolic equations in real space at large. One day of the conference will be specifically devoted to Navier-Stokes equations.
Information: http://www.wias-berlin.de/workshops/epe09.

* 30–December 4 **MSRI Upcoming Workshops: Tropical Structures in Geometry and Physics**, Mathematical Sciences Research Institute, Berkeley, California.
Organizers: Mark Gross (University of California San Diego), Kentaro Hori (University of Toronto), Viatcheslav Kharlamov (Université de Strasbourg (Louis Pasteur)), Richard Kenyon (Brown University).
Parent Program(s): Tropical Geometry.
Information: http://www.msri.org.

December 2009

* 14–18 **AMSI Workshop: New Directions in Geometric Group Theory**, The University of Queensland, Brisbane, Australia.
Description: This workshop will examine the influx of new ideas, trends, and advances in geometric group theory with focus on: (1) analysis (Baum-Connes conjecture, Kazhdan's property, amenability, soficity, rapid decay); (2) statistics (random walks, random subgroups, percolation, generic properties of groups); and (3) geometry (Cannon conjecture, boundaries, BNS invariants, bounded (co)-homology of groups, isoperimetric functions). We gratefully acknowledge support of the Australian Mathematical Sciences Institute, the Australian Mathematical Society, and the School of Mathematics and Physics at the University of Queensland.
Information: http://sites.google.com/site/ggtbrisbane/Home.

* 21–22 **Mathematical Sciences for Advancement of Science and Technology (MSAST 2009)**, IMBIC Hall, Salt Lake City, Kolkata, (Calcutta), West Bengal, India.
Description: The 3rd International Conference organized by the Institute for Mathematics, Bioinformatics, Information Technology and Computer Science (IMBIC) on "Mathematical Sciences for Advancement of Science and Technology" (MSAST 2009) will be held during December 21–22, 2009, at IMBIC Hall, Kolkata, India. Authors are requested to submit the full original papers for presentation and publication in the Proceedings of the conference related to the theme of the conference: "Mathematical Sciences for Advancement of Science and Technology" indicating the motivation of the problem, its method of solution, and important results to the Secretary of IMBIC.
Information: All correspondences in respect of the conference are to be addressed to Dr. Avishek Adhikari, Secretary, IMBIC, AH 317, Salt Lake City, Sector II, Kolkata 700091, West Bengal, India, email: avishek.adh@gmail.com; http://imbic.org/forthcoming.html.

* 28–31 **Seventh International Triennial Calcutta Symposium on Probability and Statistics**, Department of Statistics, University of Calcutta, 35 Ballygunge Circular Road, Kolkata- 700019, West Bengal, India.
Description: The Seventh International Triennial Calcutta Symposium, following the previous six symposia, will bring together researchers engaged in theoretical, methodological, and applied aspects of statistics and probability on a common platform. A large number of researchers from all over the world are expected to attend. There will be invited and technical sessions and poster sessions for students and young researchers. The best posters will be awarded. The Department of Statistics, Calcutta University, is the oldest post-graduate department in Asia offering a course in statistics. It is recognized as one of the prime departments of Statistics in India. Calcutta Statistical Association is an international learned society closely associated with the department. The Association publishes an internationally circulated journal of its own besides organizing lectures, seminars, workshops, and symposia.
Information: http://triennial.calcuttastatisticalassociation.org.

January 2010

* 5–9 **New Directions in Financial Mathematics**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California.
Overview: The workshop will introduce researchers and mathematicians to two fields of research: environmental emissions markets and mathematical models for financial markets. Among other talks, there will be a short course on the challenge of the environment and the attempts to use financial markets to control emissions of greenhouse gases in the most efficient way, and a short course on agent-based models for financial markets.
Organizing Committee: Rene Carmona, Jaska Cvitanic, Nicole El Karoui, George Papanicolaou, Eduardo Schwartz, Ronnie Sircar, Thaleia Zariphopoulou.
Application/Registration: An application and registration form is available at: http://www.ipam.ucla.edu/programs/fin2010. Applications received by Nov. 9, 2009, will receive fullest consideration. Encouraging the careers of women and minority mathematicians and scientists is an important component of IPAM's mission and we welcome their applications. You may also simply register and attend without IPAM funding.
Information: http://www.ipam.ucla.edu/programs/fin2010/.

March 2010

* 17–19 **IAENG International Conference on Operations Research 2010**, Regal Kowloon Hotel, Hong Kong, China.
Organizers: The conference ICOR'10 is held under the International MultiConference of Engineers and Computer Scientists 2010. The IMECS 2010 is organized by the International Association of Engineers (IAENG).
Important Dates: Draft Manuscript submission deadline: December 8, 2009; Camera-Ready Papers Due & Registration Deadline: January 10, 2010; ICOR 2010: March 17–19, 2010.
Topics: ICOR'10 includes, but is not limited to, the following: Management science; Managerial economics; Systems thinking and analysis; Optimization; Integer programming; Linear programming; Nonlinear programming; Assignment problem; Transportation network design; Simulation; Statistical analysis; Stochastics modelling reliability and maintenance; Queueing theory; Game theory; Graph theory OR algorithms and software developments OR applications and case studies.
Information: http://www.iaeng.org/IMECS2010/ICOR2010.html.

April 2010

* 12–16 **Climate Modeling: Numerical Hierarchies for Climate Modeling**, Introduction for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California.
Overview: This workshop will focus on advanced computational techniques which allow us to cover a wide range of spatio-temporal scales in a single simulation, and which operate reliably at various resolutions. Of particular interest will be mechanisms for selecting non-resolved scale parameterizations as a function of grid resolution and for controlling the interplay of numerical truncation with subgrid scale process representations.
Organizing Committee: Francis Giraldo, Christiane Jablonowski, Rupert Klein, Sebastian Reich.
Application/Registration: An application and registration form is available at: http://www.ipam.ucla.edu/programs/clws2. Applications received by Feb. 15, 2010, will receive fullest consideration. Encouraging the careers of women and minority mathematicians and scientists is an important component of IPAM's mission and we welcome their applications. You may also simply register and attend without IPAM funding.
Information: http://www.ipam.ucla.edu/programs/clws2/.

* 14–17 **International Workshop on Multivariate Risks and Copulas**, Mohamed Khider University of Biskra, Algeria.

Description: The first edition of the International Workshop on Multivariate Risks and Copulas which will be held April 14–17, 2010, at Mohamed Khider University of Biskra, Algeria. The workshop will serve as a forum for discussing different issues of risks, copulas, and related topics. The main goal of this scientific event is to gather researchers and practitioners from universities, institutions, industries, and government, working in these fields. The tools and methodologies in progress in probability, statistics, mathematics, and economics that are closely relevant for Univariate and Multivariate Risks will be embraced as well. We are proud to organize this workshop and look forward to welcoming you in Biskra.
Information: http://www.univ-biskra.dz/manifestations/math/stat_2010/.

* 15–17 **35th Spring Lectures Series, 2010 "Minimal Surfaces and Mean Curvature Flow"**, University of Arkansas, Fayetteville, Arkansas.
Speakers and Talks: The main speaker is William Minicozzi (Johns Hopkins University). The title of the conference is "Minimal Surfaces and Mean Curvature Flow". Professor Minicozzi will deliver a total of five lectures. There will be ten talks by the following invited speakers: Maria Calle, Julie Clutterbuck, Tobias Colding, Camillo De Lellis, Lei N, Felix Schulze, Natasa Sesum, Mu-Tao Wang, Matthias Weber, Michael Wolf.
Information: Applications for contributed talks by junior mathematicians are strongly encouraged. Titles and abstract should be received by the organizers not later than March 15th, 2010. For further questions please contact Andy Raich araich@uark.edu; http://www.math.uark.edu.

May 2010

* 23–26 **SIAM Conference on Mathematical Aspects of Materials Science (MS10)**, Doubletree Hotel Philadelphia, Philadelphia, Pennsylvania.
Description: This conference is sponsored by the SIAM Activity Group on Mathematical Aspects of Materials Science.
Information: http://www.siam.org/meetings/ms10/.

* 24–28 **Applied Linear Algebra—in Honor of Hans Schneider**, Department of Mathematics, Faculty of Science, Novi Sad, Serbia.
Description: Inspired by the success of two previous conferences Applied Linear Algebra—in honor of Richard Varga, 2005, Palić; and Applied Linear Algebra—in honor of Ivo Marek, 2008, Novi Sad we will continue in the same fashion by organizing a conference Applied Linear Algebra—in honor of Hans Schneider. ALA 2010 has the similar aim as ALA 2005 and ALA 2008—to review numerous contributions of Hans Schneider and to report and discuss recent progress through the participation of international leaders in the field, who will gather in his honor. We are pleased to announce the 10th GAMM Workshop Applied and Numerical Linear Algebra with special emphasis on Positivity which will be organized as a part of ALA 2010. A special issue of Linear Algebra and its Applications will be devoted to selected papers presented during the conference.
Information: http://www.dmi.uns.ac.rs/events/ala2010.

June 2010

* 18–August 15 **Geometry, Topology, and Dynamics of Character Varieties**, Institute for Mathematical Sciences, National University of Singapore, Singapore.
Description: This program concerns character varieties of representations in a Lie group G of a discrete group π, for example, the fundamental group of a surface. These varieties have rich geometry and are related to interesting topological objects such as locally homogeneous geometric structures on manifolds, and moduli spaces arising in gauge theory. When π is the fundamental group of a surface group S, the mapping class group acts with a complicated and mysterious dynamics.
Information: http://www.ims.nus.edu.sg/Programs/010geometry/index.htm.

* 28–July 2 **The Józef Marcinkiewicz Centenary Conference (JM 100)**, A. Mickiewicz University, Faculty of Mathematics and Computer Science, Poznańoznań, Poland.
Description: On the occasion of the upcoming centenary of birth of Józef Marcinkiewicz (1910–1940) the Faculty of Mathematics and Computer Science of Adam Mickiewicz University is organizing a scientific conference to commemorate one of the most eminent Polish mathematicians. The meeting will be devoted to some significant aspects of contemporary mathematical research related to Marcinkiewicz's scientific interests (real, complex and functional analysis, probability theory) including their applications.
Confirmed Plenary Speakers: Krzysztof Bogdan, Michael Cwikel, Tadeusz Iwaniec, Jean-Pierre Kahane, Nigel Kalton, Michael Lacey, Rafal Latala, Tomasz Luczak, Lech Maligranda, Gilles Pisier, Andreas Seeger, Marc Yor, and Bernard Roynette.
Information: http://www.jm100.amu.edu.pl.

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.

August 2010

* 8–11 **Functional Analysis and Operator theory**, Indian Statistical Institute, Bangalore, India.
Local Organizing Committee: T. S. S. R. K. Rao (ISI, Bangalore), G. Misra (IISc, Bangalore), S. H. Kulkarni (IIT, Chennai), P. Bandyopadhyay (ISI, Kolkata), T. Bhattacharya (IISc, Bangalore), N. Namboodiri (CUSAT, Cochin), S. Dutta (IIT, Kanpore).
Information: Conference email: ramanuj@isibang.ac.in; http://www.isibang.ac.in/~statmath/conferences/icmfasat/icm.htm. Registration fee: 100 Euros.

* 16–December 17 **MSRI Future Scientific Programs: Inverse Problems and Applications**, Mathematical Sciences Research Institute, Berkeley, California.
Information: http://www.msri.org.

* 16–December 17 **MSRI Future Scientific Programs: Random Matrix Theory, Interacting Particle Systems and Integrable Systems**, Mathematical Sciences Research Institute, Berkeley, California.
Information: http://www.msri.org.

* 20–25 **Third International Conference on Boundary Value Problems, Integral Equations and Related Problems**, Beijing and Baoding, Hebei, China.
Topics: The conference will be about the following six subjects: 1) Various boundary value problems for partial differential equations and functional equations; 2) The theory and methods of integral equations and integral operators including singular integral equations; 3) Applications of boundary value problems and integral equations to mechanics and physics; 4) Numerical methods of integral equations and boundary value problems; 5) Theory and methods for inverse problems of mathematical physics; 6) Clifford analysis and some related problems with above subjects.
Information: More detailed information can be found at http://www.math.pku.edu.cn/3inter.conf-bvp.ie.rps or please contact G. C. Wen, School of Math. Sci., Peking Univ., Beijing 100871, China; tel: 008610-62755937; fax: 008610-62751801; email: wengc@pku.edu.cn or wengc@math.pku.edu.cn.

January 2011

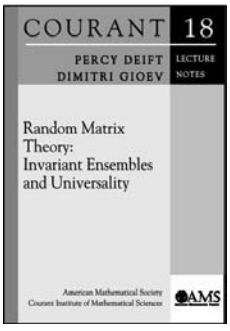
* 10–May 20 **MSRI Future Scientific Programs: Arithmetic Statistics**, Mathematical Sciences Research Institute, Berkeley, California.
Information: http://www.msri.org.

* 10–May 20 **MSRI Future Scientific Programs: Free Boundary Problems, Theory and Applications**, Mathematical Sciences Research Institute, Berkeley, California.
Information: http://www.msri.org.

New Publications Offered by the AMS

To subscribe to email notification of new AMS publications, please go to http://www.ams.org/bookstore-email.

Algebra and Algebraic Geometry



Random Matrix Theory: Invariant Ensembles and Universality

Percy Deift, *Courant Institute of Mathematical Sciences, New York University, NY*, and **Dimitri Gioev**, *University of Rochester, NY, and Wilshire Associates Inc., Santa Monica, CA*

This book features a unified derivation of the mathematical theory of the three classical types of invariant random matrix ensembles—orthogonal, unitary, and symplectic. The authors follow the approach of Tracy and Widom, but the exposition here contains a substantial amount of additional material, in particular, facts from functional analysis and the theory of Pfaffians. The main result in the book is a proof of universality for orthogonal and symplectic ensembles corresponding to generalized Gaussian type weights following the authors' prior work. New, quantitative error estimates are derived.

The book is based in part on a graduate course given by the first author at the Courant Institute in fall 2005. Subsequently, the second author gave a modified version of this course at the University of Rochester in spring 2007. Anyone with some background in complex analysis, probability theory, and linear algebra and an interest in the mathematical foundations of random matrix theory will benefit from studying this valuable reference.

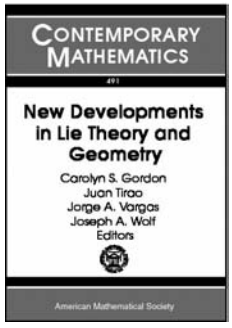
This item will also be of interest to those working in probability and discrete mathematics and combinatorics.

Titles in this series are co-published with the Courant Institute of Mathematical Sciences at New York University.

Contents: *Invariant random matrix ensembles: unified derivation of eigenvalue cluster and correlation functions:* Introduction and examples; Three classes of invariant ensembles; Auxiliary facts from functional analysis, Pfaffians, and three integral identities; Eigenvalue statistics for the three types of ensembles; *Universality for orthogonal and symplectic ensembles:* Widom's formulae for the $\beta = 1$ and 4 correlation kernels; Large N eigenvalue statistics for the $\beta = 1, 4$ ensembles with monomial potentials: universality; Bibliography; Index.

Courant Lecture Notes, Volume 18

July 2009, 217 pages, Softcover, ISBN: 978-0-8218-4737-4, LC 2009013498, 2000 *Mathematics Subject Classification:* 15A52, 60F05, 05E35, 62E20, 15A90, **AMS members US$26**, List US$33, Order code CLN/18



New Developments in Lie Theory and Geometry

Carolyn S. Gordon, *Dartmouth College, Hanover, NH*, **Juan Tirao** and **Jorge A. Vargas**, *Universidad Nacional de Cordoba, Argentina*, and **Joseph A. Wolf**, *University of California, Berkeley, CA*, Editors

This volume is an outgrowth of the Sixth Workshop on Lie Theory and Geometry, held in the province of Córdoba, Argentina in November 2007.

The representation theory and structure theory of Lie groups play a pervasive role throughout mathematics and physics. Lie groups are tightly intertwined with geometry and each stimulates developments in the other. The aim of this volume is to bring to a larger audience the mutually beneficial interaction between Lie theorists and geometers that animated the workshop.

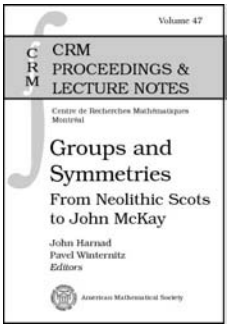
Two prominent themes of the representation theoretic articles are Gelfand pairs and the representation theory of real reductive Lie groups. Among the more geometric articles are an exposition of major recent developments on noncompact homogeneous Einstein manifolds and aspects of inverse spectral geometry presented in settings accessible to readers new to the area.

Contents: J. Lauret, Einstein solvmanifolds and nilsolitons; **C. U. Sánchez**, Algebraic sets associated to isoparametric submanifolds; **L. Ji**, Mostow strong rigidity and nonisomorphism for outer automorphism groups of free groups and mapping class groups; **R. J. Miatello** and **J. P. Rossetti**, Spectral properties of flat manifolds; **P. Gilkey**, Heat content, heat trace, and isospectrality; **D. Burde**, **K. Dekimpe**, and **S. Deschamps**, LR-algebras; **C. Benson**

and **G. Ratcliff**, Combinatorial properties of generalized binomial coefficients; **C. Benson** and **G. Ratcliff**, Spherical functions for the action of a finite unitary group on a finite Heisenberg group; **S. Gurevich** and **R. Hadani**, Application of the Weil representation: Diagonalization of the discrete Fourier transform; **J. A. Wolf**, Infinite dimensional multiplicity free spaces II: Limits of commutative nilmanifolds; **L. Barchini** and **R. Zierau**, Certain components of Springer fibers: algorithms, examples and applications; **E. Galina**, Weighted Vogan diagrams associated to real nilpotent orbits; **M. Colarusso**, The Gelfand-Zeitlin integrable system and its action on generic elements of $\mathfrak{gl}(n)$ and $\mathfrak{so}(n)$; **P. Eberlein** and **M. Jablonski**, Closed orbits of semisimple group actions and the real Hilbert-Mumford function; **N. Andruskiewitsch** and **F. Fantino**, New techniques for pointed Hopf algebras.

Contemporary Mathematics, Volume 491

August 2009, 348 pages, Softcover, ISBN: 978-0-8218-4651-3, LC 2009007622, 2000 *Mathematics Subject Classification:* 22Exx, 43A85, 53Cxx, 53C25, 53C30, 20Gxx, 58J53, **AMS members US$79**, List US$99, Order code CONM/491



Groups and Symmetries

From Neolithic Scots to John McKay

John Harnad, *Concordia University, Montreal, QC, Canada*, and **Pavel Winternitz**, *Université de Montréal, Montreal, QC, Canada*, Editors

This volume contains papers presented at a conference held in April 2007 at the CRM in Montreal honouring the remarkable contributions of John McKay over four decades of research. Papers by invitees who were unable to attend the conference are also included.

The papers cover a wide range of topics, including group theory, symmetries, modular functions, and geometry, with particular focus on two areas in which John McKay has made pioneering contributions: "Monstrous Moonshine" and the "McKay Correspondence". This book will be a valuable reference for graduate students and researchers interested in these and related areas and serve as a stimulus for new ideas.

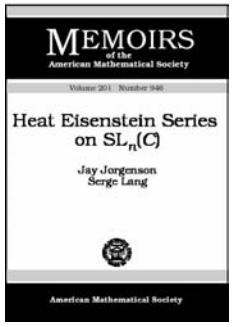
This item will also be of interest to those working in number theory.

Titles in this series are co-published with the Centre de Recherches Mathématiques.

Contents: J. McKay, Introduction and background; **H. Airault**, Symmetric sums associated to the factorization of Grunsky coefficients; **D. Allcock**, A monstrous proposal; **P. Boalch**, Quivers and difference Painlevé equations; **D. X. Charles**, **E. Z. Goren**, and **K. E. Lauter**, Families of Ramanujan graphs and quaternion algebras; **A. Clingher**, **C. F. Doran**, **J. Lewis**, and **U. Whitcher**, Normal forms, K3 surface moduli, and modular parametrizations; **H. Cohn**, Spontaneous generation of Hilbert modular functions; **C. J. Cummins** and **N. S. Haghighi**, On a class of congruence subgroups; **I. V. Dolgachev**, McKay's correspondenxe for cocompact discrete subgroups of SU(1, 1); **J. F. Duncan**, Arithmetic groups and the affine E_8 Dynkin diagram; **T. Gannon**, The Galois action on character tables; **N. Ganter**, Hecke operators in equivariant elliptic cohomology and generalized moonshine; **G. W. Hart**, Sculptural presentation of the icosahedral rotation group; **N. Hitchin**, Spherical harmonics and the iscoahedron; **A. Klimyk** and **J. Patera**, Alternating group and multivariate exponential functions; **J. Morava**, Moonshine elements in elliptic cohomology; **M. R. Murty** and **K. L. Petersen**, The generalized Artin conjecture and arithmetic orbifolds; **I. Nakamura**, McKay correspondence; **V. V. Nikulin**, On ground fields of arithmetic hyperbolic reflection groups; **S. P. Norton**, Moonshine-type functions and the CRM correspondence; **Y. Ohyama**, Monodromy evolving deformations and Halphen's equation; **D. Zagier**, Integral solutions of Apéry-like recurrence equations.

CRM Proceedings & Lecture Notes, Volume 47

August 2009, 366 pages, Softcover, ISBN: 978-0-8218-4481-6, LC 2009010376, 2000 *Mathematics Subject Classification:* 20D08; 11F03, **AMS members US$100**, List US$125, Order code CRMP/47



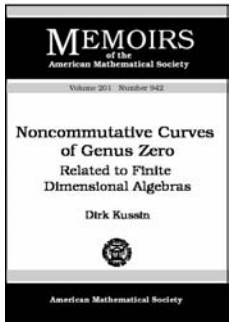
Heat Eisenstein Series on $SL_n(C)$

Jay Jorgenson, *City College of New York, CUNY, NY*, and **Serge Lang**

Contents: Introduction; Notation and terminology; Estimates on SL_n and parabolics; Eisenstein series; Adjointness and inversion relations; Applications of the heat equation; Appendix. The heat kernel; Bibliography; Index.

Memoirs of the American Mathematical Society, Volume 201, Number 946

September 2009, 127 pages, Softcover, ISBN: 978-0-8218-4044-3, 2000 *Mathematics Subject Classification:* 35K05, 58J35, 11F72; 11M36, **Individual member US$40**, List US$67, Institutional member US$54, Order code MEMO/201/946



Noncommutative Curves of Genus Zero

Related to Finite Dimensional Algebras

Dirk Kussin, *Universität Paderborn, Germany*

Contents: Introduction; Background; *Part 1. The homogeneous case:* Graded factoriality; Global and local structure of the sheaf category; Tubular shifts and prime elements; Commutativity and multiplicity freeness; Automorphism groups; *Part 2. The weighted case:* Insertion of weights; Exceptional objects; Tubular exceptional curves; Appendix A. Automorphism groups over the real numbers; Appendix B. The tubular symbols; Bibliography; Index.

Memoirs of the American Mathematical Society, Volume 201, Number 942

September 2009, 128 pages, Softcover, ISBN: 978-0-8218-4400-7, LC 2009019382, 2000 *Mathematics Subject Classification:* 14H45, 16G10; 14H60, 14A22, **Individual member US$40**, List US$67, Institutional member US$54, Order code MEMO/201/942

The Selected Works of Sigurður Helgason

Gestur Ólafsson, *Louisiana State University, Baton Rouge, LA*, and **Henrik Schlichtkrull**, *University of Copenhagen, Denmark*, Editors

Sigurður Helgason is a leading expert in harmonic analysis and integral geometry on symmetric spaces. His work has had, and continues to have, a profound influence on the field. Helgason's work is marked by an interplay of analysis, geometry, and representation theory. The articles collected here cover invariant differential operators, geometric properties of solutions to differential equations on symmetric spaces, double fibrations in integral geometry, spherical functions and spherical transforms, duality for symmetric spaces, representation theory, and the Fourier transform on G/K. The papers are supplemented by an introductory essay by Helgason.

This *Selecta* of Sigurður Helgason's important papers will be a valuable resource to research mathematicians and graduate students.

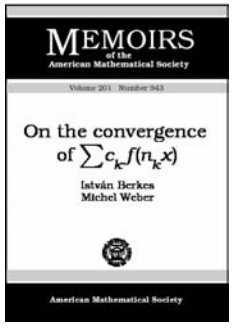
This item will also be of interest to those working in geometry and topology.

Contents: Multipliers of Banach algebras; Differential operators on homogeneous spaces; Fundamental solutions of invariant differential operators on symmetric spaces; Duality and Radon transform for symmetric spaces; Fundamental solutions of invariant differential operators on symmetric spaces; The Radon transform on Euclidean spaces, compact two-point homogeneous spaces and Grassman manifolds; Radon-Fourier transforms on symmetric spaces and related group representations; A duality in integral geometry on symmetric spaces; Totally geodesic spheres in compact symmetric spaces; An analogue of the Paley-Wiener theorem for the Fourier transform on certain symmetric spaces; (with **A. Korányi**), A Fatou-type theorem for harmonic functions on symmetric spaces; (with **K. Johnson**), The bounded spherical functions on symmetric spaces; Applications of the Radon transform to representations of semisimple Lie groups; A duality for symmetric spaces with applications to group representations; Group representations and symmetric spaces; A formula for the radial part of the Laplace-Beltrami operator; Paley-Wiener theorems and surjectivity of invariant differential operators on symmetric spaces and Lie groups; The surjectivity of invariant differential operators on symmetric spaces I; Eigenspaces of the Laplacian; integral representations and irreducibility; A duality for symmetric spaces with applications to group representations, II. Differential equations and Eigenspace representations; A duality for symmetric spaces with applications to group representations III. Tangent space analysis; (with **F. Gonzalez**), Invariant differential operators on Grassmann manifolds; Value-distribution theory for holomorphic almost periodic functions; The totally-geodesic Radon transform on constant curvature spaces; Some results on invariant differential operators on symmetric spaces; The flat horocycle transform for a symmetric space; Huygens' principle for wave equations on symmetric spaces; Radon transforms for double fibrations. Examples and viewpoints.; Integral geometry and multitemporal wave equations; (with **H. Schlichtkrull**), The Paley-Wiener space for the multitemporal wave equation; The Abel, Fourier, and Radon transforms on symmetric spaces; The inversion of the x-ray transform on a compact symmetric space.

Collected Works, Volume 22

July 2009, 715 pages, Hardcover, ISBN: 978-0-8218-4753-4, LC 2009010403, 2000 *Mathematics Subject Classification:* 33C67, 46E20, 58J35, 22E30, 43A85, 53C35, **AMS members US$113**, List US$141, Order code CWORKS/22

Analysis



On the convergence of $\sum c_k f(n_k x)$

István Berkes, *Graz University of Technology, Austria*, and **Michel Weber**, *Université Louis-Pasteur et C.N.R.S., Strasbourg, France*

Contents: Introduction; Mean convergence; Almost everywhere convergence: Sufficient conditions; Almost everywhere convergence: Necessary conditions; Random sequences; Discrepancy of random sequences $\{S_n x\}$; Some open problems; Bibliography.

Memoirs of the American Mathematical Society, Volume 201, Number 943

September 2009, 72 pages, Softcover, ISBN: 978-0-8218-4324-6, LC 2009019383, 2000 *Mathematics Subject Classification:* 42C15, 42A55, 42A61, 30B50, 11K38, 60G50, **Individual member US$37**, List US$62, Institutional member US$50, Order code MEMO/201/943

A First Course in Sobolev Spaces

Giovanni Leoni, *Carnegie Mellon University, Pittsburgh, PA*

Sobolev spaces are a fundamental tool in the modern study of partial differential equations. In this book, Leoni takes a novel

approach to the theory by looking at Sobolev spaces as the natural development of monotone, absolutely continuous, and BV functions of one variable. In this way, the majority of the text can be read without the prerequisite of a course in functional analysis.

The first part of this text is devoted to studying functions of one variable. Several of the topics treated occur in courses on real analysis or measure theory. Here, the perspective emphasizes their applications to Sobolev functions, giving a very different flavor to the treatment. This elementary start to the book makes it suitable for advanced undergraduates or beginning graduate students. Moreover, the one-variable part of the book helps to develop a solid background that facilitates the reading and understanding of Sobolev functions of several variables.

The second part of the book is more classical, although it also contains some recent results. Besides the standard results on Sobolev functions, this part of the book includes chapters on BV functions, symmetric rearrangement, and Besov spaces.

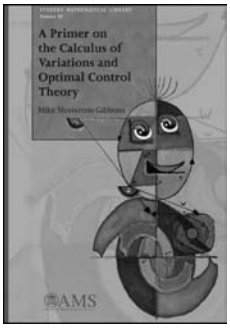
The book contains over 200 exercises.

This item will also be of interest to those working in differential equations.

Contents: *Functions of one variable:* Monotone functions; Functions of bounded pointwise variation; Absolutely continuous functions; Curves; Lebesgue–Stieltjes measures; Decreasing rearrangement; Functions of bounded variation and Sobolev functions; *Functions of several variables:* Absolutely continuous functions and change of variables; Distributions; Sobolev spaces; Sobolev spaces: Embeddings; Sobolev spaces: Further properties; Functions of bounded variation; Besov spaces; Sobolev spaces: Traces; Sobolev spaces: Symmetrization; Functional analysis; Measures; The Lebesgue and Hausdorff measures; Notes; Notation and list of symbols; Bibliography; Index.

Graduate Studies in Mathematics, Volume 105

August 2009, 607 pages, Hardcover, ISBN: 978-0-8218-4768-8, LC 2009007620, 2000 *Mathematics Subject Classification:* 46E35; 26A24, 26A27, 26A30, 26A42, 26A45, 26A46, 26A48, 26B30, **AMS members US$68**, List US$85, Order code GSM/105



A Primer on the Calculus of Variations and Optimal Control Theory

Mike Mesterton-Gibbons, *Florida State University, Tallahassee, FL*

The calculus of variations is used to find functions that optimize quantities expressed in terms of integrals. Optimal control theory seeks to find functions that minimize cost integrals for systems described by differential equations.

This book is an introduction to both the classical theory of the calculus of variations and the more modern developments of optimal control theory from the perspective of an applied mathematician. It focuses on understanding concepts and how to apply them. The range of potential applications is broad: the calculus of variations and optimal control theory have been widely used in numerous ways in biology, criminology, economics, engineering, finance, management science, and physics. Applications described in this book include cancer chemotherapy, navigational control, and renewable resource harvesting.

The prerequisites for the book are modest: the standard calculus sequence, a first course on ordinary differential equations, and some facility with the use of mathematical software. It is suitable for an undergraduate or beginning graduate course or for self study. It provides excellent preparation for more advanced books and courses on the calculus of variations and optimal control theory.

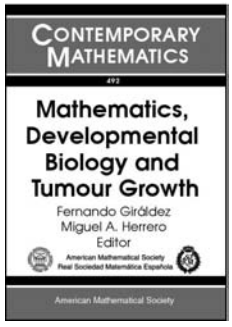
This item will also be of interest to those working in differential equations.

Contents: The Brachistochrone; The fundamental problem. Extremals; The insufficiency of extremality; Important first integrals; The du Bois-Reymond equation; The corner conditions; Legendre's necessary condition; Jacobi's necessary condition; Weak versus strong variations; Weierstrass's necessary condition; The transversality conditions; Hilbert's invariant integral; The fundamental sufficient condition; Jacobi's condition revisited; Isoperimetrical problems; Optimal control problems; Necessary conditions for optimality; Time-optional control; A singular control problem; A biological control problem; Optimal control to a general target; Navigational control problems; State variable restrictions; Optimal harvesting; Afterword; Solutions or hints for selected exercises; Bibliography; Index.

Student Mathematical Library, Volume 50

August 2009, 252 pages, Softcover, ISBN: 978-0-8218-4772-5, LC 2009007701, 2000 *Mathematics Subject Classification:* 49-01, 49K15, 49N05, 49N35; 92-02, 92D50, **AMS members US$36**, List US$45, Order code STML/50

Applications



Mathematics, Developmental Biology and Tumour Growth

Fernando Giráldez, *Universitat Pompeu Fabra, Barcelona, Spain*, and **Miguel A. Herrero**, *Universidad Complutense, Madrid, Spain*, Editors

Developmental biology and tumour growth are two important areas of current research where mathematics increasingly provides powerful new techniques and insights. The unfolding complexity of living structures from egg to embryo gives rise to a number of difficult quantitative problems that are ripe for mathematical models and analysis. Understanding this early development process involves the study of pattern formation, which mathematicians view through the lens of dynamical systems. This book addresses several issues in developmental biology, including Notch signalling pathway integration and mesenchymal compartment formation.

Tumour growth is one of the primary challenges of cancer research. Its study requires interdisciplinary approaches involving the close collaboration of mathematicians, biologists and physicians. The summer school addressed angiogenesis, modelling issues arising in

radiotherapy, and tumour growth viewed from the individual cell and the relation to a multiphase-fluid flow picture of that process.

This book is suitable for researchers, graduate students, and advanced undergraduates interested in mathematical methods of developmental biology or tumour growth.

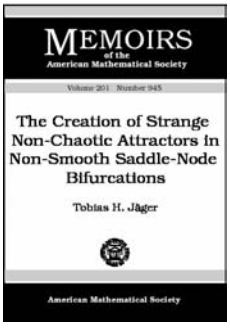
This book is copublished by the Real Sociedad Matemática Española and the American Mathematical Society.

Contents: B. Alsina, **A. L. García de Lomana**, **J. Villá-Freixa**, and **F. Giráldez**, Developmental biology and mathematics: The rules of an embryo; **C. G. Arques** and **M. Torres**, From lineage to shape: Modeling dorsal-ventral specification in the developing mouse limb; **R. Fior** and **D. Henrique**, Notch-mathics; **T. Alarcón**, Modelling tumour-induced angiogenesis: A review of individual-based models and multiscale approaches; **A. Cappuccio**, **M. A. Herrero**, and **L. Nuñez**, Tumour radiotherapy and its mathematical modelling; **J. Galle** and **L. Preziosi**, Multiphase and individual cell-based models of tumour growth.

Contemporary Mathematics, Volume 492

August 2009, approximately 129 pages, Softcover, ISBN: 978-0-8218-4663-6, LC 2009009818, 2000 *Mathematics Subject Classification:* 34K10, 34K25, 35B40, 35F25, 92C50, **AMS members US$39**, List US$49, Order code CONM/492

Differential Equations



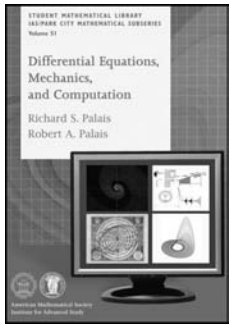
The Creation of Strange Non-Chaotic Attractors in Non-Smooth Saddle-Node Bifurcations

Tobias H. Jäger, *Universität Erlangen-Nürnberg, Germany*

Contents: Introduction; Statement of the main results and applications; Saddle-node bifurcations and sink-source-orbits; The strategy for the construction of the sink-source-orbits; Tools for the construction; Construction of the sink-source orbits: One-sided forcing; Construction of the sink-source-orbits: Symmetric forcing; Bibliography.

Memoirs of the American Mathematical Society, Volume 201, Number 945

September 2009, 106 pages, Softcover, ISBN: 978-0-8218-4427-4, 2000 *Mathematics Subject Classification:* 37D45; 37C60, 37H20, **Individual member US$40**, List US$66, Institutional member US$53, Order code MEMO/201/945



Differential Equations, Mechanics, and Computation

Richard S. Palais, *University of California, Irvine, CA*, and **Robert A. Palais**, *University of Utah, Salt Lake City, UT*

This book provides a conceptual introduction to the theory of ordinary differential equations, concentrating on the initial value problem for equations of evolution and with applications to the calculus of variations and classical mechanics, along with a discussion of chaos theory and ecological models. It has a careful introduction to the theory of numerical methods with a novel approach to the analysis of errors and stability of various numerical solution algorithms. While the book would be suitable as a textbook for an undergraduate or elementary graduate course in ordinary differential equations, the authors have designed the text also to be useful for motivated students wishing to learn the material on their own or desiring to supplement an ODE textbook being used in a course they are taking with a text offering a more conceptual approach to the subject.

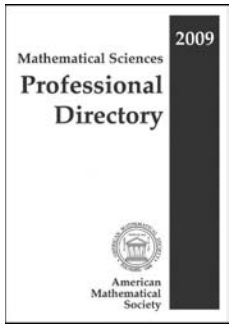
This volume was co-published with the Institute for Advanced Study/Park City Mathematics Institute.

Contents: Introduction; Differential equations and their solutions; Linear differential equations; Second-order ODE and the calculus of variations; Newtonian mechanics; Numerical methods; Linear algebra and analysis; The magic of iteration; Vector fields as differential operators; Coordinate systems and canonical forms; Parametrized curves and arclength; Smoothness with respect to initial conditions; Canonical form for linear operators; Runge-Kutta methods; Multistep methods; Iterative interpolation and its error; Bibliography; Index.

Student Mathematical Library, Volume 51

September 2009, approximately 315 pages, Softcover, ISBN: 978-0-8218-2138-1, LC 2009011294, 2000 *Mathematics Subject Classification:* 34-01, 65-01, 70-01, **AMS members US$41**, List US$51, Order code STML/51

General and Interdisciplinary

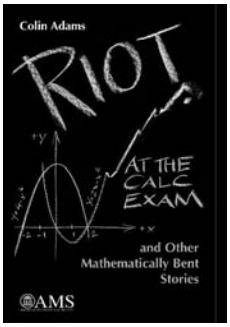


Mathematical Sciences Professional Directory, 2009

This annual directory provides a handy reference to various organizations in the mathematical sciences community. Listed

in the directory are the following: contact (address, phone, fax) info and websites of over thirty professional mathematical organizations; addresses of selected government agencies; academic departments in the mathematical sciences; and alphabetic listings of colleges and universities.

August 2009, 155 pages, Softcover, ISBN: 978-0-8218-4743-5, List US$55, Institutional member US$44, Order code PRODIR/2009



Riot at the Calc Exam and Other Mathematically Bent Stories

Colin Adams, *Williams College, Williamstown, MA*

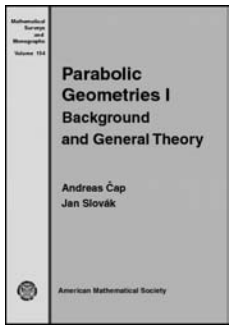
What's so funny about math? Lots! Especially if you're mathematically bent. In the world of Colin Adams, differential equations bring on tears of laughter. Hollywood producers hire algebraic geometers to punch up a script. In this world, math and humor are synonymous. *Riot at the Calc Exam* is a proof of this fact.

A collection of humorous math stories, this book gives a window into mathematics and the culture of mathematicians. Appropriate for mathematicians, math students, math teachers, lay people with an interest in mathematics, and indeed everyone else. This book is a romp through the wild world of mathematics.

Contents: The S. S. Riemann; Pythagoras's darkest hour; Mangum, P. I.; Overcoming math anxiety; A difficult delivery; A proof of God; The red badge of courage; This theorem is big; Journey to the center of mathematics; The theorem blaster; Riot at the calc exam; The mathematical ethicist; Phone interview; The integral: A horror story; The three little pigs; Northnorthwestern State University mathematics department safety manual; Trial and error; Hiring season; Class reunion; Worst-case-scenario survival handbook: Mathematics; Into thin air; Math talk; A deprogrammer's tale; Research announcement; A killer theorem; A subprime lending market primer; Fields medalist stripped; More from the mathematical ethicist; Math fall fashion preview; Dr. Yeckel and Mr. Hide; The Pepsi Putnam challenge; Vital sines; Rumpled Stiltsken; *Notes:* Notes for "The S. S. Riemann"; Notes for "Overcoming math anxiety"; Notes for "A difficult delivery"; Notes for "A proof of God"; Notes for "The red badge of courage"; Notes for "Journey to the center of mathematics"; Notes for "The integral: A horror story"; Notes for "The three little pigs"; Notes for "Class reunion"; Notes for "Into thin air"; Notes for "A deprogrammer's tale"; Notes for "Research announcement"; Notes for "Fields medalist stripped"; Notes for "Vital sines"; Notes for "Rumpled Stiltsken".

August 2009, 271 pages, Softcover, ISBN: 978-0-8218-4817-3, LC 2009009835, 2000 *Mathematics Subject Classification:* 97A90, 00A05, 00A08, **AMS members US$26**, List US$32, Order code MBK/62

Geometry and Topology



Parabolic Geometries I

Background and General Theory

Andreas Čap, *Universität Wien, Austria, and International Erwin Schrödinger Institute for Mathematical Physics, Wien, Austria*, and **Jan Slovák**, *Masaryk University, Brno, Czech Republic*

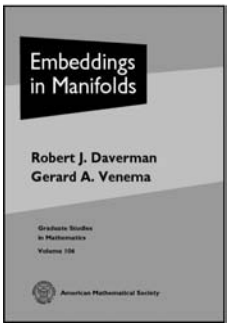
Parabolic geometries encompass a very diverse class of geometric structures, including such important examples as conformal, projective, and almost quaternionic structures, hypersurface type CR-structures and various types of generic distributions. The characteristic feature of parabolic geometries is an equivalent description by a Cartan geometry modeled on a generalized flag manifold (the quotient of a semisimple Lie group by a parabolic subgroup).

Background on differential geometry, with a view towards Cartan connections, and on semisimple Lie algebras and their representations, which play a crucial role in the theory, is collected in two introductory chapters. The main part discusses the equivalence between Cartan connections and underlying structures, including a complete proof of Kostant's version of the Bott–Borel–Weil theorem, which is used as an important tool. For many examples, the complete description of the geometry and its basic invariants is worked out in detail. The constructions of correspondence spaces and twistor spaces and analogs of the Fefferman construction are presented both in general and in several examples. The last chapter studies Weyl structures, which provide classes of distinguished connections as well as an equivalent description of the Cartan connection in terms of data associated to the underlying geometry. Several applications are discussed throughout the text.

Contents: *Background:* Cartan geometries; Semisimple Lie algebras and Lie groups; *General theory:* Parabolic geometries; A panorama of examples; Distinguished connections and curves; Other prolongation procedures; Tables; Bibliography; Index.

Mathematical Surveys and Monographs, Volume 154

August 2009, approximately 634 pages, Hardcover, ISBN: 978-0-8218-2681-2, LC 2009009335, 2000 *Mathematics Subject Classification:* 53C15, 53B15, 53A40, 53A55, 58A32; 53C30, 53D10, 53A30, 58A30, 58J70, **AMS members US$96**, List US$120, Order code SURV/154



Embeddings in Manifolds

Robert J. Daverman, *University of Tennessee, Knoxville, TN*, and **Gerard A. Venema**, *Calvin College, Grand Rapids, MI*

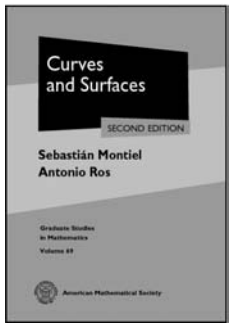
A topological embedding is a homeomorphism of one space onto a subspace of another. The book analyzes how and when objects like polyhedra or manifolds embed in a given higher-dimensional manifold. The main problem is to determine when two topological embeddings of the same object are equivalent in the sense of differing only by a homeomorphism of the ambient manifold. Knot theory is the special case of spheres smoothly embedded in spheres; in this book, much more general spaces and much more general embeddings are considered. A key aspect of the main problem is taming: when is a topological embedding of a polyhedron equivalent to a piecewise linear embedding? A central theme of the book is the fundamental role played by local homotopy properties of the complement in answering this taming question.

The book begins with a fresh description of the various classic examples of wild embeddings (i.e., embeddings inequivalent to piecewise linear embeddings). Engulfing, the fundamental tool of the subject, is developed next. After that, the study of embeddings is organized by codimension (the difference between the ambient dimension and the dimension of the embedded space). In all codimensions greater than two, topological embeddings of compacta are approximated by nicer embeddings, nice embeddings of polyhedra are tamed, topological embeddings of polyhedra are approximated by piecewise linear embeddings, and piecewise linear embeddings are locally unknotted. Complete details of the codimension-three proofs, including the requisite piecewise linear tools, are provided. The treatment of codimension-two embeddings includes a self-contained, elementary exposition of the algebraic invariants needed to construct counterexamples to the approximation and existence of embeddings. The treatment of codimension-one embeddings includes the locally flat approximation theorem for manifolds as well as the characterization of local flatness in terms of local homotopy properties.

Contents: Prequel; Tame and knotted embeddings; Wild and flat embeddings; Engulfing, cellularity, and embedding dimension; Trivial-range embeddings; Codimension-three embeddings; Codimension-two embeddings; Codimension-one embeddings; Codimension-zero embeddings; Bibliography; Selected symbols and abbreviations; Index.

Graduate Studies in Mathematics, Volume 106

September 2009, 474 pages, Hardcover, ISBN: 978-0-8218-3697-2, LC 2009009836, 2000 *Mathematics Subject Classification:* 57N35, 57N30, 57N45, 57N40, 57N60, 57N75, 57N37, 57N70, 57Q35, 57Q30, 57Q45, 57Q40, 57Q60, 57Q55, 57Q37, 57P05, **AMS members US$60**, List US$75, Order code GSM/106



Curves and Surfaces

Second Edition

Sebastián Montiel and **Antonio Ros**, *Universidad de Granada, Spain*

This introductory textbook puts forth a clear and focused point of view on the differential geometry of curves and surfaces. Following the modern point of view on differential geometry, the book emphasizes the global aspects of the subject. The excellent collection of examples and exercises (with hints) will help students in learning the material. Advanced undergraduates and graduate students will find this a nice entry point to differential geometry.

In order to study the global properties of curves and surfaces, it is necessary to have more sophisticated tools than are usually found in textbooks on the topic. In particular, students must have a firm grasp on certain topological theories. Indeed, this monograph treats the Gauss–Bonnet theorem and discusses the Euler characteristic. The authors also cover Alexandrov's theorem on embedded compact surfaces in $\mathbb{R}^3$ with constant mean curvature. The last chapter addresses the global geometry of curves, including periodic space curves and the four-vertices theorem for plane curves that are not necessarily convex.

Besides being an introduction to the lively subject of curves and surfaces, this book can also be used as an entry to a wider study of differential geometry. It is suitable as the text for a first-year graduate course or an advanced undergraduate course.

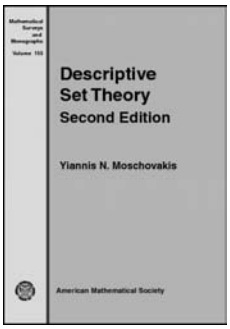
This book is jointly published by the AMS and the Real Sociedad Matemática Española.

Contents: Plane and space curves; Surfaces in Euclidean space; The second fundamental form; Separation and orientability; Integration on surfaces; Global extrinsic geometry; Intrinsic geometry of surfaces; The Gauss–Bonnet theorem; Global geometry of curves; Bibliography; Index.

Graduate Studies in Mathematics, Volume 69

August 2009, 376 pages, Hardcover, ISBN: 978-0-8218-4763-3, LC 2009008149, 2000 *Mathematics Subject Classification:* 53A04, 53A05, 53C40, **AMS members US$55**, List US$69, Order code GSM/69.R

Logic and Foundations



Descriptive Set Theory

Second Edition

Yiannis N. Moschovakis, *University of California, Los Angeles, CA, and University of Athens, Greece*

Descriptive Set Theory is the study of sets in separable, complete metric spaces that can be defined (or constructed), and so can be expected to have special properties not enjoyed by arbitrary pointsets. This subject was started by the French analysts at the turn of the 20th century, most prominently Lebesgue, and, initially, was concerned primarily with establishing regularity properties of Borel and Lebesgue measurable functions, and analytic, coanalytic, and projective sets. Its rapid development came to a halt in the late 1930s, primarily because it bumped against problems which were independent of classical axiomatic set theory. The field became very active again in the 1960s, with the introduction of strong set-theoretic hypotheses and methods from logic (especially recursion theory), which revolutionized it.

This monograph develops Descriptive Set Theory systematically, from its classical roots to the modern "effective" theory and the consequences of strong (especially determinacy) hypotheses. The book emphasizes the foundations of the subject, and it sets the stage for the dramatic results (established since the 1980s) relating large cardinals and determinacy or allowing applications of Descriptive Set Theory to classical mathematics.

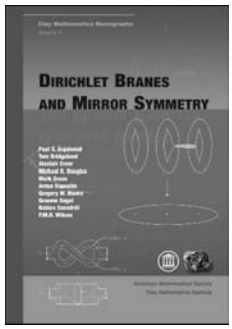
The book includes all the necessary background from (advanced) set theory, logic and recursion theory.

Contents: Introduction; The basic classical notions; κ-Suslin and λ-Borel; Basic notions of the effective theory; Structure theory for pointclasses; The constructible universe; The playful universe; The recursion theorem; Metamathematics; The axiomatics of pointclasses; References; Index.

Mathematical Surveys and Monographs, Volume 155

July 2009, 502 pages, Hardcover, ISBN: 978-0-8218-4813-5, LC 2009011239, 2000 *Mathematics Subject Classification:* 03-02; 03D55, 03E15, 28A05, 54H05, **AMS members US$92**, List US$115, Order code SURV/155

Mathematical Physics



Dirichlet Branes and Mirror Symmetry

Paul S. Aspinwall, *Duke University, Durham, NC*, **Tom Bridgeland**, *University of Sheffield, United Kingdom*, **Alastair Craw**, *University of Glasgow, United Kingdom*, **Michael R. Douglas**, *Stony Brook University, NY*, **Mark Gross**, *University of California, San Diego, La Jolla, CA*, **Anton Kapustin**, *California Institute of Technology, Pasadena, CA*, **Gregory W. Moore**, *Rutgers University, Piscataway, NJ*, **Graeme Segal** and **Balázs Szendrői**, *University of Oxford, United Kingdom*, and **P. M. H. Wilson**, *University of Cambridge, United Kingdom*

Research in string theory over the last several decades has yielded a rich interaction with algebraic geometry. In 1985, the introduction of Calabi–Yau manifolds into physics as a way to compactify ten-dimensional space-time has led to exciting cross-fertilization between physics and mathematics, especially with the discovery of mirror symmetry in 1989. A new string revolution in the mid-1990s brought the notion of branes to the forefront. As foreseen by Kontsevich, these turned out to have mathematical counterparts in the derived category of coherent sheaves on an algebraic variety and the Fukaya category of a symplectic manifold.

This has led to exciting new work, including the Strominger–Yau–Zaslow conjecture, which used the theory of branes to propose a geometric basis for mirror symmetry, the theory of stability conditions on triangulated categories, and a physical basis for the McKay correspondence. These developments have led to a great deal of new mathematical work.

One difficulty in understanding all aspects of this work is that it requires being able to speak two different languages, the language of string theory and the language of algebraic geometry. The 2002 Clay School on Geometry and String Theory set out to bridge this gap, and this monograph builds on the expository lectures given there to provide an up-to-date discussion including subsequent developments. A natural sequel to the first Clay monograph on Mirror Symmetry, it presents the new ideas coming out of the interactions of string theory and algebraic geometry in a coherent logical context. We hope it will allow students and researchers who are familiar with the language of one of the two fields to gain acquaintance with the language of the other.

The book first introduces the notion of Dirichlet brane in the context of topological quantum field theories, and then reviews the basics of string theory. After showing how notions of branes arose in string theory, it turns to an introduction to the algebraic geometry, sheaf theory, and homological algebra needed to define and work with derived categories. The physical existence conditions for branes are then discussed and compared in the context of mirror symmetry, culminating in Bridgeland's definition of stability structures, and its applications to the McKay correspondence and quantum geometry. The book continues with detailed treatments of the Strominger–Yau–Zaslow conjecture, Calabi–Yau metrics and

homological mirror symmetry, and discusses more recent physical developments.

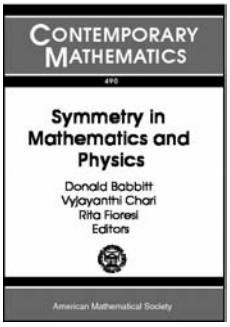
This book is suitable for graduate students and researchers with either a physics or mathematics background, who are interested in the interface between string theory and algebraic geometry.

Titles in this series are co-published with the Clay Mathematics Institute (Cambridge, MA).

Contents: Overview and physical background; D-branes and K-theory in 2D topological field theory; Open strings and Dirichlet branes; Representation theory, homological algebra and geometry; Dirichlet branes and stability conditions; The Strominger-Yau-Zaslow picture of mirror symmetry; Metric aspects of Calabi-Yau manifolds; The mathematics of homological mirror symmetry; Bibliography; Index.

Clay Mathematics Monographs, Volume 4

July 2009, approximately 684 pages, Hardcover, ISBN: 978-0-8218-3848-8, LC 2009014258, 2000 *Mathematics Subject Classification:* 14J32, 18E30, 53D12, 53D40, 53D45, 53C38, 53C29, 53C25, 81T30, 81T40, 81T45, 81T75, **AMS members US$87**, List US$109, Order code CMIM/4



Symmetry in Mathematics and Physics

Donald Babbitt, *University of California, Los Angeles, CA*, **Vyjayanthi Chari**, *University of California, Riverside, CA*, and **Rita Fioresi**, *Universita di Bologna, Italy*, Editors

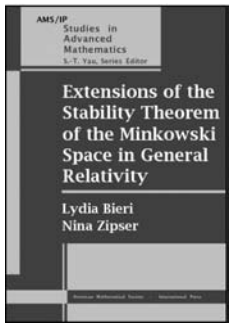
The articles in this volume mainly grew out of talks given at a conference held at UCLA in January 2008, which honored V. S. Varadarajan on his 70th birthday. The main theme of the conference was symmetry in mathematics and physics, areas of mathematics and mathematical physics in which Varadarajan has made significant contributions during the past 50 years. Very early in his career he also worked and made significant contributions in the areas of probability and the foundations of quantum mechanics.

Topics covered by the articles in this volume are probability, quantum mechanics, symmetry (broadly interpreted in mathematics and physics), finite and infinite dimensional Lie groups and Lie algebras and their representations, super Lie groups and supergeometry (relatively new but active and important fields at the interface between mathematics and physics), and supersymmetry. The latter topic takes on a special importance since one of the first experiments at the Large Hadron Collider at CERN will be a test of whether supersymmetry exists in the world of elementary particles. A reprint of an exposition of supersymmetry by one of its founders, B. Zumino, appears in this volume.

Contents: *Probability:* **S. R. S. Varadhan**, The role of weak convergence in probability theory; *Foundations of quantum mechanics:* **E. G. Beltrametti**, Statistical models on a simplex; *Quantum error correcting codes:* **K. R. Parthasarathy**, Quantum error correcting codes and Weyl commutation relations; *Finite and infinite dimensional Lie groups and algebras and their representations:* **V. Chari**, **R. J. Dolbin**, and **T. Ridenour**, Ideals in parabolic subalgebras of simple Lie algebras; **C. H. Conley**, Quantizations of modules of differential operators; **I. Dimitrov** and **M. Roth**, Geometric realization of PRV components and the Littlewood-Richardson cone; **S. Jijo** and **V. S. Sunder**, Kaç algebras, quantum doubles and planar algebras; **B. Kostant** and **N. Wallach**, On a theorem of Ranee Brylinski; **H. Salmasian**, Conjugacy of maximal toral subalgebras of direct limits of loop algebras; **N. Wallach** and **O. Yacobi**, A multiplicity formula for tensor products of SL_2 modules and an explicit Sp_{2n} to $Sp_{2n-2} \times Sp_2$ branching formula; *Super Lie groups and supergeometry:* **L. Balduzzi**, **C. Carmeli**, and **G. Cassinelli**, Super G-spaces; **L. Balduzzi**, **C. Carmeli**, and **R. Fioresi**, Quotients in supergeometry; **M. A. Lledó** and **J. A. López**, Special geometry of D=4, 5 supersymmetry; *Supersymmetry:* **S. Ferrara** and **A. Marrani**, Symmetric spaces in supergravity; **M. K. Gaillard**, Symmetry and superstring phenomenology; **B. Zumino**, Supersymmetry: A personal view.

Contemporary Mathematics, Volume 490

August 2009, 251 pages, Softcover, ISBN: 978-0-8218-4731-2, LC 2009004434, 2000 *Mathematics Subject Classification:* 16Sxx, 17Bxx, 20Gxx, 32Cxx, 51Bxx, 60Fxx, 81Pxx, 81Txx, 81-02, **AMS members US$63**, List US$79, Order code CONM/490



Extensions of the Stability Theorem of the Minkowski Space in General Relativity

Lydia Bieri and **Nina Zipser**, *Harvard University, Cambridge, MA*

This book consists of two independent works: Part I is "Solutions of the Einstein Vacuum Equations", by Lydia Bieri. Part II is "Solutions of the Einstein-Maxwell Equations", by Nina Zipser.

A famous result of Christodoulou and Klainerman is the global nonlinear stability of Minkowski spacetime. In this book, Bieri and Zipser provide two extensions to this result. In the first part, Bieri solves the Cauchy problem for the Einstein vacuum equations with more general, asymptotically flat initial data, and describes precisely the asymptotic behavior. In particular, she assumes less decay in the power of r and one less derivative than in the Christodoulou–Klainerman result. She proves that in this case, too, the initial data, being globally close to the trivial data, yields a solution which is a complete spacetime, tending to the Minkowski spacetime at infinity along any geodesic. In contrast to the original situation, certain estimates in this proof are borderline in view of decay, indicating that the conditions in the main theorem on the decay at infinity on the initial data are sharp.

In the second part, Zipser proves the existence of smooth, global solutions to the Einstein–Maxwell equations. A nontrivial solution of these equations is a curved spacetime with an electromagnetic field. To prove the existence of solutions to the Einstein–Maxwell equations, Zipser follows the argument and methodology introduced by Christodoulou and Klainerman. To generalize the original results, she needs to contend with the additional curvature terms that arise due to the presence of the electromagnetic field F; in her case the Ricci curvature of the spacetime is not identically zero but rather represented by a quadratic in the components of F. In particular the Ricci curvature is a constant multiple of the stress-energy tensor for F. Furthermore, the traceless part of the

Riemann curvature tensor no longer satisfies the homogeneous Bianchi equations but rather inhomogeneous equations including components of the spacetime Ricci curvature. Therefore, the second part of this book focuses primarily on the derivation of estimates for the new terms that arise due to the presence of the electromagnetic field.

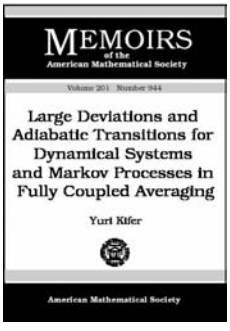
Titles in this series are co-published with International Press, Cambridge, MA.

Contents: *Solutions of the Einstein vacuum equations, by Lydia Bieri:* Introduction; Preliminary tools; Main theorem; Comparison; Error estimates; Second fundamental form k: estimates for the components of k; Second fundamental form χ: estimating χ and ζ; Uniformization theorem; χ on the surfaces S-changes in r and s; The last slice; Curvature tensor-components; Uniformation theorem: standard situation, cases 1 and 2; Bibliography; Index; *Solutions of the Einstein-Maxwell equations, by Nina Zipser:* Introduction; Norms and notation; Existence theorem; The electromagnetic field; Error estimates for F; Interior estimates for F; Comparison theorem for the Weyl tensor; Error estimates for W; Second fundamental form; The lapse function; Optical function; Conclusion; Bibliography; Index.

AMS/IP Studies in Advanced Mathematics, Volume 45

July 2009, 491 pages, Hardcover, ISBN: 978-0-8218-4823-4, LC 2009008908, 2000 *Mathematics Subject Classification:* 83C05; 58J45, 53C80, **AMS members US$95**, List US$119, Order code AMSIP/45

Probability



Large Deviations and Adiabatic Transitions for Dynamical Systems and Markov Processes in Fully Coupled Averaging

Yuri Kifer, *Hebrew University, Jerusalem, Israel*

Contents: Part 1. Hyperbolic Fast Motions; Part 2. Markov Fast Motions; Bibliography; Index.

Memoirs of the American Mathematical Society, Volume 201, Number 944

September 2009, 129 pages, Softcover, ISBN: 978-0-8218-4425-0, LC 2009019381, 2000 *Mathematics Subject Classification:* 34C29; 37D20, 60F10, 60J25, **Individual member US$40**, List US$67, Institutional member US$54, Order code MEMO/201/944

New AMS-Distributed Publications

Discrete Mathematics and Combinatorics

A First Course in Graph Theory and Combinatorics

Sebastian M. Cioabă and **M. Ram Murty**, *Queen's University, Kingston, Ontario, Canada*

The concept of a graph is fundamental in mathematics since it conveniently encodes diverse relations and facilitates combinatorial analysis of many complicated counting problems. In this book, the authors have traced the origins of graph theory from its humble beginnings of recreational mathematics to its modern setting for modeling communication networks as is evidenced by the World Wide Web graph used by many Internet search engines.

This book is an introduction to graph theory and combinatorial analysis. It is based on courses given by the second author at Queen's University at Kingston, Ontario, Canada between 2002 and 2008. The courses were aimed at students in their final year of their undergraduate program.

A publication of Hindustan Book Agency. Distributed on an exclusive basis by the AMS in North America. Online bookstore rights worldwide.

Contents: Basic notions of graph theory; Recurrence relations; The principle of inclusion and exclusion; Matrices and graphs; Trees; Möbius inversion and graph colouring; Enumeration under group action; Matching theory; Block designs; Planar graphs; Edges and cycles; Regular graphs; Hints; Bibliography; Index.

Hindustan Book Agency

May 2009, 186 pages, Hardcover, ISBN: 978-81-85931-98-2, 2000 *Mathematics Subject Classification:* 05-01, **AMS members US$30**, List US$38, Order code HIN/42

General and Interdisciplinary

Sixth International Congress on Industrial and Applied Mathematics

Zürich, Switzerland, July 16–20, 2007

Rolf Jeltsch, *ETH Zürich, Switzerland*, and **Gerhard Wanner**, *Université de Genévé, Switzerland*, Editors

The International Council for Industrial and Applied Mathematics (ICIAM) is the worldwide organization of societies which are dedicated primarily or significantly to applied and/or industrial mathematics. The ICIAM Congresses, held every four years, are run under the auspices of the Council with the aim to advance the applications of mathematics in all parts of the world. The Sixth ICIAM Congress was held in Zürich, Switzerland, July 16–20, 2007, and was attended by more than 3000 scientists from 47 countries.

This volume collects the invited lectures of this Congress, the appreciations of the ICIAM Prize winners' achievements, and the Euler Lecture celebrating the 300th anniversary of Euler. The authors of these papers are leading researchers in their fields, rigorously selected by a distinguished international program committee. The book presents an overview of contemporary applications of mathematics, new perspectives, and open problems. Topics embrace analysis of and numerical methods for:

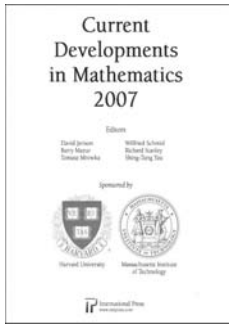
- linear and nonlinear partial differential equations
- multiscale modeling
- nonlinear problems involving integral operators
- controllability and observability
- asymptotic solutions of Hamilton–Jacobi equations
- contact problems in solid mechanics
- topology optimization of structures
- dissipation inequalities in systems theory
- greedy algorithms
- sampling in function space
- order-value optimization
- parabolic partial differential equations and deterministic games

Moreover, particular applications involve risk in financial markets, radar imaging, brain dynamics, and complex geometric optics applied to acoustics and electromagnetics.

A publication of the European Mathematical Society (EMS). Distributed within the Americas by the American Mathematical Society.

Contents: *Invited Lectures:* **G. Allaire**, **F. Jouve**, and **N. Van Goethem**, A level set method for the numerical simulation of damage evolution; **C. Ebenbauer**, **T. Raff**, and **F. Allgöwer**, Dissipation inequalities in systems theory: An introduction and recent results; **L. Caffarelli**, Some nonlinear problems involving non-local diffusions; **C. Canuto**, High-order methods for PDEs: Recent advances and new perspectives; **M. Cheney**, Radar imaging; **A. Cohen**, Adaptive approximations by greedy algorithms; **Weinan E**, Multiscale analysis of density functional theory; **M. Fortin**, **C. Robitaille**, **A. Fortin**, and **A. Rezgui**, Frictional contact in solid mechanics; **R. Glowinski**, Numerical methods for fully nonlinear elliptic equations; **H. Ishii**, Asymptotic solutions of Hamilton–Jacobi equations for large time and related topics; **B. Keyfitz**, Hyperbolic conservation laws. Past and future; **R. Kohn** and **S. Serfaty**, Second-order PDE and deterministic games; **T. Li**, Controllability and observability: From ODEs to quasilinear hyperbolic systems; **J. Martínez**, Order-value optimization and new applications; **C. Schütte**, **F. Noe**, **E. Meerbach**, **P. Metzner**, and **C. Hartmann**, Conformation dynamics; **A. Beskos** and **A. Stuart**, MCMC methods for sampling function space; **I. Tsuda**, Chaotic itinerancy reality in the dynamic brain—episodic memory formation; **G. Uhlmann**, Visibility and invisibility; **J. Xu**, Optimal algorithms for discretized partial differential equations; *Euler Special Lecture:* **W. Gautschi**, Leonhard Euler: His life, the man, and his works.

June 2009, 530 pages, Hardcover, ISBN: 978-3-03719-056-2, 2000 *Mathematics Subject Classification:* 00Bxx, **AMS members US$118**, List US$148, Order code EMSICIAM/2007



Current Developments in Mathematics, 2007

Barry Mazur, **Wilfried Schmid**, and **Shing-Tung Yau**, *Harvard University, Cambridge, MA*, and **David Jerison**, **Tomasz Mrowka**, and **Richard P. Stanley**, *Massachusetts Institute of Technology, Cambridge, MA*, Editors

The Current Developments in Mathematics (CDM) conference is an annual seminar, jointly hosted by Harvard University and the Massachusetts Institute of Technology, and devoted to surveying the most recent developments in mathematics. In choosing speakers, the hosts take a broad look at the field of geometry and select geometers who transcend classical perceptions within their field. All speakers are prominent specialists in the fields of algebraic geometry, mathematical physics, and other areas. International Press is pleased to present the full contents of these proceedings in the CDM book series.

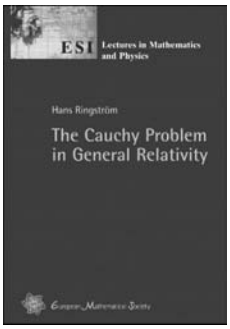
A publication of International Press. Distributed worldwide by the American Mathematical Society.

Contents: **B. Green**, Three topics in additive prime number theory; **Y. Kawamata**, Finite generation of a canonical ring; **J. Li**, Recent progress in GW-invariants of Calabi–Yau threefolds; **D. H. Phong** and **J. Sturm**, Lectures on stability and constant scalar curvature; **Y.-T. Siu**, Techniques for the analytic proof of the finite generation of the canonical ring; **C. H. Taubes**, Notes on the Seiberg–Witten equations, the Weinstein conjecture and embedded contact homology.

International Press

April 2009, 245 pages, Softcover, ISBN: 978-1-57146-134-6, 2000 *Mathematics Subject Classification:* 00Bxx, **AMS members US$38**, List US$48, Order code INPR/82

Mathematical Physics



The Cauchy Problem in General Relativity

Hans Ringström, *KTH Royal Institute of Technology, Stockholm, Sweden*

The general theory of relativity is a theory of manifolds equipped with Lorentz metrics and fields which describe the matter content. Einstein's equations equate the Einstein tensor (a curvature quantity associated with the Lorentz metric) with the stress energy tensor (an object constructed using the matter fields). In addition, there are equations describing the evolution of the matter. Using symmetry as a guiding principle, one is naturally led to the Schwarzschild and Friedmann–Lemaître–Robertson–Walker solutions, modelling an isolated system and the entire universe respectively. In a different approach, formulating Einstein's equations as an initial value problem allows a closer study of their solutions.

This book first provides a definition of the concept of initial data and a proof of the correspondence between initial data and development. It turns out that some initial data allow non-isometric maximal developments, complicating the uniqueness issue. The second half of the book is concerned with this and related problems, such as strong cosmic censorship.

The book presents complete proofs of several classical results that play a central role in mathematical relativity but are not easily accessible to those without prior background in the subject. Prerequisites are a good knowledge of basic measure and integration theory as well as the fundamentals of Lorentz geometry. The necessary background from the theory of partial differential equations and Lorentz geometry is included.

A publication of the European Mathematical Society (EMS). Distributed within the Americas by the American Mathematical Society.

Contents: Introduction; Outline; *Part I. Background from the theory of partial differential equations:* Functional analysis; The Fourier transform; Sobolev spaces; Sobolev embedding; Symmetric hyperbolic systems; Linear wave equations; Local existence, non-linear wave equations; *Part II. Background in geometry, global hyperbolicity and uniqueness:* Basic Lorentz geometry; Characterizations of global hyperbolicity; Uniqueness of solutions to linear wave equations; *Part III. General relativity:* The constraint equations; Local existence; Cauchy stability; Existence of a maximal globally hyperbolic development; *Part IV. Pathologies, strong cosmic censorship:* Preliminaries; Constant mean curvature; Initial data; Einstein's vacuum equations; Closed universe recollapse; Asymptotic behaviour; LRS Bianchi class A solutions; Existence of extensions; Existence of inequivalent extensions; Appendices; Bibliography; Index.

ESI Lectures in Mathematics and Physics, Volume 6

June 2009, 307 pages, Softcover, ISBN: 978-3-03719-053-1, 2000 *Mathematics Subject Classification:* 83-02, 83C75, **AMS members US$46**, List US$58, Order code EMSESILEC/6

Number Theory

Number Theory and Applications

Proceedings of the International Conferences on Number Theory and Cryptography

S. D. Adhikari and **B. Ramakrishnan**, *Harish-Chandra Research Institute, Allahabad, India*, Editors

This collection of articles contains the proceedings of the two international conferences (on Number Theory and Cryptography) held at the Harish–Chandra Research Institute. In recent years the interest in number theory has increased due to its applications in areas like error-correcting codes and cryptography. These proceedings contain papers in various areas of number theory, such as combinatorial, algebraic, analytic and transcendental aspects, arithmetic algebraic geometry, as well as graph theory and cryptography. While some papers do contain new results, several of the papers are expository articles that mention open questions, which will be useful to young researchers.

A publication of Hindustan Book Agency. Distributed on an exclusive basis by the AMS in North America. Online bookstore rights worldwide.

Contents: R. Balasubramanian, **G. Garg**, and **C. E. Veni Madhavan**, Analysis of the lattice sieve 1; **I. Baoulina**, On the number of solutions to the equation $(x_1 + \dots X_n)^m = ax_1 \dots x_n$ over the finite field F_q for $gcd(m-n, q-1) = 7$ and $gcd(m-n, q-1) = 14$; **Y. J. Choie**, **A. Sankaranarayanan**, and **J. Sengupta**, On the sign changes of Hecke eigenvalues; **A. Dubickas**, Distribution of some sequences modulo 1; **S. Ganguly**, Large sieves and cusp forms of weight one; **G. Grekos**, Open problems on densities; **A. Hoshi** and **K. Miyake**, A geometric framework for the subfield problem of generic polynomials via Tschirnhausen transformation; **I. Kátai**, On q-additive and q-multiplicative functions; **M. R. Murty**, Variations of the Sato–Tate conjecture; **D. S. Nagaraj** and **P. Sastri**, On the determination of Diophantine triples; **A. M. Raigorodskii** and **O. I. Rubanov**, On the clique and the chromatic numbers of high-dimensional distance graphs; **A. Saikia**, On units generated by Euler systems; **N. Saradha** and **R. Thangadurai**, Pillai's problem on consecutive integers; **W. A. Schmid**, Characterization of class groups of Krull monoids via their systems of sets of lengths: A status report; **W. M. Schmidt**, Diophantine approximation by numbers of small height; **J.-H. Yang**, Theory of the Siegel modular variety.

Hindustan Book Agency

June 2009, 290 pages, Hardcover, ISBN: 978-81-85931-97-5, 2000 *Mathematics Subject Classification:* 05C15, 05C80, 05D10, 11A25, 11B05, 11D09, 11F66, 11F72, 11G25, 11J17, 11K06, 11M41, 11N69, 11R16, 11R18, 11R27, 11Y05, 12E25, 14K10, **AMS members US$42**, List US$52, Order code HIN/43

Classified Advertisements

Positions available, items for sale, services available, and more

CALIFORNIA

MATHEMATICAL SCIENCES RESEARCH INSTITUTE
Berkeley, CA

MSRI invites applications for 40 Research Professors, 200 Research Members, and 30 semester-long Post-Doctoral Fellows in the following programs: Random Matrix Theory, Interacting Particle Systems and Integrable Systems (August 16, 2010, to December 17, 2010); Inverse Problems and Applications (August 16, 2010, to December 17, 2010); Free Boundary Problems, Theory and Applications (January 10, 2011, to May 20, 2011); and Arithmetic Statistics (January 10, 2011, to May 20, 2011). A very small number of positions that are unaffiliated with these four programs may be available as part of our Complementary Program. Research professorships are intended for senior researchers who will be making key contributions to a program, including the mentoring of postdoctoral fellows, and who will be in residence for three or more months. Research memberships are intended for researchers who will be making contributions to a program and who will be in residence for one or more months. Post-doctoral fellowships are intended for recent Ph.D.'s. Interested individuals should carefully describe the purpose of their proposed visit, and indicate why a residency at MSRI will advance their research program. To receive full consideration, application must be complete, including all letters of support. Application deadlines: Research Professorships, October 1, 2009; Research Memberships, December 1, 2009; Post-doctoral Fellowships, December 1, 2009. Application information: `http://www.msri.org/propapps/applications/application_material`. The Institute is committed to the principles of Equal Opportunity and Affirmative Action.

000034

OREGON

ON TIME SYSTEMS, INC.
Research Scientist

We are currently hiring for the position of Research Scientist for our company in Eugene, Oregon. The successful candidate will be responsible for solving computational problems through developing new algorithms and improving existing ones, researching and developing new mathematical models, performing computations and applying mathematical analysis, validating algorithms and mathematical models, writing reports and presentations concerning algorithms. The candidate must also be able to pass a programming test, uniformly administered to all applicants for the position.

If interested, please mail resume to:
On Time Systems, Inc.
1850 Millrace Drive, Ste. 1
Eugene, OR 97403
Attn: Ms. Buchanan

000035

CYPRUS

UNIVERSITY OF CYPRUS
Department of Mathematics and Statistics

The Department of Mathematics and Statistics of the University of Cyprus invites applications for one position in the field of Global Analysis-Analysis on Manifolds at the rank of assistant professor or lecturer. The official languages of the university are Greek and/or Turkish. Holding a citizenship of the Republic of Cyprus is not a requirement. The deadline for applications is Monday, October 12, 2009. For more information, see `http://www.mas.ucy.ac.cy`.

000036

Suggested uses for classified advertising are positions available, books or lecture notes for sale, books being sought, exchange or rental of houses, and typing services.

The 2007 rate is $110 per inch or fraction thereof on a single column (one-inch minimum), calculated from top of headline. Any fractional text of 1/2 inch or more will be charged at the next inch rate. No discounts for multiple ads or the same ad in consecutive issues. For an additional $10 charge, announcements can be placed anonymously. Correspondence will be forwarded.

Advertisements in the "Positions Available" classified section will be set with a minimum one-line headline, consisting of the institution name above body copy, unless additional headline copy is specified by the advertiser. Headlines will be centered in boldface at no extra charge. Ads will appear in the language in which they are submitted.

There are no member discounts for classified ads. Dictation over the telephone will not be accepted for classified ads.

Upcoming deadlines for classified advertising are as follows: September 2009 issue–June 29, 2009; October 2009 issue–July 29, 2009; November 2009 issue–August 28, 2009; December 2009 issue–September 28, 2009; January 2010 issue–October 28, 2009; February 2010 issue–November 25, 2009.

U.S. laws prohibit discrimination in employment on the basis of color, age, sex, race, religion, or national origin. "Positions Available" advertisements from institutions outside the U.S. cannot be published unless they are accompanied by a statement that the institution does not discriminate on these grounds whether or not it is subject to U.S. laws. Details and specific wording may be found on page 1373 (vol. 44).

Situations wanted advertisements from involuntarily unemployed mathematicians are accepted under certain conditions for free publication. Call toll-free 800-321-4AMS (321-4267) in the U.S. and Canada or 401-455-4084 worldwide for further information.

Submission: Promotions Department, AMS, P.O. Box 6248, Providence, Rhode Island 02940; or via fax: 401-331-3842; or send email to `classads@ams.org`. AMS location for express delivery packages is 201 Charles Street, Providence, Rhode Island 20904. Advertisers will be billed upon publication.

Conferences

Call for Proposals for the 2011 von Neumann Symposium

Through a bequest from Carroll V. Newson to memorialize the late John von Neumann and his accomplishments, the Society established a quadrennial symposium called the von Neumann Symposium. Subjects of these one-week symposia are to be topics of emerging significance that are expected to underlie future mathematical development. Ideas expressed and shared at these symposia, and the new understandings embodied in the von Neumann proceedings, will reflect exceptional mathematical leadership.

Conference topics in this series have included Quantization and Nonlinear Wave Equations (1994); Arithmetic Fundamental Groups and Noncommutative Algebra (1999); and Symposium on Complex Geometry, Calibrations and Special Holonomy (2003).

Proposals for topics for the 2011 symposium are invited from mathematicians, either singly or in groups. Proposals must include (1) the names and affiliations of proposed members and the chair of the Organizing Committee; (2) a two-to-four page narrative addressing the focus of the topic, including its importance and timeliness; (3) estimated attendance; (4) a list of recent conferences in the same or closely related areas; (5) a tentative list of names and affiliations of the proposed principal speakers; and (6) a list of likely candidates who would be invited to participate and their current affiliations.

Individuals willing to serve as organizers should be aware that the professional meetings staff in the Society's Providence office will provide full support and assistance before, during, and after the conference, thus relieving the organizers of most of the administrative detail. There is some flexibility on the dates for when the symposium can be held in 2011.

Organizers should also note that it is required that the proceedings be published by the AMS and a member of the Organizing Committee must be willing to serve as editor of the proceedings.

An application form to be used when submitting suggested proposal(s) may be obtained by writing to the director of Meetings and Conferences, American Mathematical Society, 201 Charles St., Providence, RI 02904; or by telephone: 401-455-4146; fax: 401-455-4004; email: meet@ams.org.

Deadline for proposals is **September 30, 2009**. Proposals will be considered by the Von Neumann Symposium Selection Committee.

Meetings & Conferences of the AMS

IMPORTANT INFORMATION REGARDING MEETINGS PROGRAMS: AMS Sectional Meeting programs do not appear in the print version of the *Notices*. However, comprehensive and continually updated meeting and program information with links to the abstract for each talk can be found on the AMS website. See `http://www.ams.org/meetings/`. Final programs for Sectional Meetings will be archived on the AMS website accessible from the stated URL and in an electronic issue of the *Notices* as noted below for each meeting.

Waco, Texas

Baylor University

October 16–18, 2009

Friday – Sunday

Meeting #1051

Central Section
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: August 2009
Program first available on AMS website: September 3, 2009
Program issue of electronic *Notices*: October 2009
Issue of *Abstracts*: Volume 30, Issue 4

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: August 25, 2009

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

David Ben-Zvi, University of Texas at Austin, *Title to be announced.*

Alexander A. Kiselev, University of Wisconsin, *Title to be announced.*

Michael C. Reed, Duke University, *Title to be announced.*

Igor Rodnianski, Princeton University, *Title to be announced.*

Special Sessions

Applicable Algebraic Geometry (Code: SS 12A), **Luis David Garcia-Puente**, Sam Houston State University, and **Frank Sotille**, Texas A&M University.

Commutative Algebra: Module and Ideal Theory (Code: SS 4A), **Lars W. Christensen**, Texas Tech University, **Louiza Fouli**, University of Texas at Austin, and **David Jorgensen**, University of Texas at Arlington.

Contemporary Complex and Special Function Theory (Code: SS 14A), **Roger W. Barnard** and **Kent Pearce**, Texas Tech University, **Kendall Richards**, Southwestern University, and **Alexander Solynin** and **Brock Williams**, Texas Tech University.

Dynamic Equations on Time Scales: Analysis and Applications (Code: SS 1A), **John M. Davis**, **Ian A. Gravagne**, and **Robert J. Marks**, Baylor University.

Formations of Singularities in Geometric Flows (Code: SS 15A), **Maria-Cristina Caputo**, University of Texas at Austin, and **Natasa Sesum**, Columbia University.

Fusion Categories and Applications (Code: SS 7A), **Deepak Naidu** and **Eric Rowell**, Texas A&M University.

Global Analysis on Homogeneous Spaces (Code: SS 13A), **Ruth Gornett**, University of Texas at Arlington, and **Ken Richardson**, Texas Christian University.

Harmonic Analysis and Partial Differential Equations (Code: SS 8A), **Susan Friedlander**, University of Southern California, **Natasa Pavlovic**, University of Texas at Austin, and **Nikolaos Tzirakis**, University of Illinois at Urbana-Champaign.

Interdisciplinary Session on Stochastic Partial Differential Equations (Code: SS 11A), **M. Chekroun**, ENS-Paris and University of California Los Angeles, and **Shouhong Wang** and **Nathan Glatt-Holtz**, Indiana University.

Lie Groups, Lie Algebras, and Representations (Code: SS 6A), **Markus Hunziker**, **Mark Sepanski**, and **Ronald Stanke**, Baylor University.

Mathematical Aspects of Spectral Problems Related to Physics (Code: SS 10A), **Klaus Kirsten**, Baylor University, **Gregory Berkolaiko** and **Stephen Fulling**, Texas A&M University, **Jon Harrison**, Baylor University, and **Peter Kuchment**, Texas A&M University.

Mathematical Models of Neuronal and Metabolic Mechanisms (Code: SS 3A), **Janet Best**, Ohio State University, and **Michael Reed**, Duke University.

Numerical Solutions of Singular or Perturbed Partial Differential Equation Problems with Applications (Code: SS 2A), **Peter Moore**, Southern Methodist University, and **Qin Sheng**, Baylor University.

Recent Developments on Turbulence (Code: SS 9A), **Eleftherios Gkioulekas**, University of Texas-Pan American, and **Michael Jolly**, Indiana University.

The Topology of Continua (Code: SS 16A), **David Ryden**, Baylor University, **Chris Mouron**, Rhodes College, and **Sergio Macias**, Universidad Nacional Autonoma de Mexico.

Topological Methods for Boundary Value Problems for Ordinary Differential Equations (Code: SS 5A), **Richard Avery**, Dakota State University, **Paul W. Eloe**, University of Dayton, and **Johnny Henderson**, Baylor University.

Accommodations

Participants should make their own arrangements directly with the hotel of their choice and state that they are with the "Baylor AMS Group". The AMS is not responsible for rate changes or for the quality of the accommodations.

Clarion Hotel Waco, 801 South 4th Street, Waco, TX 76706; Tel: 254-757-2000, Fax: 254-757-1110. Rates start at US$89 per night with breakfast. Free airport shuttle.

Court Yard by Marriott Waco, 101 Washington Avenue, Waco, Texas 76701; Tel: 254-752-8686, Fax: 254-752-1011. Rates start at US$104 per night. The hotel offers free shuttle service to Baylor as well as the airport.

Hilton Waco, 113 South University Parks Drive, Waco, Texas, 76701-2241; Tel: 254-754-8484 Fax: 254-752-2214. Rates start at US$119 per night. This hotel is located approximately one mile from the campus. The hotel offers free shuttle service to Baylor as well as the airport.

Judge Baylor House Bed and Breakfast, 908 Speight Street, Waco, Texas 76706; Tel: 254-756-0273, Toll Free 1-888-JBAYLOR, Fax 254-756-0711; Rates start at US$82 per night with breakfast. The hotel offers free shuttle service to Baylor as well as the airport.

Residence Inn by Marriott, 501 University Parks Drive, Waco, Texas 76706; Tel: 254-714-1386 Fax: 254-714-1386. Rates start at US$99.99 per night with breakfast. The hotel offers free shuttle service to Baylor as well as the airport.

Food Service

For a list of restaurants that are of varying distances to Baylor University, please see the restaurant guide at `http://www.baylor.edu/content/services/document.php/84074.pdf`.

Local Information

All the talks will take place in the Baylor Science Building (BSB). A campus map is available at `http://www.baylor.edu/map`. The BSB appears as the "three-fingered" building near the corner of University Parks and Bagby Avenues.

Computer Access

Participants will have access to computers located in the atrium of the Baylor Science Building.

Mayborn Museum Complex/Strecker Museum

During the meeting, free admission to the Strecker Museum will be granted to participants when they show their registration badge. `http://www.maybornmuseum.com`.

Please visit the website maintained by the Baylor Department of Mathematics for more local information at: `http://www.baylor.edu/math/` and `http://www.baylor.edu/math/index.php?id=63149`. Additional information about Waco attractions can be found at the website maintained by the Waco Convention & Visitors Bureau at `http://www.wacocvb.com`.

Other Activities

Book Sales: Stop by the on-site AMS Bookstore and review the newest titles from the AMS, enjoy up to 25% off all AMS publications, or take home an AMS t-shirt! Complimentary coffee will be served courtesy of AMS Membership Services. The AMS Book Exhibit will be located in the atrium of the BSB.

AMS Editorial Activity: An acquisitions editor from the AMS book program will be present to speak with prospective authors. If you have a book project that you would like to discuss with the AMS, please stop by the book exhibit.

Parking

Baylor will be on Fall Break during the meeting so there will be ample free parking near the Baylor Science Building. Please refer to the campus map at `http://www.baylor.edu/map`.

Registration and Meeting Information

The registration desk will be located in the atrium of the Baylor Science Building (BSB) and will be open from noon to 4:00 p.m. on Friday and 7:30 a.m. to 4:00 p.m. on Saturday; it will not be open Sunday, October 18. All talks will take place in the BSB.

Registration fees: (payable on-site only) US$40 for AMS or CMS members; US$60 for nonmembers; US$5 for students, unemployed mathematicians, and emeritus members. Fees are payable by cash, check, VISA, MasterCard, Discover, or American Express.

Social Event

All participants are invited to a reception hosted by the department of mathematics at the Hilton (one of the recommended conference hotels), located at 113 South University Parks Drive, on Saturday evening October 17,

2009, from 6:30 p.m. to 8:30 p.m. There will be light snacks and beverages provided; there will also be a cash bar at the reception.

Travel

By Air: Waco is served by the Waco Regional Airport. Flights are offered by American Eagle (800-433-7300) and the Continental Connection (800-523-3273). Also, see http://www.waco-texas.com/airport/airport.htm. Airport car rentals should be reserved well in advance; the link to renting a car from the Waco airport is http://www.waco-texas.com/airport/carrentals.htm. Taxi service is available through Yellow Cab (254-756-1861).

Participants from outside Central Texas will likely first fly into Dallas or Houston before connecting to Waco. Instead of getting a connecting flight from these cities, you may want to rent a car in Dallas (100 mile drive to Waco) or Houston (about 180 miles to Waco). It is also possible to fly into Austin, rent a car there and drive 100 miles to Waco; however, at the present time, there are no connecting flights from Austin to Waco. Similarly, one can fly into Killeen (about 45 miles away), rent a car and drive to Waco; there are no connecting flights from Killeen to Waco.

Car Rental: Avis is the official car rental company for the sectional meeting in Waco. All rates include unlimited free mileage. Weekend daily rates are available from noon Thursday to Monday at 11:59 p.m. Rates do not include any state or local surcharges, tax, optional coverages, or gas refueling charges. Renters must meet Avis' age, driver, and credit requirements. For the best available rate and to make a reservation please call Avis at 800-331-1600 or go online at http://www.avis.com. Please use the AMS meeting **Avis Discount Number J098887**.

Driving: The Baylor campus is easily accessed from I-35. To get to the Baylor Science Building, exit I-35 North or South at Exit 335B onto University Parks Drive and go east (away from downtown and towards the Ferrell Center). Turn right on Bagby and right on Speight. Your first right turn will be into a parking lot for the BSB.

- From Dallas/Fort Worth: Take I-35 South to Exit 335B and turn left onto University Parks Drive.
- From Austin: Take I-35 North to Exit 335B and turn right onto University Parks Drive.
- From Houston: Take US-290 West and merge right onto TX-6 North; merge onto TX-434 SPUR North; merge left onto US-77 Business South ramp then turn right onto University Parks Drive.

Please visit http://www.baylor.edu/map/index.php?id=10724 to view a map with driving directions.

Weather

The weather in Waco in October is usually warm-hot during the day and cool-warm in the evenings. The average low for October 16–18 is 56° while the average high is about 79°. Participants should consult weather information on the Web prior to the meeting at http://www.weather.com/weather/local/USTX1413?.

Information for Intrenational Participants

Information for International Participants Visa regulations are continually changing for travel to the United States. Visa applications may take from three to four months to process and require a personal interview, as well as specific personal information. International participants should view the important information about traveling to the U.S. found at http://www7.nationalacademies.org/visas/Traveling_to_US.html and http://travel.state.gov/visa/index.html. If you need a preliminary conference invitation in order to secure a visa, please send your request to wsd@ams.org.

If you discover you do need a visa, the National Academies website (see above) provides these tips for successful visa applications:

* Visa applicants are expected to provide evidence that they are intending to return to their country of residence. Therefore, applicants should provide proof of "binding" or sufficient ties to their home country or permanent residence abroad. This may include documentation of the following:

* family ties in home country or country of legal permanent residence

* property ownership

* bank accounts

* employment contract or statement from employer stating that the position will continue when the employee returns;

* Visa applications are more likely to be successful if done in a visitor's home country than in a third country;

* Applicants should present their entire trip itinerary, including travel to any countries other than the United States, at the time of their visa application;

* Include a letter of invitation from the meeting organizer or the U.S. host, specifying the subject, location, and dates of the activity, and how travel and local expenses will be covered;

* If travel plans will depend on early approval of the visa application, specify this at the time of the application;

* Provide proof of professional scientific and/or educational status (students should provide a university transcript).

University Park, Pennsylvania

Pennsylvania State University

October 24–25, 2009

Saturday – Sunday

Meeting #1052

Eastern Section
Associate secretary: Steven H. Weintraub
Announcement issue of *Notices*: August 2009
Program first available on AMS website: September 10, 2009
Program issue of electronic *Notices*: October 2009
Issue of *Abstracts*: Volume 30, Issue 4

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: September 1, 2009

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Michael K. H. Kiessling, Rutgers University, *N-body problems in relativity*.

Kevin R. Payne, Universita degli di Milano, *PDE of mixed type: The twin challenges of globalization and diversity*.

Laurent Saloff-Coste, Cornell University, *Subelliptic heat kernel measures and holomorphic functions on complex Lie groups*.

Robert C. Vaughan, Pennsylvania State University, *Title to be announced*.

Special Sessions

Algebraic Combinatorics (Code: SS 6A), **Peter McNamara**, Bucknell University, and **Mark Skandera**, Lehigh University.

Analytic Number Theory (Code: SS 16A), **Angel V. Kumchev**, Towson University, **Michael P. Knapp**, Loyola College, and **Robert C. Vaughan**, Pennsylvania State University.

Arithmetic and Profinite Groups (Code: SS 19A), **Alireza Salehi-Golsefidy**, Princeton University, **Martin D. Kassabov**, Cornell University, and **Mikhail V. Ershov**, University of Virginia.

Automorphisms of Riemann Surfaces and Related Topics (Code: SS 15A), **S. Allen Broughton**, Rose-Hulman Institute of Technology, **Anthony Weaver**, Bronx Community College, the City University of New York, and **Aaron D. Wootton**, University of Portland.

Combinatorial and Homological Aspects of Commutative Algebra (Code: SS 3A), **Amanda I. Beecher**, United States Military Academy, and **Alexandre B. Tchernev**, University at Albany.

Commutative Algebra and Applications to Algebraic Geometry (Code: SS 11A), **Janet Striuli**, Fairfield University, and **Jooyoun Hong**, Southern Connecticut State University.

Difference Equations and Applications (Code: SS 2A), **Michael A. Radin**, Rochester Institute of Technology.

Function Fields and Their Applications (Code: SS 20A), **Mihran Papikian** and **Kirsten Eisentrager**, Pennsylvania State University.

Geometry of Integrable and Non-Integrable Dynamics (Code: SS 5A), **Boris Khesin**, University of Toronto, and **Mark Levi** and **Sergei Tabachnikov**, Pennsylvania State University.

Heat Kernel Analysis (Code: SS 8A), **Maria Gordina**, University of Connecticut, and **Laurent Saloff-Coste**, Cornell University.

Homotopy Theory (Code: SS 1A), **James Gillespie** and **Mark W. Johnson**, Pennsylvania State University, Altoona, **Simona Paoli**, University of Haifa, and **Donald Yau**, Ohio State University.

Integrable Systems and Related Areas (Code: SS 4A), **Sam Evans** and **Michael Gekhtman**, University of Notre Dame, and **Luen-Chau Li**, Pennsylvania State University.

Microlocal Analysis and Spectral Theory on Singular Spaces (Code: SS 14A), **Juan B. Gil** and **Thomas Krainer**, Pennsylvania State University, Altoona.

Accommodations

Participants should make their own arrangements directly with a hotel of their choice. Special rates have been negotiated at the hotels listed below but do not include the 8.5% occupancy tax. Participants should state that they will be attending the **PSU-AMS Meeting at Pennsylvania State University**. All rooms will be on a space available basis after the deadline given. The AMS is not responsible for rate changes or for the quality of the accommodations chosen. Because the Penn State area is a popular destination in the fall, participants should make reservations as early as possible. Be sure to check cancellation and checkout policies.

Days Inn, 240 South Pugh St., State College, PA 16801; Tel: 814-238-8454, Fax 814-237-1607; (`http://www.daysinn.com/DaysInn/control/Booking/property_info?propertyId=...`). The hotel is located approximately one block from the meeting site. Rates start at US$87 per night (you must reference group code CGAMSS). Amenities include free wireless Internet, indoor heated pool, complimentary parking and airport shuttle service. There is a full-service restaurant at the hotel. **Deadline for reservations is September 23, 2009**. Be sure to check cancellation and checkout policies.

Quality Inn (formerly Motel 6 as of May '09), 1274 North Atherton St., State College, PA 16801; Tel: 814-234-1600, Fax 814-234-6665; `http://www.motel6.com/reservations/motel_detail.aspx?num=4101`. The hotel is located approximately five blocks from the meeting site. Rates start at US$85 per night (you must reference group code #222819). Amenities include free 24-hour coffee, free high-speed wireless Internet access and parking.

Deadline for reservations is September 23, 2009. Be sure to check cancellation and checkout policies.

Ramada Inn, 1450 South Atherton St. (Business Route 322), State College, PA 16801; Tel: 814-238-3001, Fax: 814-237-1527; http://www.ramadasc.com/. The hotel is approximately two miles from the meeting site. Rates start at US$85 per night. Amenities include complimentary high speed Internet access in all guest rooms, free newspaper, cable TV, free HBO, indoor pool, Jacuzzi, seasonal outdoor pool, and recreation facility. There is casual dining on-site serving breakfast, lunch, and dinner. Complimentary parking and transportation from University Park Airport is available. **Deadline for reservations is October 23, 2009**. Be sure to check cancellation and checkout policies.

Sleep Inn, 111 Village Drive, State College, PA 16803; Tel: 814-235-1020, Fax: 814-235-1388; http://www.sleepinn.com/hotel-state_college-pennsylvania-PA421. The hotel is approximately three blocks from the meeting site. Rates start at US$65 per night (you must reference group code AMS "09"). Complimentary amenities include wireless high-speed Internet access, deluxe continental breakfast, newspaper, local calls, parking, and a fitness center. **Deadline for reservations is October 9, 2009**. Be sure to check cancellation and checkout policies.

Atherton Hotel, 125 South Atherton St. (Business Route 322), State College, PA 16801; Tel: 814-231-2100, Fax: 814-237-1130; http://www.athertonhotel.net/. The hotel is approximately a half mile from the meeting site. Rates start at US$90 per night. Complimentary amenities include LodgeNet Internet access, newspaper, room, parking, and complimentary shuttle service to airport and local businesses. There is casual dining on-site serving breakfast and dinner. **Deadline for reservations is September 23, 2009**. Be sure to check cancellation and checkout policies.

Hampton Inn, 1101 East College Ave., State College, PA 16801; Tel: 814-231-1590, Fax: 814-238-7320; http://www.hamptoninn.com/en/hp/hotels/index.jhtml?ctyhocn=SCECLHX. The hotel is approximately a half mile from the meeting site. Rates start at US$88 (you must reference group code AMS). Amenities include complimentary breakfast, airport shuttle, fitness center, pool, wireless high-speed Internet, and parking. **Deadline for reservations is September 25, 2009**. Be sure to check cancellation and checkout policies.

Food Service

There is no dining on the campus. The closest eatery is at the HUB-Robeson Center (http://www.hfs.psu.edu/unionstreet/), a food service facility located on the ground floor of the HUB-Robeson Center, Union Street Marketplace, which features a wide selection of foods at each of its eleven units. Within a short walking distance to College Street there are a variety of choices for dining; see http://www.statecollege.com/dining/index.php. Additional information and recommendations will be provided on-site.

Local Information

The Penn State visitors guide featuring a campus map and parking areas can be found at http://www.campusmaps.psu.edu/print/. Additional informatio n about the surrounding area can be found on the Downtown Map http://www.statecollegecentral.com/comm/maps/downtown.htm.

Other Activities

AMS Book Sale: Examine the newest titles from AMS. Most books will be available at a special 25% discount offered only at meetings. Complimentary coffee will be served courtesy of AMS Membership Services.

AMS Editorial Activity: An acquisitions editor from the AMS book program will be present to speak with prospective authors. If you have a book project that you would like to discuss with the AMS, please drop by the book exhibit.

Parking

There are multiple parking garages located on campus. Parking is free on campus on the weekends, except in posted "24-hour restricted lots". The closest parking area to the meeting site is the Eisenhower Parking Deck just outside the Thomas Building. For a map, see http://www.campusmaps.psu.edu/print/pdf/main.pdf.

Registration and Meeting Information

Invited Addresses, all sessions, Registration and Book Exhibit will be held in Thomas Building. Registration and the Book Exhibit will take place on the first floor in the lobby of Thomas Building on Saturday, October 24, from 7:30 a.m. to 4:00 p.m. and on Sunday, October 25, from 8:00 a.m. to noon. Fees are US$40 for AMS or CMS members, US$60 for nonmembers; and US$5 for students, unemployed mathematicians, and emeritus members. Fees are payable on site by cash, check, or credit card.

Computer Labs

Computer labs are available in the McAllister building in rooms 103 and 105 to check email and access the Internet. The rooms are open from 8:00 a.m.–5:00 p.m. on Saturday and Sunday. More details will be provided at registration.

Banquet

There will be a banquet Saturday, October 24, 2009, at the Days Inn, 240 South Pugh St., State College, PA 16801, from 6:30 p.m.–9:00 p.m. The cost is US$35 per person including tax and gratuity. **If you wish to attend the banquet please send an email to Hope Shaffer as soon as possible and send your check payable to Penn State University, c/o Hope Shaffer by October 15, 2009. Reservations will not be taken after this date and no money for the banquet will be accepted during the meeting**.

Hope Shaffer, Staff Assistant
The Pennsylvania State University
Department of Mathematics
107A McAllister Building
University Park, PA 16802
shaffer@math.psu.edu

The dinner buffet includes a create-your-own-salad station with mixed seasonal greens, assorted fresh garden vegetables, mixed olives, and assorted cheeses, with home style croutons and choice of dressings; grilled marinated

strip steak with sautéed wild mushrooms and natural reduction; oven baked chicken breast with parmesan cream; stuffed flounder with crab-laced white wine cream; freshly prepared seasonal vegetables and accompaniments; select artisan style rolls and breads; coffee (regular and decaf), tea, iced tea; chocolate cake and New York cheesecake.

Travel

Pennsylvania State University at University Park is located approximately in the geographic center of the state, in the town of State College. All modes of public transportation and several major highways service the university, making it easily accessible from metropolitan areas.

By Air: Airlines serve the State College area through the University Park Airport (SCE) located five miles from campus.

Limousine or taxi service is available from the airport to campus. The approximate cost from the airport to Penn State campus is about US$20. For taxi service call 814-353-6001 or 814-238-4901; limousine service is available by calling 814-353-6000.

By Bus: Bus service on and around campus is provided by CATA. Maps and schedules are available at `http://www.catabus.com/`, at the information desks in the HUB-Robeson Center and Kern Graduate Building. For schedule information, call 814-238-CATA (814-238-2282).

Trailways, 814-238-7362, and Greyhound Lines, 814-237-5865, provide connections to and from State College. The bus station is about two blocks from the meeting rooms on Penn State campus.

Driving directions: University Park (State College) is readily accessible from both ends of the state via Interstate 80(I-80):

From New York City: Take the George Washington Bridge to I-80 West, which becomes the Keystone Shortway. Take Exit #161 (Bellefonte) and follow Route 220 South to State College exit #74.

From Philadelphia: Take the northeast extension of the Pennsylvania Turnpike to I-80. Take Exit #161 (Bellefonte) and follow Route 220 South to State College exit #74. Or, you may take Philadelphia Schuylkill Expressway to the Pennsylvania Turnpike, leave the Turnpike at Exit #247 (Harrisburg East), and follow I-283 to I-83 and proceed north on I-83 to the I-81 interchange. Then follow I-81 west to Route 322, 22 West exit. Proceed west on Route 322 through Lewistown to State College exit #74.

From Pittsburgh: Follow Route 22 East to Duncansville, I-99/Route 220 North to Route 322 East to Mt. Nittany Expressway/State College Exit #73. Or you may follow Route 22 East beyond Duncansville to Water Street, Route 45 East to Pine Grove Mills, and Route 26 North to State College.

From Washington D.C.: Take Route 270 to Frederick then Route 70 to the Breezewood, PA turnpike (Exit #161). Then go one exit west to Bedford (Exit #146); take I-99 North to Rt. 220 to Route 322 East to State College Exit #74. Or take I-95 or the Baltimore-Washington Parkway to Baltimore, West loop I-695 to I-83 North. Continue on I-83 North to the I-81 interchange. Then follow I-81 west to Route 322, 22 Exit. Proceed west on Route 322 to Lewistown and State College.

From the West: Take I-80 to Exit #123 (Woodland) just east of Clearfield, then Route 322 East to State College. Or, one may also Exit I-80 at Exit #161 (Bellefonte) and follow Route 220 South to State College Exit #74.

Car Rental: Avis is the official car rental company for the sectional meeting in State College. All rates include unlimited free mileage. Weekend daily rates are available from noon Thursday to Monday at 11:59 p.m. Rates do not include any state or local surcharges, tax, optional coverages, or gas refueling charges. Renters must meet Avis' age, driver, and credit requirements. For the best available rate and to make a reservation please call Avis at 800-331-1600 or go online at `http://www.avis.com`. Please use the **AMS meeting Avis Discount Number J098887**.

Weather

The weather at Penn State during the end of October is typically cool with possible rain showers and high temperatures around 60 degrees and lows about 40 degrees.

Information for International Participants

Visa regulations are continually changing for travel to the United States. Visa applications may take from three to four months to process and require a personal interview, as well as specific personal information. International participants should view the important information about traveling to the U.S. found at `http://www7.nationalacademies.org/visas/Traveling_to_US.html` and `http://travel.state.gov/visa/index.html`. If you need a preliminary conference invitation in order to secure a visa, please send your request to `dls@ams.org`.

If you discover you do need a visa, the National Academies website (see above) provides these tips for successful visa applications:

* Visa applicants are expected to provide evidence that they are intending to return to their country of residence. Therefore, applicants should provide proof of "binding" or sufficient ties to their home country or permanent residence abroad. This may include documentation of the following:

· family ties in home country or country of legal permanent residence

· property ownership

· bank accounts

· employment contract or statement from employer stating that the position will continue when the employee returns;

* Visa applications are more likely to be successful if done in a visitor's home country than in a third country;

* Applicants should present their entire trip itinerary, including travel to any countries other than the United States, at the time of their visa application;

* Include a letter of invitation from the meeting organizer or the U.S. host, specifying the subject, location and dates of the activity, and how travel and local expenses will be covered;

* If travel plans will depend on early approval of the visa application, specify this at the time of the application;

* Provide proof of professional scientific and/or educational status (students should provide a university

transcript). This list is not to be considered complete. Please visit the web sites above for the most up-to-date information.

Boca Raton, Florida

Florida Atlantic University

October 30 – November 1, 2009

Friday – Sunday

Meeting #1053

Southeastern Section
Associate secretary: Matthew Miller
Announcement issue of *Notices*: August 2009
Program first available on AMS website: September 17, 2009
Program issue of electronic *Notices*: October 2009
Issue of *Abstracts*: Volume 30, Issue 4

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: September 8, 2009

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Spyridon Alexakis, Massachusetts Institute of Technology, *Global conformal invariants: A conjecture of Deser and Schwimmer*.

Kai-Uwe Bux, University of Virginia, *Arithmetic groups in positive characteristic*.

Dino J. Lorenzini, University of Georgia, *The index of an algebraic variety*.

Eduardo D. Sontag, Rutgers University, *Title to be announced*.

Special Sessions

Applied Partial Differential Equations (Code: SS 10A), **Shar Sajjadi** and **Timothy A. Smith**, Embry Riddle Aeronautical University.

Arithmetic Geometry (Code: SS 16A), **Pete L. Clark** and **Dino Lorenzini**, University of Georgia.

Commutative Ring Theory (Code: SS 3A), **Alan Loper**, Ohio State University, and **Lee C. Klingler**, Florida Atlantic University.

Concentration, Functional Inequalities, and Isoperimetry (Code: SS 2A), **Mario Milman**, Florida Atlantic University, **Christian Houdre**, Georgia Institute of Technology, and **Emanuel Milman**, Institute for Advanced Study.

Constructive Mathematics (Code: SS 1A), **Robert Lubarsky**, **Fred Richman**, and **Martin Solomon**, Florida Atlantic University.

Dynamical Systems (Code: SS 6A), **William D. Kalies** and **Vincent Naudot**, Florida Atlantic University.

Enumerative Combinatorics (Code: SS 4A), **Christian Krattenthaler**, University of Vienna, and **Aaron D. Meyerowitz**, **Heinrich Niederhausen**, and **Wandi Wei**, Florida Atlantic University.

General Relativity and Related Partial Differential Equations (Code: SS 18A), **Spyridon Alexakis**, Massachusetts Institute of Technology, and **Gilbert Weinstein**, University of Alabama Birmingham.

Geometry and Topology (Code: SS 20A), **Alexander N. Dranishnikov** and **Yuli B. Rudyak**, University of Florida.

Graded Resolutions (Code: SS 13A), **Christopher Francisco**, Oklahoma State University, and **Irena Peeva**, Cornell University.

Graph Theory (Code: SS 11A), **Zixia Song** and **Yue Zhao**, University of Central Florida.

Harmonic Analysis (Code: SS 5A), **Galia D. Dafni**, Concordia University, and **J. Michael Wilson**, University of Vermont, Burlington.

Homological Aspects of Module Theory (Code: SS 7A), **Andrew R. Kustin**, University of South Carolina, **Sean M. Sather-Wagstaff**, North Dakota State University, and **Janet Vassilev**, University of New Mexico.

Hypercomplex Analysis (Code: SS 12A), **Craig A. Nolder**, Florida State University, and **John Ryan**, University of Arkansas at Fayetteville.

Invariants of Knots and Links (Code: SS 9A), **Heather A. Dye**, McKendree University, **Mohamed Elhamdadi**, University of South Florida, and **Louis H. Kauffman**, University of Illinois at Chicago.

Inverse Problems and Signal Processing (Code: SS 14A), **M. Zuhair Nashed** and **Qiyu Sun**, University of Central Florida.

Lattices, Coxeter Groups, and Buildings (Code: SS 19A), **Kai-Uwe Bux**, University of Virginia, **Jon McCammond**, University of California Santa Barbara, and **Kevin Wortman**, University of Utah.

Mathematical Models in Biology (Code: SS 17A), **Patrick de Leenheer**, University of Florida, and **Yuan Wang**, Florida Atlantic University.

Modular Forms and Automorphic Forms (Code: SS 21A), **Jonathan P. Hanke**, University of Georgia.

Partial Differential Equations from Fluid Mechanics (Code: SS 15A), **Chongsheng Cao**, Florida International University, **Jiahong Wu**, Oklahoma State University, and **Baoquan Yuan**, Henan Polytechnic University.

Recent Advances in Probability and Statistics (Code: SS 8A), **Lianfen Qian** and **Hongwei Long**, Florida Atlantic University.

Accommodations

Participants should make their own arrangements directly with a hotel of their choice as early as possible. Special rates have been negotiated with the hotels listed below. Rates quoted do not include sales tax of 11.5%. The AMS is not responsible for rate changes or for the quality of the accommodations. When making a reservation, participants should state that they are with the **American Mathematical Society (AMS) Meeting at FAU** group. Cancellation and early checkout policies vary; be sure to check when you make your reservation.

Hampton Inn Boca Raton, 1455 Yamato Rd., Boca Raton, FL 33431; 561-988-0200 (phone) or 561-988-0203 (fax); prices per room are US$79/Deluxe King, US$89/Double Bed, and US$99/King Suite; includes coffeemaker, free Internet access, complimentary full-service exercise room, and outside pool. Complimentary hot breakfast served 7:00 a.m. to 10:00 a.m. on Saturday and Sunday (6:00 a.m. to 10:00 a.m. on Friday) or pick up a healthy "breakfast-in-a-bag" to go. Complimentary coffee, tea, and fruit are always available in the lobby. The hotel is located about 5.2 miles northeast of the meeting site, and is within walking distance of many restaurants and shops. **Deadline for reservations is October 15, 2009**. Be sure to check cancellation and early checkout policies.

Hilton Garden Inn Boca Raton, 8201 Congress Ave., Boca Raton, FL 33487; 561-988-6110 (phone), 561-988-9256 (fax); US$99/single or double; includes refrigerator, microwave, coffeemaker, free wireless Internet, and complimentary full hot breakfast; complimentary 24-hour business center access; Great American Grill serving breakfast, lunch, and dinner; fitness center; and outdoor pool. Limited van service to/from campus and area restaurants (advance reservation requested); located about 6.25 miles from the meeting site. **Deadline for reservations is October 2, 2009**. Participants may book online through www.bocaraton.stayhgi.com using the group code "MATH". Be sure to check cancellation and early checkout policies. N.B. Cancel a minimum of 72 hours prior to arrival to avoid paying a penalty of first-night room and tax.

Embassy Suites Hotel, Boca Raton, 661 NW 53rd St., Boca Raton, FL 33487; 561-994-8200 (phone), 561-994-9518 (fax); US$89/single king bed or two double-bedded suite with mini-refrigerator, microwave, and coffee/coffee maker, and high-speed wireless (fee). Also includes complimentary cooked-to-order breakfast with hot items; free fitness center, outside heated pool/whirlpool, daily complimentary manager's reception, and free access to business center. Limited van service to/from campus and area restaurants; located about 4.25 miles northeast of the meeting site. Deadline for reservations is October 2, 2009. Be sure to check cancellation and early checkout policies.

Guest Suites of Boca Raton, 701 NW 53rd St., Boca Raton, FL 33487; 561-997-9500 (phone), 561-994-3565 (fax); US$69/single or double, US$79/triple, or $89/quad, includes complimentary hot breakfast (7:00 a.m. to 10:00 a.m.), wireless Internet (fee), free coffee in lobby, restaurant in hotel providing limited room service, and outside pool/spa. Limited van service to/from campus and area restaurants; located about 4.25 miles northeast of the meeting site. **Deadline for reservations is October 15, 2009**. Be sure to check cancellation and early checkout policies.

Marriott Courtyard Boca Raton, 2000 NW Executive Center Court, Boca Raton, FL 33431; 561-241-7070 (phone), 561-241-7080 (fax); US$69/single or double, includes free wireless Internet, in-room coffeemaker, fitness center, outdoor pool, breakfast buffet (fee), convenience store on premises. Located about 1.75 miles west of the meeting site. **Deadline for reservations is October 5, 2009**. Be sure to check cancellation and early checkout policies.

Hilton Suites Boca Raton, 7920 Glades Rd., Boca Raton, FL 33434; 561-483-3600 (phone), 561-852-9976 (fax); US$85/single or double suite (private bedroom with separate living area and pullout sofa bed), includes coffeemaker, microwave, mini-refrigerator, high-speed Internet (fee); also complimentary are a cooked-to-order breakfast as well as a two-hour evening cocktail reception (held daily), and limited van service to/from campus and area restaurants. Hotel has a heated pool, Jacuzzi, and fitness center, and is located about 4.3 miles west of the meeting site. **Deadline for reservations is October 8, 2009**. Be sure to check cancellation and early checkout policies.

Food Service

Information will be available at the meeting.

Local Information

The university's website is www.fau.edu; the department of mathematics is at www.math.fau.edu.

Local attractions in Boca Raton:

The quietest and prettiest beach is South Beach, 400 N. Ocean Blvd., half a mile long, and backed by the scenic South Beach Park. South Beach Park features over 25 acres and 1,600 feet of beach. Lifeguards are on duty, and the park also offers picnic areas, showers, restrooms, and more.

Families enjoy the action on the Delray municipal beach which features restrooms and lifeguards, and is popular for surfing, windsurfing, volleyball, and boating. Several restaurants are adjacent.

The Boca Raton Museum of Art's new 44,000 square-foot facility at 501 Plaza Real in Mizner Park features new exhibition, education, and collection galleries, and enhances fourfold the museum's programming capabilities. The Museum was founded in 1950 as the Art Guild of Boca Raton.

Caldwell Theatre, 7873 N. Federal Hwy., offers a myriad of theatrical works throughout the course of their season. Off-Broadway plays, as well as well-known dramas, comedies, and classics are performed by this group.

Dagger Wing Nature Center, 11200 Park Access Rd., is a 39-acre park featuring a vast variety of birds. Woodpeckers, songbirds, egrets, herons, warblers, and more can be viewed here.

Gumbo Limbo Environmental Complex, 1801 N. Ocean Blvd., is a 20-acre complex that is home to one of the few surviving coastal hammocks, also known as a forest island. An elevated boardwalk takes visitors through the hammock. This site is also where sea turtles come to lay their eggs. Turtle walks are available May through July.

Other Activities

Book Sales: Stop by the on-site AMS Bookstore and review the newest titles from the AMS, enter the free book drawing, enjoy up to 25% off all AMS publications, or take home an AMS t-shirt! Complimentary coffee will be served courtesy of AMS Membership Services.

AMS Editorial Activity: An acquisitions editor from the AMS book program will be present to speak with prospective authors. If you have a book project that you would like to discuss with the AMS, please stop by the book exhibit.

Parking

Watch the AMS website at http://www.ams.org/amsmtgs/sectional.html for updated information.

Registration and Meeting Information

The meeting is on the campus of Florida Atlantic University, Boca Raton, Florida. The locations for the Invited Addresses, sessions, and registration are currently being determined. Watch the AMS website at http://www.ams.org/amsmtgs/sectional.html for updated information.

The registration desk will be open Friday, October 30, noon to 4:30 p.m., and Saturday, October 31, 7:30 a.m. to 4:00 p.m.; it will not be open on Sunday, November 1. Fees are US$40 for AMS or CMS members, US$60 for nonmembers; and US$5 for students, unemployed mathematicians, and emeritus members. Fees are payable on site by cash, check, or credit card.

Satellite Workshops

Some participants may be interested in these additional activities scheduled just before the AMS Sectional Meeting; please note there will be Special Sessions on these same topics during the meeting:

International Workshop on Concentration, Functional Inequalities, and Isoperimetry, organized by Christian Houdré, Georgia Institute of Technology; Emanuel Milman, Institute for Advanced Study; and Mario Milman, Florida Atlantic University. Watch the website at http://math.fau.edu/~internationalworkshop/index.html for more details.

Constructive Mathematics, organized by Robert Lubarsky, Fred Richman, and Martin Solomon, Florida Atlantic University. See the website at http://math.fau.edu/Richman/Worshop/.

Travel, Campus Map, and Directions

A campus map is found at http://uavp.fau.edu/Flashmap/FAUMap.html.

The Boca Raton area is served by three main airports located in Fort Lauderdale, West Palm Beach, and Miami. The first two are much closer to campus than Miami.

Fort Lauderdale/Hollywood International Airport (FLL), http://www.broward.org/airport, is about 27 miles south of campus. GO Airport Shuttle (800-244-8252 or 954-561-888) provides service to Boca Raton for US$22 (shared ride, walk-up service) or US$75 private car.

Palm Beach International Airport (PBI), http://www.pbia.org/guide/ground.aspx, is about 27 miles north of campus. Taxi fare to campus is approximately US$82 plus gratuity; town car flat rate is US$77 plus 20% gratuity. Call Palm Beach Transportation at 561-684-9900 for more information. SuperShuttle provides service to Boca Raton for US$30 for the first passenger and US$11 for each additional passenger; call 561-233-0600 for reservations.

Miami International Airport (MIA), http://www.miami-airport.com/html/ground_transportation.html, is about 48 miles south of campus. Taxi fare is about $125 plus tax.

Driving directions to campus: Using your favorite Internet mapping service (e.g., http://maps.yahoo.com, http://www.mapquest.com), enter your starting location, then use 777 Glades Rd., Boca Raton, FL 33431 as your ending point for directions and mileage estimates.

Car Rental: Avis is the official car rental company for the sectional meeting in Boca Raton. All rates include unlimited free mileage. Weekend daily rates are available from noon Thursday to Monday at 11:59 p.m. Rates do not include any state or local surcharges, tax, optional coverages, or gas refueling charges. Renters must meet Avis' age, driver, and credit requirements. For the best available rate and to make a reservation please call Avis at 800-331-1600 or go online at http://www.avis.com. Please use the AMS meeting **Avis Discount Number J098887**.

Weather

Late October temperatures in Boca Raton range from the mid 60s F. to the mid 80s F. Showers are possible so bringing an umbrella is advisable.

Information for International Participants

Visa regulations are continually changing for travel to the United States. Visa applications may take from three to four months to process and require a personal interview, as well as specific personal information. International participants should view the important information about traveling to the U.S. found at http://www7.nationalacademies.org/visas/Traveling_to_US.html and http://travel.state.gov/visa/index.html. If you need a preliminary conference invitation in order to secure a visa, please send your request to dls@ams.org.

If you discover you do need a visa, the National Academies website (see above) provides these tips for successful visa applications:

* Visa applicants are expected to provide evidence that they are intending to return to their country of residence. Therefore, applicants should provide proof of "binding" or sufficient ties to their home country or permanent residence abroad. This may include documentation of the following:

· family ties in home country or country of legal permanent residence

· property ownership

· bank accounts

· employment contract or statement from employer stating that the position will continue when the employee returns;

* Visa applications are more likely to be successful if done in a visitor's home country than in a third country;

* Applicants should present their entire trip itinerary, including travel to any countries other than the United States, at the time of their visa application;

* Include a letter of invitation from the meeting organizer or the U.S. host, specifying the subject, location and

dates of the activity, and how travel and local expenses will be covered;

* If travel plans will depend on early approval of the visa application, specify this at the time of the application;

* Provide proof of professional scientific and/or educational status (students should provide a university transcript). This list is not to be considered complete. Please visit the web sites above for the most up-to-date information.

Riverside, California

University of California

November 7–8, 2009

Saturday – Sunday

Meeting #1054

Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: September 2009
Program first available on AMS website: September 24, 2009
Program issue of electronic *Notices*: November 2009
Issue of *Abstracts*: Volume 30, Issue 4

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: July 21, 2009
For abstracts: September 15, 2009

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Christopher Hacon, University of Utah, *Classification of algebraic varieties*.

Birge Huisgen-Zimmerman, University of California Santa Barbara, *Representations of quivers with relations. Geometric aspects*.

Jun Li, Stanford University, *Toward high genus GW-invariants of quintic Calabi-Yau threefolds*.

Joseph Teran, University of California Los Angeles, *Title to be announced*.

Special Sessions

Algebraic Geometry (Code: SS 1A), **Christopher Hacon**, University of Utah, and **Ziv Ran**, University of California Riverside.

Algebraic Structures in Knot Theory (Code: SS 17A), **Alissa S. Crans**, Loyola Marymount University, and **Sam Nelson**, Claremont McKenna College.

Arithmetic Combinatorics (Code: SS 16A), **Mei-Chu Chang**, University of California Riverside, and **Alex Gamburd**, University of California Santa Cruz and Northwestern University.

Calabi-Yau Manifolds (Code: SS 15A), **Owen Dearricott**, University of California Riverside, **Jun Li**, Stanford University, and **Bun Wong** and **Yat-Sun Poon**, University of California Riverside.

Dynamical Systems (Code: SS 18A), **Nicolai Haydn**, University of Southern California, and **Huyi Hu**, Michigan State University.

Fluid Mechanics (Code: SS 5A), **James Kelliher** and **Qi Zhang**, University of California Riverside.

Fractal Geometry, Dynamical Systems, Number Theory and Analysis on Rough Spaces (Code: SS 6A), **Michel L. Lapidus**, University of California Riverside, **Hung Lu**, Hawaii Pacific University, and **Erin P. J. Pearse**, University of Iowa.

Global Riemannian Geometry (Code: SS 14A), **Fred Wilhelm**, University of California Riverside, and **Peter Petersen**, University of California Los Angeles.

History and Philosophy of Mathematics (Code: SS 4A), **Shawnee L. McMurran**, California State University San Bernardino, and **James J. Tattersall**, Providence College.

Homotopy Theory and Higher Algebraic Structures (Code: SS 8A), **John Baez** and **Julie Bergner**, University of California Riverside.

Interactions Between Algebraic Geometry and Noncommutative Algebra (Code: SS 9A), **Kenneth R. Goodearl**, University of California Santa Barbara, **Daniel S. Rogalski**, University of California San Diego, and **James Zhang**, University of Washington.

Knotting Around Dimension Three: A Special Session in Memory of Xiao-Song Lin (Code: SS 11A), **Martin Scharlemann**, University of California Santa Barbara, and **Mohammed Ait Nouh**, University of California Riverside.

Noncommutative Geometry (Code: SS 2A), **Vasiliy Dolgushev** and **Wee Liang Gan**, University of California Riverside.

Operator Algebras (Code: SS 13A), **Marta Asaeda** and **Aviv Censor**, University of California Riverside, and **Adrian Ioana**, Clay Institute and Caltech.

Representation Theory (Code: SS 3A), **Vyjayanthi Chari**, **Wee Liang Gan**, and **Jacob Greenstein**, University of California Riverside.

Representations of Finite Dimensional Algebras (Code: SS 7A), **Frauke Bleher**, University of Iowa, **Birge Huisgen-Zimmermann**, University of California at Santa Barbara, and **Markus Schmidmeier**, Florida Atlantic University.

Research Conducted by Students (Code: SS 10A), **Robert G. Niemeyer** and **Jack R. Bennett**, University of California Riverside.

Stochastic Analysis and Applications (Code: SS 12A), **Michael L. Green**, **Alan C. Krinik**, and **Randall J. Swift**, California State Polytechnic University Pomona.

Seoul, South Korea

Ewha Womans University

December 16–20, 2009

Wednesday – Sunday

Meeting #1055

First Joint International Meeting of the AMS and the Korean Mathematical Society.
Associate secretary: Georgia Benkart
Announcement issue of *Notices*: August 2009
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: To be announced
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: October 31, 2009

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/internmtgs.html`.

AMS Invited Addresses

Young Ju Choi, Pohang University of Science and Technology, *Title to be announced*.

Bumsig Kim, Korea Institute for Advanced Study, *Title to be announced*.

Minhyong Kim, University College London, *Title to be announced*.

Ki-ahm Lee, Seoul National University, *Title to be announced*.

James T. McKernan, Massachusetts Institute of Technology, *Title to be announced*.

Frank Morgan, Williams College, *Title to be announced*.

Hee Oh, Brown University, *Title to be announced*.

Terence Tao, University of California Los Angeles, *Title to be announced*.

Van Vu, Rutgers University, *Title to be announced*.

AMS Special Sessions

(Code: SS 3A), **Jaeyoung Byeon**, Pohang University of Science & Technology, and **Zhi-Qiang Wang**, Utah State University.

(Code: SS 4A), **Youn-Seo Choi**, Korea Institute for Advanced Study, **YoungJu Choie**, Pohang University of Science & Technology, and **Wen-ching Winnie Li**, Pennsylvania State University.

Algebraic Geometry (Code: SS 2A), **Yongnam Lee**, Sogang University, **Ian Morrison**, Fordham University, and **James McKernan**, Massachusetts Institute of Technology.

Arithmetic of Quadratic Forms (Code: SS 13A), **Myung-Hwan Kim**, Seoul National University, and **Wai Kiu Chan**, Wesleyan University.

Combinatorial Matrix Theory (Code: SS 8A), **Suk-Geun Hwang**, Kyungpook National University, and **Bryan Shader**, University of Wyoming.

Combinatorics (Code: SS 17A), **Dongsu Kim**, Korea Advanced Institute of Science & Technology, **Soojin Cho**, Ajou University, and **Bruce Sagan**, Michigan State University.

Computational Science and Engineering (Code: SS 25A), **Jeehyun Lee**, Yonsei University, and **Max Gunzburger**, Florida State University.

Creativity, Giftedness, and Talent Development in Mathematics (Code: SS 23A), **Kyeong-Hwa Lee**, Seoul National University, and **Bharath Sriraman**, University of Montana.

Cryptography (Code: SS 22A), **Hyang-Sook Lee**, Ewha Womans University, and **Alice Silverberg**, University of California Irvine.

Differential and Integral Geometry (Code: SS 28A), **Young Jin Suh**, Kyungpook National University, **Byung Hak Kim**, Yonsei University, **Yongdo Lim**, Kyungpook National University, **Gaoyong Zhang**, Polytechnic University of NYU, and **Jiazu Zhou**, Southwest University.

Ergodic Theory and Dynamical Systems (Code: SS 18A), **Keonhee Lee**, Chungnam National University, **Jeong-Yup Lee**, Korea Institute for Advanced Study, and **Jane Hawkins**, University of North Carolina.

Financial Mathematics (Code: SS 10A), **Hyejin Ku**, York University, **Hyunggeon Koo**, Ajou University, and **Kiseop Lee**, University of Louisville.

Geometric Structures and Geometric Group Theory (Code: SS 1A), **In Kang Kim**, Korea Advanced Institute of Science & Technology, and **Seonhee Lim**, Cornell University.

Geometry of Syzygies and Computations (Code: SS 6A), **Sijong Kwak**, Korea Advanced Institute of Science & Technology, **Hyungju Park**, Korea Institute for Advanced Study, and **Jerzy Weyman**, Northeastern University.

Harmonic Analysis and Its Applications (Code: SS 12A), **Sunggeum Hong**, Chosun University, and **Andreas Seeger**, University of Wisconsin.

Inverse Problems and Imaging (Code: SS 19A), **Hyeonbae Kang**, Inha University, and **Gunther Uhlmann**, University of Washington.

Knot Theory and Related Topics (Code: SS 24A), **Jae Choon Cha**, Pohang University of Science and Technology, and **Kent Orr**, Indiana University.

Lie Symmetries and Solitons (Code: SS 11A), **Woo-Pyo Hong**, Catholic University of Daegu, **Anjan Biswas**, Delaware State University, and **Chaudry M. Khalique**, North-West University.

Mathematical Analysis in Fluid, Gas Dynamics, and Related Equations (Code: SS 21A), **Minkyu Kwak**, Chonnam National University, **Hyeong-Ohk Bae**, Ajou University, **Seung-Yeal Ha**, Seoul National University, and **Simon Seok Hwang**, LaGrange College.

Mathematical Biology (Code: SS 26A), **Eunok Jung**, Konkuk University, and **Jae-Hun Jung**, SUNY at Buffalo.

Mathematical Logic and Foundation (Code: SS 27A), **Byunghan Kim**, Yonsei University, and **Ivo Herzog**, Ohio State University.

Noncommutative Ring Theory (Code: SS 7A), **Yang Lee**, Pusan National University, and **Nam Kyun Kim**, Hanbat National University.

Nonlinear Partial Differential Equations and Viscosity (Code: SS 15A), **Ki-ahm Lee**, Seoul National University, and **Inwon Kim**, University of California Los Angeles.

Operator Theory and Operator Algebras (Code: SS 9A), **Il Bong Jung**, Kyungpook National University, **Ja A. Jeong**, Seoul National University, **George Exner**, Bucknell University, and **Ken Dykema**, Texas A&M University.

Operator Theory in Analytic Function Spaces (Code: SS 20A), **Hyung Woon Koo** and **Boo Rim Choe**, Korea University, and **Kehe Zhu**, SUNY at Albany.

Representation Theory (Code: SS 5A), **Jae-Hoon Kwan**, University of Seoul, and **Kyu-Hwan Lee**, University of Connecticut.

Spectral Geometry and Global Analysis (Code: SS 16A), **Jinsung Park**, Korea Institute for Advanced Study, and **Maxim Braverman**, Northeastern University.

Symplectic Geometry and Mirror Symmetry (Code: SS 14A), **Jae-Suk Park**, Yonsei University, **Cheol-Hyun Cho**, Seoul National University, and **Yong-Geun Oh**, University of Wisconsin.

This announcement was composed with information taken from the website maintained by the local organizers at http://www.kms.or.kr/kmsams/. Please watch this website for the most up-to-date information.

This is the first joint meeting of the Korean Mathematical Society (KMS) and the American Mathematical Society (AMS). All scientific sessions and events will take place at Ewha Womans University from December 16 to 20, 2009. The meeting is specifically organized to bring mathematicians from the United States and Korea together. The scientific objectives of this meeting are to disseminate recent research results to a wider audience. The meeting is open to all areas of the mathematical sciences.

Abstracts

The deadline for abstracts is October 15, 2009. Talks are invited in any area of the mathematical sciences, with acceptance at the discretion of the organizers. If your talk falls under the heading of one of the special sessions already listed, please contact one of the session organizers before submitting an abstract, as special sessions have limited time slots. An online system for abstract submission will be available on the KMS-AMS website at http://www.kms.or.kr/kmsams/.

Accommodations

Hotel reservation procedures are available on the official conference website at http://www.kms.or.kr/KmsAms/contents/Accommodations.html. Reservations can be made directly by email with the hotel of your choice. Please contact the hotel of your choice directly for current rates, methods of payment, and cancellation polices.

Somerset Palace Hotel, No. 85, Susong-Dong, Jongno-Gu, Seoul, 110-885, Korea. Contact: Sales Manager Jimmy Lee, 1+82-2-6730 8005, fax +82-2-6730 8001, email: jimmy.lee@the-ascott.com, http://www.somersetpalace.co.kr/, reservation form: http://www.kms.or.kr/kmsams/reservation_form/somerset_palace_seoul.doc. (Please fill out this form and send it to Jimmy Lee via email). Somerset Palace is located in the downtown Seoul, Gangbuk district. It offers a tranquil environment with a beautiful garden and city views. Breakfast included with room rate.

Lotte City Hotel (MAPO), 423-3, Gongduk-Dong, Mapo-Ku, Seoul, 121-705, Korea. Contact: Sales Manager Lena Kim, 1+82-2-6009-1041, fax +82-2-6009-1004, email: lena.kim@lotte.net, http://www.lottecityhotel.co.kr/, reservation form: http://www.kms.or.kr/kmsams/reservation_form/lotte_city_hotel.doc. (Please fill out this form and send it to Lena Kim via email).

Koreana Hotel, 61-1, 1-Ga, Tae Pyung-Ro, Joong-Gu, Seoul, 100-101, Korea. Contact: Sales Manager Young Kim, 1+82-2-2171-7913, fax +82-2-730-9025, email: sunwoo@koreanahotel.com, http://www.koreanahotel.co.kr/. The Koreana Hotel is located at the Gwanghwamun Intersection in the heart of Seoul, surrounded by the best that the city has to offer, including the ancient Doksugung Palace which is within walking distance and scenic Mt. Namsan.

Casaville (Shinchon), 15F, 57-26 Nogosan-dong, Mapo-gu, Seoul, 121-807, Korea. Contact: Marketing Manager Jeong se jin, 1+82-2-6220-4100, fax +82-2-6352-1101, email: sjjeong@htc21.co.kr, http://www.casaville.co.kr/, reservation form: http://www.kms.or.kr/kmsams/reservation_form/casaville.xls. (Please fill out this form and send it to Jeong se jin via email). The Casaville is a 15-story building, and is located in the trendy area of Sinchon. Located in the heart of Gangbuk, the largest commercial area, and near all modes of transportation, the Casaville is just a few steps away from the Shinchon subway station line 2 and a 60-minute drive from the Incheon International Airport.

Conference Location and Preliminary Program

All scientific sessions will take place within the Ewha Campus Complex (ECC), Ewha Womans University, 11-1 Daehyun-Dong, Seodaemun-Gu, Seoul 120-750, Korea (Tel: +82-2-3277-2114, Fax: +82-2-393-5903), from Wednesday, December 16, to Sunday, December 20. A very preliminary program sketch may be found at http://www.kms.or.kr/KmsAms/contents/Programs.html.

The ECC is a high-tech underground campus. The six-story building dips deep into the earth and accommodates a large auditorium and some forty seminar rooms, and Cinecube, an independent movie theater chain. Other public facilities include a Kyobo Bookstore, convenience store, flower shop, Starbucks Coffee, gym and cafes/restaurants.

Local Information/Tourism

For further information visit http://www.kms.or.kr/kmsams/contents/generalinformation.html, or contact kms@kms.or.kr.

Other Events

A special public lecture will be given by Frank Morgan, Williams College, on Wednesday evening, December 18,

at 6:00 p.m. The title and location of the talk will be announced at a later date.

Restaurants/Food Service

Cafes and restaurants are conveniently located within the Ewha Campus Complex. Other restaurant Information will be available at the registration desk.

Registration and Meeting Information

The meeting will take place on the campus of Ewha Womans University, 11-1 Daehyun-Dong, Seodaemun-Gu, Seoul 120-750, Korea. For more information about the campus see http://www.ewha.ac.kr/english/.

Registration: Type A Regular includes conference documents, banquet on Thursday evening, three lunches (December 16–18) and tea/coffee breaks. Type ARegular registration is US$50/KRW60,00, and student registration is US$25/KRW30,000. Type B registration does not include lunch and is US$40/KRW50,000, and student registration is US$20/KRW25,000. Additional information about registration procedures will be available soon at http://www.kms.or.kr/KmsAms/contents/Registration.html.

Social Events

Reception: Date, time and location to be announced.

Excursions: Additional information to be announced. Conference banquet: Thursday evening, December 17, 2010. Additional information to be announced.

Travel and Maps

Incheon International Airport serves the Seoul area and is located approximately one hour away by car or bus from Seoul. For detailed information on various forms of travel from the airport to Seoul visit http://www.kms.or.kr/kmsams/contents/airporttoseoul.html.

An excellent site for general information about traveling to Seoul and Korea can be found at http://english.visitkorea.or.kr/enu/1001_About%20Korea.jsp.

VISA Information: All visitors to the Republic of Korea must have a valid passport and visa. Visitors with roundtrip tickets from countries who have a special agreement with Korea may be exempt from the visa requirement, and can stay in Korea visa-free for periods up to 30 days, or 90 days, depending on the type of agreement between two countries. When uncertain as to the requirement for entry visa to Korea, please contact the Korean embassy or a consulate as early as possible. For more information, visit the website of the **Korean Ministry of Foreign Affairs and Trade**.

Weather

For up-to-date weather reports and local information visit http://www.wunderground.com/global/stations/47112.html.

San Francisco, California

Moscone Center West and the San Francisco Marriott

January 13–16, 2010

Wednesday – Saturday

Meeting #1056

Joint Mathematics Meetings, including the 116th Annual Meeting of the AMS, 93rd Annual Meeting of the Mathematical Association of America (MAA), annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association for Symbolic Logic (ASL), with sessions contributed by the Society of Industrial and Applied Mathematics (SIAM).
Associate secretary: Matthew Miller
Announcement issue of *Notices*: October 2009
Program first available on AMS website: November 1, 2009
Program issue of electronic *Notices*: January 2010
Issue of *Abstracts*: Volume 31, Issue 1

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: July 28, 2009
For abstracts: September 22, 2009

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/national.html.

AMS Invited Addresses

James G. Glimm, Stony Brook University, *Title to be announced* (AMS Retiring Presidential Address).

Olga Holtz, University of California Berkeley, *Title to be announced.*

Richard W. Kenyon, Brown University, *Title to be announced.*

Igor Y. Rodnianski, Princeton University, *Title to be announced.*

Peter W. Shor, Massachusetts Institute of Technology, *Title to be announced* (AMS Josiah Willard Gibbs Lecture).

Richard P. Stanley, MIT, *Title to be announced* (AMS Colloquium Lectures).

Amie Wilkinson, Northwestern University, *Title to be announced.*

AMS Special Sessions

Some sessions are cosponsored with other organizations. These are noted within the parenthesis at the end of each listing, where applicable.

Algebraic Aspects of Cryptology (Code: SS 2A), **Jintai Ding**, University of Cincinnati, and **Chris Christensen**, Northern Kentucky.

Algebraic Methods in Signal Processing (Code: SS 3A), **Shamgar Gurevich**, University of California Berkeley, **Ronny Hadani**, University of Chicago, **Olga Holtz**, University of California Berkeley and Technical University Berlin, **Oded Schwartz**, Technical University Berlin, and **Nir Sochen**, Tel Aviv University.

Analysis and Control Under Uncertainty (Code: SS 4A), **Xioaming Wang**, Florida State University, **Yanzhao Cao**, Auburn University, and **Catalin Trenchea**, University of Pittsburgh.

Applications of Algebraic Geometry (Code: SS 5A), **Frank Sottile**, Texas A&M University, and **Luis Garcia-Puente**, Sam Houston State University.

Applications of Graph Theory (Code: SS 6A), **Richard Low**, San Jose State University, and **Ralucca M. Gera**, Naval Postgraduate School.

Applications of Time Scales to Biology, Economics, and Engineering (Code: SS 7A), **Martin Bohner**, Missouri University of Science and Technology, **Billur Kaymakcalan**, Southern University-Statesboro, and **Allan Peterson**, University of Nebraska-Lincoln.

Arithmetic Geometry (Code: SS 9A), **Bo-Hae Im**, Chung-Ang University, **Jennifer Johnson-Leung**, University of Idaho, and **Jennifer Paulhus**, Kansas State University.

Arithmetic and Nonarchimedean Dynamics (Code: SS 8A), **Joseph Silverman**, Brown University, **Michelle Manes**, University of Hawaii, and **Raphael Jones**, College of the Holy Cross.

Arithmetic of Function Fields (Code: SS 10A), **Allison Pacelli**, Williams College, and **Michael Rosen**, Brown University.

Biomathematics: Modeling in Biology, Ecology, and Epidemiology (Code: SS 12A), **Lih-Ing Roeger**, **Linda Allen**, and **Sophia Jang**, Texas Tech University, and **Olcay Akman**, Ilinois State University.

Categorical and Algebraic Methods in Representation Theory (Code: SS 13A), **Jon Brundan**, University of Oregon, **Julia Pevtsova**, University of Washington, and **Eric Friedlander**, University of Southern California.

Commutative Algebra (Code: SS 15A), **Susan Cooper**, University of Nebraska-Lincoln, and **Graham Leuschke**, Syracuse University.

Degenerate and Singular Elliptic Partial Differential Equations (Code: SS 16A), **Marian Bocea** and **Cristina Popovici**, North Dakota State University.

Difference Equations and Applications (Code: SS 17A), **Michael Radin**, Rochester Institute of Technology.

Differential Galois Theory and Group Representations: A Tribute to Andy Magid (Code: SS 19A), **James Carrell**, University of British Columbia, **Lourdes Juan**, Texas Tech University, **Alex Lubotzky**, Hebrew University, **Brian Parshall**, University of Virginia, and **Marius van der Put**, University of Groningen.

Enumerative Combinatorics (Code: SS 18A), **Brian Miceli**, Trinity University, and **Jeff Remmel**, University of California San Diego.

Geometric Aspects of Lnk and 3-manifold Invariants (Code: SS 20A), **Oliver Dasbach**, Louisiana State University, and **Effie Kalfagianni**, Michigan State University.

Graph Algebras in Analysis and Algebra (Code: SS 21A), **Gene Abrams**, University of Colorado at Colorado Springs, and **Mark Tomforde**, University of Houston.

Harmonic Analysis and Representations of Reductive p-adic Groups (Code: SS 23A), **Robert Doran**, Texas Christian University, **Paul Sally**, University of Chicago, and **Loren Spice**, Texas Christian University.

History of Mathematics (Code: SS 24A), **Craig Fraser**, University of Toronto, **Deborah Kent**, Hillsdale College, and **Sloan Despeaux**, Western Carolina University (AMS-MAA).

Integrability of Dynamical Systems and Solitons Equations (Code: SS 25A), **Zhijun Qiao**, University of Texas-Pan American, **Taixi Xu**, Southern Polytechnic State University, and **Wenxiu Ma**, University of South Florida.

Interactions of Inverse Problems, Signal Processing and Imaging (Code: SS 26A), **M. Zuhair Nashed**, University of Central Florida.

L-Functions and Analytic Number Theory (Code: SS 28A), **Alina Bucur**, Massachusetts Institute of Technology, **Chantal David**, Concordia University, and **Matilde Lalin**, University of Alberta.

Mathematics and Physical Experiment (Code: SS 30A), **Roger Thelwell**, **Anthony Tongen**, and **Paul Warne**, James Madison University.

Mathematics of Computation (Code: SS 31A), **Susanne Brenner**, Louisiana State University, and **Chi-Wang Shu**, Brown University (AMS-SIAM).

Nonlinear Hyperbolic Equations and Control Systems in Physics and Engineering (Code: SS 11A), **Petronela Radu** and **Daniel Toundykov**, University of Nebraska-Lincoln.

Optimal Frames and Operator Algebras (Code: SS 35A), **David Larson**, Texas A&M University, **Deguang Han**, University of Central Florida, and **Shidong Li**, San Francisco State University.

Parabolic Geometries, Integrable Systems, and Twistor Theory (Code: SS 36A), **Dana Mihai**, Carnegie Mellon University, and **Jonathan Holland** and **George Sparling**, University of Pittsburgh.

Recent Advances in Evolution Equations and Applications (Code: SS 38A), **Guoping Zhang** and **Gaston N'Guerekata**, Morgan State University, **Yi Li**, University of Iowa, **Wen-Xiu Ma**, University of South Florida, and **Michael Goldberg**, Johns Hopkins University.

Representation Theory and Nonassociative Algebras (Code: SS 40A), **Andrew Douglas**, City University of New York.

Research in Mathematics by Undergraduates (Code: SS 41A), **Darren Narayan**, Rochester Institute of Technology (AMS-MAA-SIAM).

Spectral Problems on Compact Riemannian Manifolds (Code: SS 43A), **Carolyn Gordon**, Dartmouth College, **Ruth Gornet**, University of Texas at Arlington, and **Craig Sutton**, Dartmouth College (AMS-AWM).

Surreal Numbers (Code: SS 45A), **Lou van den Dries**, University of Illinois, and **Philip Ehrlich**, Ohio University (AMS-ASL).

The Mathematics of Information and Knowledge (Code: SS 46A), **Naoki Saito**, University of California Davis, **Ronald R. Coifman**, Yale University, **James G. Glimm**, SUNY

at Stony Brook, **Peter W. Jones**, Yale University, **Mauro Maggioni**, Duke University, and **Jared Tanner**, University of Edinburgh.

Use of Technology in Modern Complex Analysis Research (Code: SS 47A), **Beth Schaubroeck**, U.S. Air Force Academy, **Michael Dorff**, Brigham Young University, and **James Rolf**, U.S. Air Force Academy.

Voting Theory (Code: SS 48A), **Michael Jones**, Mathematical Reviews, **Brian Hopkins**, Saint Peter's College, and **Tommy Ratliff**, Wheaton College.

Zonotopal Algebra and Its Applications (Code: SS 49A), **Olga Holtz**, University of California Berkeley and Technical University Berlin, and **Amos Ron**, University of Wisconsin.

Call for MAA Contributed Papers

The MAA Committee on Contributed Paper Sessions solicits contributed papers pertinent to the sessions listed below. Contributed Paper Session organizers generally limit presentations to fifteen minutes. Each session room is equipped with a computer projector, an overhead projector, and a screen. Please note that the dates and times scheduled for these sessions remain tentative.

The Arts and Mathematics, Saturday afternoon, **Douglas E. Norton**, Villanova University. The Special Interest Group of the MAA on Math and the Arts continues its successful series on connections between things artistic and things mathematical, with all three terms broadly defined: Arts, mathematics, and connections! Dance and drama and design, music and mathematical metaphor, fabrics and fractals and functions and formulas, OULIPO and do-si-do, calculated and woven and ricocheted with splines or in hyperbolic space or on tori. Whether research, classroom, or hobby; whether from one side or another or from no side at all, bring your interest, knowledge, experience, and/or aesthetic sense, to learn, share, and enjoy.

Developmental Mathematics Education: Helping Under-Prepared Students Transition to College-Level Mathematics, Thursday afternoon, **Kimberly J. Presser** and **J. Winston Crawley**, Shippensburg University. The number of students arriving at college today under-prepared for college-level mathematics courses is on the rise. Many colleges and universities are developing new curriculum and programs to help ease the transition for these students into higher level mathematics courses. In order to help these students to be successful there are a number of issues to be considered, such as new strategies for support services, what remedial courses are being offered, and perhaps even the developmental education program university-wide. This session invites papers on all aspects of developmental mathematics education. In particular, what classroom practices are effective with such students and how does research in student learning inform these practices? For students interested in math-intensive majors such as the sciences, how can we best prepare these students for several subsequent mathematics courses? How can we best coordinate support services with the courses offered in our mathematics departments?

Engaging Students with Classroom Voting, Thursday morning, **Derek Bruff**, Vanderbilt University, **Kien Lim**, University of Texas at El Paso, and **Kelly Cline**, Carroll College. Classroom voting is a teaching method in which students are asked to respond to multiple-choice or numeric-result questions posed by their instructors during class, often using handheld transmitters ("clickers") that allow for the instant display of distributions of responses. Classroom voting can be used to make on-the-fly teaching choices that are responsive to student learning needs, to generate small-group and whole-class discussion, and to create "times for telling" in which student misconceptions are uncovered and addressed. Clickers allow students to respond to questions independently and without their peers knowing how they have responded while allowing instructors to track student responses and thus expect full participation.

We seek papers on classroom voting that focus on at least one of these areas: teaching objectives (e.g., writing effective questions, engendering cognitive conflicts, addressing misconceptions), instructional strategies (e.g., peer instruction, team-based learning, methods of guiding class discussions), new technologies (e.g., using cell phones as clickers, integration with online resources), impact on students (e.g., enhanced student learning, increased student engagement, improved retention), overcoming constraints (e.g., limited class time for active learning), development of new materials (e.g., new sets of classroom voting questions), and strategies for getting started at the course and department level.

Experiences that Enrich the Education of Mathematics Majors, Wednesday afternoon, **Suzanne M. Lenhart**, University of Tennessee, **Steven J. Schlicker**, Grand Valley State University, **J. Douglas Faires**, Youngstown State University, and **Michael J. Dorff**, Brigham Young University. This session will feature models of programs that have been successful in enriching the education of mathematics majors beyond the standard curriculum. We are interested in talks that describe such experiences as internship programs, career seminars, research experiences, and similar programs for students that help inform them about the whole spectrum of opportunities within the mathematical sciences community. The session is sponsored by the MAA CUPM Subcommittee on Research by Undergraduates.

How Assessment Results Changed Our Program, Thursday afternoon, **Dick Jardine**, Keene State College, and **Barbara Edwards**, Oregon State University. The purpose of assessment in higher education is to improve student learning and to improve our programs. Is there evidence that program assessment has made a positive difference in student learning mathematics? This session will provide faculty teaching mathematics or quantitative literacy/reasoning courses the opportunity to disseminate how they have "closed the loop" in program assessment, making changes that have resulted in improvements in their programs, in their teaching, and ultimately in student learning.

Improving a Second Course in Statistics, Wednesday morning, **Nancy J. Boynton**, SUNY Fredonia, **Patricia B. Humphrey**, Georgia Southern University, and **Michael A. Posner**, Villanova University. This session seeks to provide a forum in which to discuss approaches to a second statistics course. Most colleges have a first course in statistics

that introduces many topics including the normal distribution, the t-distribution, hypothesis testing, confidence intervals and regression. The growth in enrollment in AP Statistics means that many college students may never take another course unless we have a good offering. In addition many "quantitatively challenged" students may shy away from majors that require the second course. Second courses may be pure "follow-ons" to the first (introductory) course (like Calculus II is to Calculus I) or something completely different. Of interest in this session are presentations related to the following: How to convince students to take a second course, innovative ideas for curriculum (what makes your course different), as well as successfully implemented activities, projects, and assessment practices particularly aimed at this course.

The session is sponsored by the SIGMAA on Statistics Education. In order to be considered for this session, applicants should submit a one-page summary of the presentation to Nancy Boynton at nancy.boynton@fredonia.edu along with the abstract to JMM website. Presenters in the session will be considered for the SIGMAA on Statistics Education's Best Contributed Presentation Award.

Innovative and Effective Ways to Teach Linear Algebra, Saturday morning, **David M. Strong**, Pepperdine University, **Gilbert Strang**, Massachusetts Institute of Technology, and **David C. Lay**, University of Maryland. Linear algebra is one of the most interesting and useful areas of mathematics, because of its beautiful and multifaceted theory, as well as the enormous importance it plays in understanding and solving many real world problems. Consequently, many valuable and creative ways to teach its rich theory and its many applications are continually being developed and refined. This session will serve as a forum in which to share and discuss new or improved teaching ideas and approaches.

These innovative and effective ways to teach linear algebra include, but are not necessarily limited to: (1) hands-on, in-class demos; (2) effective use of technology, such as Matlab, Maple, Mathematica, Java Applets or Flash; (3) interesting and enlightening connections between ideas that arise in linear algebra and ideas in other mathematical branches; (4) interesting and compelling examples and problems involving particular ideas being taught; (5) comparing and contrasting visual (geometric) and more abstract (algebraic) explanations of specific ideas; and (6) other novel and useful approaches or pedagogical tools.

The MAA SUMMA Program Turns 20—A Retrospective, Wednesday morning, **William A. Hawkins Jr.**, MAA and the University of the District of Columbia, **Efraim Armendariz**, University of Texas at Austin, **Camille A. McKayle**, University of the Virgin Islands, and **Robert E. Megginson**, University of Michigan, Ann Arbor. The late Marcia P. Sward created the Strengthening Underrepresented Minority Mathematics Achievement (SUMMA) Program in 1990 a year after she became MAA Executive Director. The goals of SUMMA are to increase minority participation in mathematics, science, and engineering and to improve the mathematics education of minorities. In the 20 years of SUMMA's existence the nation has seen many initiatives and some successes toward achieving these goals.

Speakers will be invited and papers solicited to discuss progress and setbacks. Talks will be grouped into areas such as successful initiatives with pre-college students, undergraduate programs successful in developing and enhancing minority participation, successful REUs, graduate programs, and professional development/mentoring. There will be an invited lead presenter in each category together with shorter contributed papers. This session is co-sponsored by SUMMA and the Committee on Minority Participation in Mathematics.

Mathematical Texts: Famous, Infamous, and Influential, Saturday morning, **Fernando Q. Gouvêa**, Colby College, and **Amy Shell-Gellasch**, Pacific Lutheran University. Texts—books, articles, even letters—play a central role in the life of the mathematics community. This session will consist of historical papers discussing such texts, focusing on those that have had significant impact, for good or ill, on mathematics. This session is an extension of the MAA Short Course to be offered at the Joint Meetings.

Mathematics and Sports, Saturday morning, **Howard L. Penn**, U.S. Naval Academy. Sports provide a host of applications of mathematics. Examples exist that use concepts taught in calculus, differential equations, probability, statistics, and combinatorics. In this contributed paper session, we will showcase interesting applications of mathematics in various sports. The application should be suitable for use in the classroom. The mathematics may be at any level from freshman to senior. Talks may be expository or may highlight research, including undergraduate research.

Mathematics Courses for the Liberal Arts Student, Friday morning, **Reva Kasman**, Salem State College. Many mathematics departments now offer survey courses specifically designed to introduce the nonmajor to a vast array of mathematical topics and ideas, sometimes called Mathematics for Liberal Arts. These terminal courses frequently satisfy a general education core requirement in mathematics or quantitative reasoning. Textbook topics range from the extremely practical to the highly esoteric, including such subjects as voting theory, cryptography, symmetry, fractals, mathematical modeling, probability, number systems, and infinity. Assessment methods may incorporate creative projects and writing assignments, or encourage the students to connect mathematical topics to their own life experience or major field. This session seeks the presentation of innovative assignments and classroom activities, novel approaches to particular topics, and interdisciplinary projects that have been used successfully in such courses.

Mathematics, Equity, Diversity, and Social Justice, Friday morning, **Patricia Hale**, California State Polytechnic University Pomona, **Shandy Hauk**, University of Northern Colorado, and **Dave Kung**, St. Mary's College, Maryland. Papers presented at this session address topics at the intersection of mathematics teaching and learning and the myriad issues of equity, diversity, and social justice. Papers are sought that address one or more of the following: developing college mathematics curricula that focus on social justice issues, preparing K-20 teachers to teach mathematics equitably to diverse populations, bringing

issues of social justice into the mathematics classroom, designing or implementing programs that address issues of equity in mathematics, reviewing policies in various mathematical communities (e.g., school, undergraduate, or research mathematics) that interact with issues of social justice and equity. Potential topics for a paper submitted to this session include: lessons learned about implementing and maintaining an Emerging Scholars Program, defining social justice and mathematics—what it looks like and what the goals are, culturally responsive college mathematics curriculum and instruction, equity in the design of mathematics assessments. Proposals are sought from mathematicians; mathematics education researchers; and mathematics educators, including those involved with K–20 instructional professional development and those who can inform a national audience about current endeavors (e.g., The Algebra Project, the Math for Social Justice Group).

Mathematics Experiences in Business, Industry and Government, Thursday morning, **Philip Gustafson**, Mesa State College, and **Michael Monticino**, University of North Texas. This contributed paper session will provide a forum for mathematicians with experience in Business, Industry and Government (BIG) to present papers or discuss projects involving the application of mathematics to BIG problems. BIG mathematicians as well as faculty and students in academia, who are interested in learning more about BIG practitioners, projects, and issues, will find this session of interest. This session is sponsored by the MAA Business, Industry and Government Special Interest Group (BIG SIGMAA).

Mathlets for Teaching and Learning Mathematics, Saturday afternoon, **Joe Yanik**, Emporia State University, **Thomas E. Leathrum**, Jacksonville State University, and **David M. Strong**, Pepperdine University. This session seeks to provide a forum in which presenters may demonstrate and discuss the effectiveness of mathlets and related materials that they have created or further developed. Mathlets are small computer-based (but ideally platform-independent) interactive tools for teaching math, frequently developed as World Wide Web materials such as scripts or Java applets, but there may be many other innovative variations. Mathlets allow students to experiment with and visualize a variety of mathematical concepts, and they can be easily shared by mathematics instructors around the world. The Mathlets introduced in this session will be available at `http://cs.jsu.edu/~leathrum/JMMsession2010.html`. This session is sponsored by the MAA Committee on Technology in Mathematics Education (CTiME).

My Most Successful Math Club Activity, Wednesday morning, **Jacqueline A. Jensen**, Sam Houston State University, **Deanna B. Haunsperger**, Carlton College, and **Robert W. Vallin**, Slippery Rock University and the MAA. Math clubs enhance the culture of a mathematics department. How does one develop a new group? How about refreshing an existing one? What sets apart effective, active, and engaging mathematics clubs? This session will answer those questions by featuring papers from math club advisors and others who will share their favorite non-standard activity for math clubs. Our goal is to provide ideas and support for mentors of math clubs, especially those trying to begin or reactivate a group. Speakers should focus on a single activity that motivates and engages students, and, when applicable, suggestions for acquiring funding for such activities. It is our hope that these talks will spur immediate discussion between speakers and audience members, and possibly lead to a document to help math club advisors or possibly the development of an electronic forum. This session is sponsored by the MAA Committee on Undergraduate Student Activities and Chapters.

Online Homework—Innovation and Assessment, Thursday afternoon, **Michael E. Gage**, **Arnold K. Pizer**, and **Vicki Roth**, University of Rochester. The use of online homework systems such as the open source system WeBWorK, commercial systems WebAssign, MapleTA and others has increased in recent years. This session gives instructors who are using these systems in an innovative manner and/or studying their educational effectiveness an opportunity to report on their findings. The first theme is innovative uses of online homework systems. Many instructors use these systems simply as a replacement for standard homework, but some employ them, for example, to promote a more interactive classroom. Others use them in conjunction with a workshop or to encourage students to review material before class. In this session, instructors will have an opportunity to share these and other innovative uses of these systems and to report on how successful these new approaches have been.

The second theme is assessment and evaluation of the impact of online homework systems on student learning, both when used simply as a replacement for standard homework and when used in innovative approaches. Topics may include, but are not limited to, changes in student behavior and persistence when using online homework systems, effects on student retention in courses, and the overall impact on student learning and success in courses.

Philosophy of Mathematics for Working Mathematicians, Friday afternoon, **Bonnie Gold**, Monmouth University, and **Carl Behrens**, Alexandria, Virginia. Philosophers have a wide range of views on the nature and existence of mathematical objects. How is it that mathematics continues to flourish, year after year, when philosophical questions about the fundamental nature of mathematical objects remain controversial and unsettled? This session invites papers that address, and clarify the relevance of, this issue, and propose views of mathematical objects that are consistent with mathematical practice. Papers on other topics in the philosophy of mathematics will be considered within time constraints. This session is sponsored by POMSIGMAA, the SIGMAA for the Philosophy of Mathematics.

Preparing K–12 Teachers to Teach Algebra, Wednesday afternoon, **Elizabeth Burroughs**, Montana State University, **Angela M. Hodge**, North Dakota State University, and **William G. McCallum**, University of Arizona. Several recent reports (e.g., from The National Mathematics Advisory Panel, Achieve Inc., and The National Council on Teacher Quality) have emphasized that the teaching and learning of algebra plays a central role in the K–12 mathematics curriculum. In recognition of these reports, the MAA's

Committee on the Mathematical Education of Teachers (COMET) is sponsoring this session.

COMET promotes "timely renewal efforts of mathematics courses designed for prospective K–12 teachers" and "thoughtful participation of MAA members in schools and professional development programs that enhance the mathematical understanding of in-service K–12 teachers." Presentations are invited that support COMET's mission by reporting on work with prospective or practicing teachers that has a particular focus on curriculum, learning standards, or teacher preparation in support of the teaching and learning of algebra.

Publishing Mathematics on the Web, Friday afternoon, **Thomas E. Leathrum**, Jacksonville State University, **William F. Hammond**, The University at Albany, and **Kyle T. Siegrist**, University of Alabama in Huntsville. Emerging technologies, such as browser support for MathML, are changing the ways authors will be expected to present mathematical material in online documents. As academic journals move toward online formats, online presentation will become essential to the profession. Many useful tools have become available recently, including visual editors and simplified embedded mark-up. This session seeks to provide a venue for developers of new technologies and tools, and authors familiar with them, to demonstrate their work and share their experiences. This session is sponsored by the MAA Committee on Technology in Mathematics Education (CTiME).

Quantitative Reasoning and the Environment, Friday morning, **Maura B. Mast**, University of Massachusetts Boston, **Karen D. Bolinger**, Clarion University, and **Cinnamon Hillyard**, University of Washington Bothell. The combination of teaching quantitative literacy and environmental issues in the classroom can be a powerful one. Both fields naturally focus on mathematical topics such as understanding basic numeracy, constructing models, and generating and interpreting statistics. Furthermore, both fields emphasize concrete data, real-world applications, and mathematics in context. Courses that integrate quantitative literacy and the study of environmental issues are suitable for students at a range of levels, from those with a limited mathematics background, to calculus students, and beyond. This combination is also timely, given the active national conversation about implementing quantitative literacy requirements and the public's increased awareness of environmental issues. There is a growing source of support material, from textbooks to workshops to web pages, providing further evidence of the interest in developing course materials that draw from both of these fields. We invite presentations addressing the teaching of quantitative literacy and environmental problems. This could include ideas and examples for how to bringing quantitative literacy and environmental mathematics together in the classroom, suggestions for how quantitative literacy can be used in the study of environmental problems, and resources available for this type of work. This session is jointly sponsored by SIGMAA-EM and SIGMAA-QL.

Research on the Teaching and Learning of Undergraduate Mathematics, Friday afternoon, **Keith Weber**, Rutgers University, **Stacy Brown**, Pitzer College, **Natasha A. Speer**, University of Maine, and **Karen A. Marrongelle**, Portland State University. As part of its ongoing activities to foster research in undergraduate mathematics education and the dissemination of such research, the Special Interest Group of the Mathematical Association of America on Research in Undergraduate Mathematics Education (SIGMAA on RUME) solicits reports of research on the learning and teaching of undergraduate mathematics for its contributed paper session. We solicit proposals for research reports presenting results from completed research studies on undergraduate mathematics education that address one or more of the following themes: (1) results of current research; (2) contemporary theoretical perspectives and research paradigms, and (3) innovative methodologies and analytical approaches as they pertain to the study of undergraduate mathematics education. We also welcome preliminary reports on research projects in early stages of development or execution.

The Scholarship of Teaching and Learning in Undergraduate Mathematics, Wednesday afternoon, **Edwin P. Herman**, and **Nathan M. Wodarz**, University of Wisconsin-Stevens Point. The Scholarship of Teaching and Learning is a growing field in which faculty bring disciplinary knowledge to bear on questions of teaching and learning and use student-based evidence to support their conclusions. Work in this area emphasizes pedagogical techniques and questions. The scope of the research can range from small, relatively informal investigations about teaching innovations in the classroom to larger or more formal investigations of student learning.

Reports that address issues concerning the teaching and learning of undergraduate mathematics are invited. Appropriate for this session are reports of classroom-based investigations of teaching methods, student learning difficulties, or curricular assessment. Papers must discuss more than anecdotal evidence. For example, papers might reference the following types of evidence: student work, interviews, surveys, etc.

Goals of this session are to feature scholarly work focused on teaching of undergraduate mathematics; to provide a venue for mathematicians to make public their scholarly work on teaching; and to highlight evidence-based arguments for the value of teaching innovations.

Undergraduate Mathematical Biology, Friday morning, **Timothy D. Comar**, Benedictine University, and **Raina S. Robeva**, Sweet Briar College. "Future Research Biologists" (NRC, 2003) and "Math and BIO 2010: Linking Undergraduate Disciplines" (Steen, 2005) emphasize that aspects of biological research are becoming more quantitative and that life science students should be introduced to a greater array of mathematical and computational techniques and to the integration of mathematics and biological content at the undergraduate level. Since these reports, many successful programs and materials have been designed to address these issues.

This session will highlight successful implementations of biomathematics courses in undergraduate curriculum, new course materials for biomathematics courses, efforts to recruit students into biomathematics courses,

involvement of undergraduate students in biomathematics research, preparation for graduate work in biomathematics and computational biology, and assessment of how these courses and activities impact the students. Topics may include the issues related to the design of effective biomathematics courses, integration of biology into existing mathematics courses, collaborations between mathematicians and biologists that have led to new courses, course modules, or undergraduate research projects, effective use of appropriate technology in biomathematics courses, and assessment issues. Presenters are encouraged to provide handouts, electronic materials, or online references to their materials. This session is sponsored by the BIO SIGMAA.

Using Computer Algebra Systems in the Calculus Sequence, Thursday morning, **William Marion**, Valparaiso University. Since the calculus reform movement took hold in the late 1980s, mathematics faculty teaching calculus have used a number of tools to enhance student learning: Writing projects, oral presentations, portfolios, computer labs and computer demonstrations, to name a few. Many calculus courses now include a required laboratory experience. With the aid of mathematical software students solve a variety of well-designed problems in a "closed lab" environment.

This session solicits papers highlighting an innovative lab exercise in a Calculus I, II or III course that requires the use of a computer algebra system. The example to be presented should go beyond or expand upon ones usually found in standard calculus texts. It should have an "aha" quality to it. The paper should include a detailed description of the problem, rationale for why the exercise enhances student learning, the problem solution, a grading rubric, and any suggestions for adaptation by others.

Visualization in Mathematics, Saturday afternoon, **Sarah J. Greenwald**, Appalachian State University, and **Walter Whiteley**, York University. The ability to understand and create interesting visuals is essential in mathematics and in interdisciplinary research. Recent research on visualization highlights the extent to which significant portions of the student body bring a visual approach to their mathematics but some studies suggest that teachers may find it difficult to recognize visual reasoning and support the development of visual abilities.

We invite papers related to the following aspects of visualization: What skills are needed for success? What are the visual practices of research mathematicians? What is considered visually pleasing in mathematics? When are visuals helpful or detrimental for student learning? How do teachers develop visualization skills and train students to use visual information? How should we assess visualization skills?

Wavelets in Undergraduate Education, Thursday afternoon, **Caroline Haddad**, SUNY Geneseo, **Catherine Beneteau**, University of South Florida, **David Ruch**, Metropolitan State College of Denver, **Patrick Van Fleet**, University of St. Thomas. Wavelets are functions that satisfy certain mathematical properties and are used to represent data or other functions. They work extremely well in analyzing data with finite domains having different scales or resolutions. Interesting applications include digital image processing, FBI fingerprint compression, signal processing of audio files, de-noising noisy data, earthquake prediction, and solving partial differential equations. Wavelets have typically been studied at the graduate level, but are making their way into the undergraduate curriculum. We are interested in presentations that effectively incorporate wavelets in an innovative way at the undergraduate level. This may include an undergraduate course in wavelets; a topic on wavelets in some other course using, but not limited to, hands-on demonstrations, projects, labs that utilize technology such as Matlab, Mathematica, Maple, Java applets, etc.; or research opportunities for undergraduates.

General Contributed Paper Sessions, Wednesday, Thursday, Friday and Saturday morning and afternoons, **Eric S. Marland**, Appalachia State University, and **Daniel J. Curtin**, Northern Kentucky University. Papers may be presented on any mathematical topics. Papers that fit into one of the other sessions should be sent to that session, not to the general session.

Submission Procedures for MAA Contributed Paper Abstracts

Abstracts must be submitted electronically at `http://www.ams.org/cgi-bin/abstracts/abstract.pl`. Simply select the San Francisco meeting, fill in the number of authors, and then follow the step-by-step instructions. The deadline for abstracts is Tuesday, **September 22, 2009**.

Participants may submit at most two abstracts for MAA contributed paper sessions at any one meeting. If your paper cannot be accommodated in the session in which it is submitted, it will automatically be considered for the general session. Speakers in the general session are limited to one talk.

The organizer(s) of your session will automatically receive a copy of the abstract, so it is not necessary for you to send it directly to the organizer. However, some sessions require separate submissions directly to the organizer, so check for this detail. All accepted abstracts are published in a book that is available to registered participants at the meeting. Questions concerning the submission of abstracts should be addressed to `abs-coord@ams.org`.

Lexington, Kentucky

University of Kentucky

March 27–28, 2010

Saturday – Sunday

Meeting #1057

Southeastern Section
Associate secretary: Matthew Miller
Announcement issue of *Notices*: January 2010
Program first available on AMS website: February 11, 2010
Program issue of electronic *Notices*: March
Issue of *Abstracts*: Volume 31, Issue 2

Deadlines

For organizers: August 28, 2009
For consideration of contributed papers in Special Sessions: December 8, 2009
For abstracts: February 2, 2010

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Percy A. Deift, Courant Institute-New York University, *Title to be announced.*

Irina Mitrea, University of Virginia, *Title to be announced.*

Bruce Reznick, University of Illinois at Urbana Champaign, *Title to be announced.*

Bernd Ulrich, Purdue University, *Title to be announced.*

Doron Zeilberger, Rutgers University, *Title to be announced* (Erdős Memorial Lecture).

Special Sessions

Advances in Algebraic Coding Theory (Code: SS 6A), **Heide Gluesing-Luerssen**, **University of Kentucky**, and **Jon-Lark Kim**, University of Louisville.

Advances in Algebraic Statistics (Code: SS 2A), **Sonja Petrović**, University of Illinois, Chicago, and **Ruriko Yoshida**, University of Kentucky.

Combinatorial Algebra (Code: SS 7A), **Juan C. Migliore**, University of Notre Dame, and **Uwe Nagel**, University of Kentucky.

Commutative Algebra (Code: SS 1A), **Alberto Corso**, University of Kentucky, **Claudia Polini**, University of Notre Dame, and **Bernd Ulrich**, Purdue University.

Complex Analysis and Potential Theory (Code: SS 4A), **James E. Brennan** and **Vladimir Eiderman**, University of Kentucky.

Function Theory, Harmonic Analysis, and Partial Differential Equations (Code: SS 5A), **Joel Kilty**, Centre College, **Irina Mitrea**, Worcester Poytechnic Institute, and **Katharine Ott**, University of Kentucky.

Geometric Function Theory and Analysis on Metric Spaces (Code: SS 3A), **John L. Lewis**, University of Kentucky, and **Nageswari Shanmugalingam**, University of Cincinnati.

St. Paul, Minnesota

Macalester College

April 10–11, 2010

Saturday – Sunday

Meeting #1058

Central Section
Associate secretary: Georgia Benkart
Announcement issue of *Notices*: February 2010
Program first available on AMS website: February 25, 2010
Program issue of electronic *Notices*: April 2010
Issue of *Abstracts*: Volume 31, Issue 2

Deadlines

For organizers: September 10, 2009
For consideration of contributed papers in Special Sessions: December 22, 2009
For abstracts: February 16, 2010

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Charles Doering, University of Michigan, *Title to be announced.*

Vladimir Touraev, University of Indiana, *Title to be announced.*

Peter Webb, University of Minnesota, *Title to be announced.*

Special Sessions

Quantum Invariants of 3-manifolds and Modular Categories (Code: SS 1A), **Thang Le**, Georgia Institute of Technology, **Eric Rowell**, Texas A&M University, and **Vladimir Touraev**, Indiana University.

Albuquerque, New Mexico

University of New Mexico

April 17–18, 2010

Saturday – Sunday

Meeting #1059

Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: February 2010
Program first available on AMS website: March 4, 2010
Program issue of electronic *Notices*: April 2010
Issue of *Abstracts*: Volume 31, Issue 3

Deadlines

For organizers: September 17, 2009
For consideration of contributed papers in Special Sessions: December 29, 2009
For abstracts: February 23, 2010

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Kenneth Bromberg, University of Utah, *Title to be announced.*

Danny Calegari, California Institute of Technology, *Title to be announced.*

Ioana Dumitriu, University of Washington, *Title to be announced.*

Steffen Rhode, University of Washington, *Title to be announced.*

Newark, New Jersey

New Jersey Institute of Technology

May 22–23, 2010

Saturday – Sunday

Meeting #1060

Eastern Section
Associate secretary: Steven H. Weintraub
Announcement issue of *Notices*: February 2010
Program first available on AMS website: April 8, 2010
Program issue of electronic *Notices*: May
Issue of *Abstracts*: Volume 31, Issue 3

Deadlines

For organizers: November 23, 2009
For consideration of contributed papers in Special Sessions: February 2, 2010
For abstracts: March 30, 2010

Berkeley, California

University of California Berkeley

June 2–5, 2010

Wednesday – Saturday

Meeting #1061

Eighth Joint International Meeting of the AMS and the Sociedad Matemática Mexicana.
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: February 2010
Program first available on AMS website: April 22, 2010
Program issue of electronic *Notices*: June 2010
Issue of *Abstracts*: Volume 31, Issue 3

Deadlines

For organizers: November 3, 2009
For consideration of contributed papers in Special Sessions: February 16, 2010
For abstracts: April 13, 2010

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/internmtgs.html`.

Invited Addresses

Alejandro Adem, University of British Columbia and PIMS, *Title to be announced.*

Peter W-K Li, University of California Irvine, *Title to be announced.*

Ernesto Lupercio, CINVESTAV, *Title to be announced.*

Victor Perez Abreu, CIMAT, *Title to be announced.*

Alberto Verjovsky, IM-UNAM, *Title to be announced.*

Maciej Zworski, University of California Berkeley, *Title to be announced.*

Special Sessions

Analytic Aspects of Differential Geometry (Code: SS 2A), **Lizhen Ji**, University of Michigan, and **Jiaping Wang**, University of Minnesota.

Harmonic Analysis, Microlocal Analysis, and Partial Differential Equations (Code: SS 1A), **Gunther Uhlmann**, University of Washington, and **Salvador Perez Esteva**, UNAM.

Syracuse, New York

Syracuse University

October 2–3, 2010

Saturday – Sunday

Meeting #1062

Eastern Section
Associate secretary: Steven H. Weintraub
Announcement issue of *Notices*: To be announced
Program first available on AMS website: August 19, 2010
Program issue of electronic *Notices*: October
Issue of *Abstracts*: Volume 31, Issue 4

Deadlines

For organizers: March 2, 2010
For consideration of contributed papers in Special Sessions: June 15, 2010
For abstracts: August 10, 2010

Los Angeles, California

University of California Los Angeles

October 9–10, 2010

Saturday – Sunday

Meeting #1063

Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: August 2010
Program first available on AMS website: August 26, 2010
Program issue of electronic *Notices*: October 2010
Issue of *Abstracts*: Volume 31, Issue 4

Deadlines

For organizers: March 10, 2010

For consideration of contributed papers in Special Sessions: June 22, 2010
For abstracts: August 17, 2010

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Greg Kuperberg, University of California Davis, *Title to be announced.*

Cris Moore, University of New Mexico, *Title to be announced.*

Stanley Osher, University of California Los Angeles, *Title to be announced.*

Terence Tao, University of California Los Angeles, *Title to be announced* (Einstein Public Lecture in Mathematics).

Melanie Wood, Princeton University, *Title to be announced.*

Special Sessions

Large Cardinals and the Continuum (Code: SS 2A), **Matthew Foreman**, University of California Irvine, **Alekos Kechris**, California Institute of Technology, **Itay Neeman**, University of California Los Angeles, and **Martin Zeman**, University of California Irvine.

Topology and Symplectic Geometry (Code: SS 1A), **Robert Brown** and **Ciprian Manolescu**, University of California Los Angeles, and **Stefano Vidussi**, University of California Riverside.

Notre Dame, Indiana

Notre Dame University

October 29–31, 2010

Friday – Sunday

Meeting #1064

Central Section
Associate secretary: Georgia Benkart
Announcement issue of *Notices*: August 2010
Program first available on AMS website: September 16, 2010
Program issue of electronic *Notices*: October 2010
Issue of *Abstracts*: Volume 31, Issue 4

Deadlines

For organizers: February 19, 2010
For consideration of contributed papers in Special Sessions: July 20, 2010
For abstracts: September 7, 2010

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Laura DeMarco, University of Illinois at Chicago, *Title to be announced.*

David Fisher, Indiana University, *Title to be announced.*

Jared Wunsch, Northwestern University, *Title to be announced.*

Richmond, Virginia

University of Richmond

November 6–7, 2010

Saturday – Sunday

Meeting #1065

Southeastern Section
Associate secretary: Matthew Miller
Announcement issue of *Notices*: September
Program first available on AMS website: September 23, 2010
Program issue of electronic *Notices*: November
Issue of *Abstracts*: Volume 31, Issue 4

Deadlines

For organizers: March 8, 2010
For consideration of contributed papers in Special Sessions: July 27, 2010
For abstracts: September 14, 2010

New Orleans, Louisiana

New Orleans Marriott and Sheraton New Orleans Hotel

January 5–8, 2011

Wednesday – Saturday
Joint Mathematics Meetings, including the 117th Annual Meeting of the AMS, 94th Annual Meeting of the Mathematical Association of America, annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association for Symbolic Logic (ASL), with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).
Associate secretary: Steven H. Weintraub
Announcement issue of *Notices*: October 2010
Program first available on AMS website: November 1, 2010
Program issue of electronic *Notices*: January 2011
Issue of *Abstracts*: Volume 32, Issue 1

Deadlines

For organizers: April 1, 2010
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Statesboro, Georgia

Georgia Southern University

March 12–13, 2011

Saturday – Sunday
Southeastern Section
Associate secretary: Matthew Miller
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: August 12, 2010
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Iowa City, Iowa

University of Iowa

March 18–20, 2011

Friday – Sunday
Central Section
Associate secretary: Georgia Benkart
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: July 16, 2010
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Worcester, Massachusetts

College of the Holy Cross

April 9–10, 2011

Saturday – Sunday
Eastern Section
Associate secretary: Steven H. Weintraub
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: September 9, 2010
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Boston, Massachusetts

John B. Hynes Veterans Memorial Convention Center, Boston Marriott Hotel, and Boston Sheraton Hotel

January 4–7, 2012

Wednesday – Saturday
Joint Mathematics Meetings, including the 118th Annual Meeting of the AMS, 95th Annual Meeting of the Mathematical Association of America, annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association for Symbolic Logic (ASL), with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: October 2011
Program first available on AMS website: November 1, 2011
Program issue of electronic *Notices*: January 2012
Issue of *Abstracts*: Volume 33, Issue 1

Deadlines

For organizers: April 1, 2011
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

San Diego, California

San Diego Convention Center and San Diego Marriott Hotel and Marina

January 9–12, 2013

Wednesday – Saturday
Joint Mathematics Meetings, including the 119th Annual Meeting of the AMS, 96th Annual Meeting of the Mathematical Association of America, annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association for Symbolic Logic (ASL), with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).
Associate secretary: Georgia Benkart
Announcement issue of *Notices*: October 2012
Program first available on AMS website: November 1, 2012
Program issue of electronic *Notices*: January 2012
Issue of *Abstracts*: Volume 34, Issue 1

Deadlines

For organizers: April 1, 2012
For consideration of contributed papers in Special Sessions: To be announced

For abstracts: To be announced

Baltimore, Maryland

Baltimore Convention Center, Baltimore Hilton, and Marriott Inner Harbor

January 15–18, 2014

Wednesday – Saturday
Joint Mathematics Meetings, including the 120th Annual Meeting of the AMS, 97th Annual Meeting of the Mathematical Association of America, annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association for Symbolic Logic, with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).
Associate secretary: Matthew Miller
Announcement issue of *Notices*: October 2013
Program first available on AMS website: November 1, 2013
Program issue of electronic *Notices*: January 2013
Issue of *Abstracts*: Volume 35, Issue 1

Deadlines

For organizers: April 1, 2013
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

San Antonio, Texas

Henry B. Gonzalez Convention Center and Grand Hyatt San Antonio

January 10–13, 2015

Saturday – Tuesday
Joint Mathematics Meetings, including the 121st Annual Meeting of the AMS, 98th Annual Meeting of the Mathematical Association of America, annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association of Symbolic Logic, with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).
Associate secretary: Steven H. Weintraub
Announcement issue of *Notices*: October 2014
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: January 2015
Issue of *Abstracts*: Volume 36, Issue 1

Deadlines

For organizers: April 1, 2014
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Seattle, Washington

Washington State Convention & Trade Center and the Sheraton Seattle Hotel

January 6–9, 2016

Wednesday – Saturday
Joint Mathematics Meetings, including the 122nd Annual Meeting of the AMS, 99th Annual Meeting of the Mathematical Association of America, annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association of Symbolic Logic, with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: October 2015
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: January 2016
Issue of *Abstracts*: Volume 37, Issue 1

Deadlines

For organizers: April 1, 2015
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Atlanta, Georgia

Hyatt Regency Atlanta and Marriott Atlanta Marquis

January 4–7, 2017

Wednesday – Saturday
Joint Mathematics Meetings, including the 123rd Annual Meeting of the AMS, 100th Annual Meeting of the Mathematical Association of America, annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association of Symbolic Logic, with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).
Associate secretary: Georgia Benkart
Announcement issue of *Notices*: October 2016
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: January 2017
Issue of *Abstracts*: Volume 38, Issue 1

Deadlines

For organizers: April 1, 2016
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Meetings and Conferences of the AMS

Associate Secretaries of the AMS

Western Section: Michel L. Lapidus, Department of Mathematics, University of California, Surge Bldg., Riverside, CA 92521-0135; e-mail: lapidus@math.ucr.edu; telephone: 951-827-5910.

Central Section: **Susan J. Friedlander**, Department of Mathematics, University of Illinois at Chicago, 851 S. Morgan (M/C 249), Chicago, IL 60607-7045; e-mail: susan@math.nwu.edu; telephone: 312-996-3041. **Georgia Benkart** (after January 31, 2010), University of Wisconsin-Madison, Department of Mathematics, 480 Lincoln Drive, Madison, WI 53706-1388; e-mail: benkart@math.wisc.edu; telephone: 608-263-4283.

Eastern Section: **Steven H. Weintraub**, Department of Mathematics, Lehigh University, Bethlehem, PA 18105-3174; e-mail: steve.weintraub@lehigh.edu; telephone: 610-758-3717.

Southeastern Section: **Matthew Miller,** Department of Mathematics, University of South Carolina, Columbia, SC 29208-0001, e-mail: miller@math.sc.edu; telephone: 803-777-3690.

2009 Seoul, Korea Meeting: Georgia Benkart, University of Wisconsin-Madison, Department of Mathematics, 480 Lincoln Drive, Madison, WI 53706-1388; e-mail: benkart@math.wisc.edu; telephone: 608-263-4283.

The Meetings and Conferences section of the *Notices* gives information on all AMS meetings and conferences approved by press time for this issue. Please refer to the page numbers cited in the table of contents on this page for more detailed information on each event. Invited Speakers and Special Sessions are listed as soon as they are approved by the cognizant program committee; the codes listed are needed for electronic abstract submission. For some meetings the list may be incomplete. **Information in this issue may be dated. Up-to-date meeting and conference information can be found at** www.ams.org/meetings/.

Meetings:

Important Information Regarding AMS Meetings

Potential organizers, speakers, and hosts should refer to page 89 in the January 2009 issue of the *Notices* for general information regarding participation in AMS meetings and conferences.

Abstracts

Speakers should submit abstracts on the easy-to-use interactive Web form. No knowledge of LaTeX is necessary to submit an electronic form, although those who use LaTeX may submit abstracts with such coding, and all math displays and similarly coded material (such as accent marks in text) must be typeset in LaTeX. Visit http://www.ams.org/cgi-bin/abstracts/abstract.pl. Questions about abstracts may be sent to abs-info@ams.org. Close attention should be paid to specified deadlines in this issue. Unfortunately, late abstracts cannot be accommodated.

Conferences: (see http://www.ams.org/meetings/ for the most up-to-date information on these conferences.)

Co-sponsored conferences:

March 18-21, 2010: First International Conference on Mathematics and Statistics, AUS-ICMS '10, American University of Sharjah, Sharjah, United Arab Emirates (please see http://www.aus.edu/conferences/icms10/ for more information).

June 17-19, 2010: Coimbra Meeting on 0-1 Matrix Theory and Related Topics, University of Coimbra, Portugal (for more information please see http://www.mat.uc.pt/~cmf/01MatrixTheory).

CAMBRIDGE

FANTASTIC NEW TITLES FROM **CAMBRIDGE**!

Differential Tensor Algebras and their Module Categories
R. Bautista, L. Salmerón, and R. Zuazua
London Mathematical Society Lecture Note Series
$70.00: Pb: 978-0-521-75768-3: 456 pp.

Waves and Mean Flows
Oliver Bühler
Cambridge Monographs on Mechanics
$99.00: Hb: 978-0-521-86636-1: 370 pp.

Elements of Automata Theory
Jacques Sakarovitch
Translated by Reuben Thomas
$145.00: Hb: 978-0-521-84425-3: 785 pp.

Galois Groups and Fundamental Groups
Tamás Szamuely
Cambridge Studies in Advanced Mathematics
$55.00: Hb: 978-0-521-88850-9: 304 pp.

Partial Differential Equations and Fluid Mechanics
Edited by James C. Robinson and José L. Rodrigo
London Mathematical Society Lecture Note Series
$60.00: Pb: 978-0-521-12512-3: 300 pp.

Unitary Reflection Groups
Gustav I. Lehrer and Donald E. Taylor
Australian Mathematical Society Lecture Series
$65.00: Pb: 978-0-521-74989-3: 305 pp.

Conceptual Mathematics
A First Introduction to Categories
Second Edition
F. William Lawvere and Stephen H. Schanuel
$140.00: Hb: 978-0-521-89485-2: 408 pp.
$60.00: Pb: 978-0-521-71916-2

NOW IN PAPERBACK!

Classical and Quantum Orthogonal Polynomials in One Variable
Mourad E. H. Ismail
Encyclopedia of Mathematics and its Applications
$70.00: Pb: 978-0-521-14347-9: 730 pp.

Logic Colloquium 2006
Edited by S. Barry Cooper, Herman Geuvers, Anand Pillay, and Jouko Väänänen
Lecture Notes in Logic
$99.00: Hb: 978-0-521-11081-5: 384 pp.

Topics in Topological Graph Theory
Edited by Lowell W. Beineke and Robin J. Wilson
In consultation with Jonathan L. Gross and Thomas W. Tucker
Encyclopedia of Mathematics and its Applications
$99.00: Hb: 978-0-521-80230-7: 416 pp.

Dynamics of Linear Operators
Frédéric Bayart and Étienne Matheron
Cambridge Tracts in Mathematics
$80.00: Hb: 978-0-521-51496-5: 352 pp.

Surveys in Combinatorics 2009
Edited by Sophie Huczynska, James D. Mitchell, and Colva M. Roney-Dougal
London Mathematical Society Lecture Note Series
$70.00: Pb: 978-0-521-74173-6: 336 pp.

Purity, Spectra and Localisation
Mike Prest
Encyclopedia of Mathematics and its Applications
$170.00: Hb: 978-0-521-87308-6: 798 pp.

Prices are subject to change.

www.cambridge.org/us/mathematics

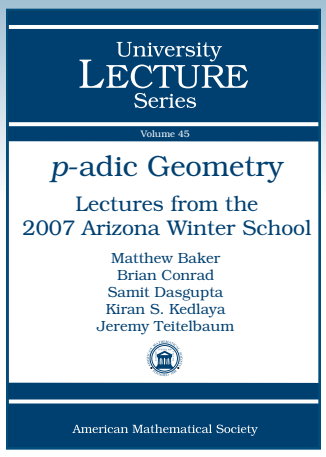
CAMBRIDGE UNIVERSITY PRESS

1584 · 2009
425 YEARS OF CAMBRIDGE PRINTING AND PUBLISHING

American Mathematical Society

University LECTURE Series

Each book in this series focuses on an important and rapidly developing topic, and is designed to give readers the most current information on the subject area. Some books in the series originated from important lecture series given by outstanding mathematicians worldwide.



p-adic Geometry

Lectures from the 2007 Arizona Winter School

Matthew Baker, *Georgia Institute of Technology, Atlanta, GA*, **Brian Conrad**, *University of Michigan, Ann Arbor, MI*, **Samit Dasgupta**, *Harvard University, Cambridge, MA*, **Kiran S. Kedlaya**, *Massachusetts Institute of Technology, Cambridge, MA*, **Jeremy Teitelbaum**, *University of Illinois at Chicago, IL*, and **edited by David Savitt** and **Dinesh S. Thakur**, *University of Arizona, Tucson, AZ*

Volume 45; 2008; 203 pages; Softcover; ISBN: 978-0-8218-4468-7; List US$45; AMS members US$36; Order code ULECT/45

Topology of Tiling Spaces

Lorenzo Sadun, *University of Texas, Austin, TX*

A modern mathematical perspective on tilings achieved through a unique examination of families of tilings

Volume 46; 2008; 118 pages; Softcover; ISBN: 978-0-8218-4727-5; List US$29; AMS members US$23; Order code ULECT/46

Inevitable Randomness in Discrete Mathematics

József Beck, *Rutgers, The State University of New Jersey, Piscataway, NJ*

Volume 49; 2009; approximately 257 pages; Softcover; ISBN: 978-0-8218-4756-5; List US$59; AMS members US$47; Order code ULECT/49

Residues and Duality for Projective Algebraic Varieties

Ernst Kunz, *University of Regensburg, Germany* with the assistance of and contributions by David A. Cox, *Amherst College, MA*, and Alicia Dickenstein, *University of Buenos Aires, Argentina*

Development of local and global duality theory in the special case of algebraic varieties over algebraically closed base fields

Volume 47; 2008; 158 pages; Softcover; ISBN: 978-0-8218-4760-2; List US$39; AMS members US$31; Order code ULECT/47

Computational Geometry of Positive Definite Quadratic Forms

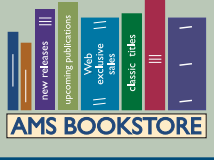
Polyhedral Reduction Theories, Algorithms, and Applications

Achill Schürmann, *Otto-von-Guericke Universität Magdeburg, Germany*

Volume 48; 2008; 147 pages; Softcover; ISBN: 978-0-8218-4735-0; List US$39; AMS members US$31; Order code ULECT/48

For more information on this series visit:
http://www.ams.org/bookstore/ulectseries

1-800-321-4AMS (4267), in the U. S. and Canada, or 1-401-455-4000 (worldwide); fax: 1-401-455-4046; email: cust-serv@ams.org.
American Mathematical Society, 201 Charles Street, Providence, RI 02904-2294 USA



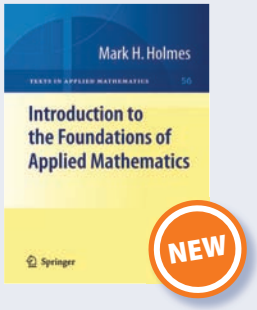
For many more publications of interest, visit the AMS Bookstore
www.ams.org/bookstore

AMS
American Mathematical Society

Springer
the language of science

springer.com

Highlights in Springer's eBook Collection

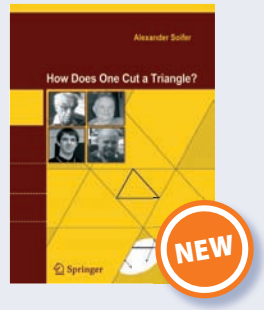


The objective of this textbook is the construction, analysis, and interpretation of mathematical models to help us understand the world we live in. Students and researchers interested in mathematical modelling in mathematics, physics, engineering and the applied sciences will find this text useful.

2009. Approx. 480 p. (Texts in Applied Mathematics, Vol. 56) Hardcover
ISBN 978-0-387-87749-5 ► **$69.95**

Blackjack is among the most popular casino table games, one where astute choices of playing strategy can create an advantage for the player. **Risk and Reward** analyzes the game in depth, pinpointing not just its optimal strategies but also its financial performance, in terms of both expected cash flow and associated risk.

2009. Approx. 140 p. 23 illus. Hardcover
ISBN 978-1-4419-0252-8 ► **$49.95**



This second edition of Alexander Soifer's **How Does One Cut a Triangle?** demonstrates how different areas of mathematics can be juxtaposed in the solution of a given problem. The author employs geometry, algebra, trigonometry, linear algebra, and rings to develop a miniature model of mathematical research.

2nd ed. 2009. XXX, 174 p. 80 illus. Softcover
ISBN 978-0-387-74650-0 ► **approx. $24.95**

For access check with your librarian

A Primer on Scientific Programming with Python

H. P. Langtangen

The book serves as an introduction to computer programming of scientific applications, using the Python language. The book teaches both "Matlab-style" and procedural programming and object-oriented programming. Readers will learn how to program computers and how to solve mathematical problems, arising in various branches of science and engineering.

2009. Approx. 700 p.
(Texts in Computational Science and Engineering, Volume 6) Hardcover
ISBN 978-3-642-02474-0 ► **$59.95**

Data Mining in Agriculture

A. Mucherino, P. J. Papajorgji, P. M. Pardalos

This book represents a comprehensive effort to provide readers with an analytical text on data mining techniques applied to agriculture and environmental related fields. The focus is on theoretical and practical insights while presenting the context of each technique.

2009. Approx. 290 p. 92 illus.
(Springer Optimization and Its Applications, Volume 34) Hardcover
ISBN 978-0-387-88614-5 ► **$59.95**

Explorations in Monte Carlo Methods

R. W. Shonkwiler, F. Mendivil

This new text provides a hands-on approach to learning this subject. Each new idea is motivated by realistic problems, leading from questions to theory via examples and numerical simulations. Programming exercises are integrated throughout and each chapter ends with numerous problems illustrating the material.

2009. XII, 248 p. 50 illus. (Undergraduate Texts in Mathematics) Hardcover
ISBN 978-0-387-87836-2 ► **$59.95**

Easy Ways to Order for the Americas ► Write: Springer Order Department, PO Box 2485, Secaucus, NJ 07096-2485, USA ► **Call: (toll free)** 1-800-SPRINGER ► **Fax:** 1-201-348-4505 ► **Email:** orders-ny@springer.com or **for outside the Americas** ► **Write:** Springer Customer Service Center GmbH, Haberstrasse 7, 69126 Heidelberg, Germany ► **Call:** +49 (0) 6221-345-4301 ► **Fax :** +49 (0) 6221-345-4229 ► **Email:** orders-hd-individuals@springer.com ► Prices are subject to change without notice. All prices are net prices.

014287x

Notices of the American Mathematical Society
Volume 56, Number 7, Pages 793–904, August 2009
0002-9920(200908)56:7;1-W