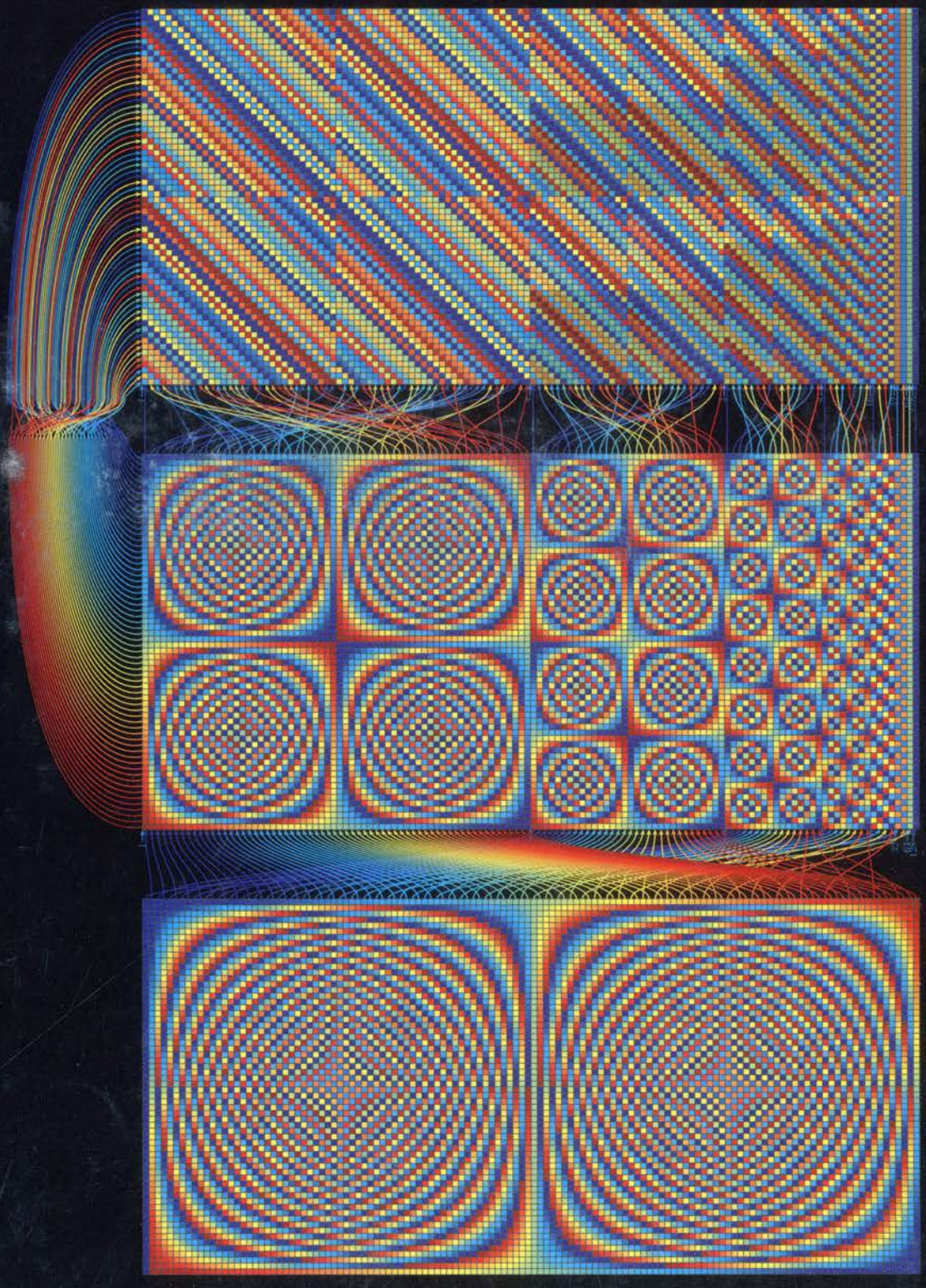
ISSN 0002-9920

Notices

of the American Mathematical Society

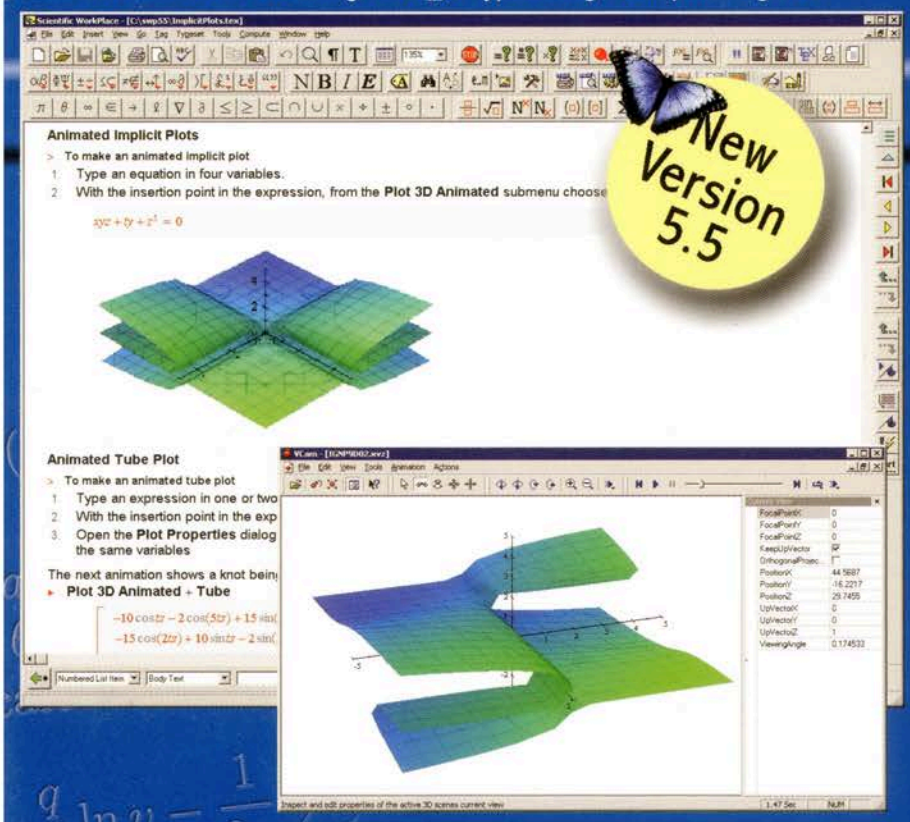
December 2005 Volume 52, Number 11



Fast construction of a good lattice rule (see page 1329)

Scientific WorkPlace®

Mathematical Word Processing • LaTeX Typesetting • Computer Algebra



Animate, Rotate, Zoom, and Fly

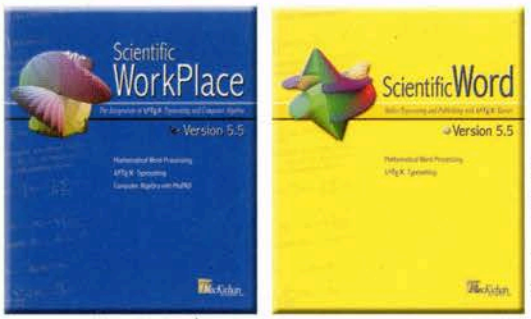
New in Version 5.5

- Compute and plot using the *MuPAD® 3* computer algebra engine
- Animate 2D and 3D plots using *MuPAD's VCAM*
- Rotate, move, zoom in and out, and fly through 3D plots with new OpenGL® 3D graphics
- Label 2D and 3D plots so that the label moves when you rotate or zoom a plot
- Import LaTeX files produced by other programs
- Use many new LaTeX packages
- Get help from the new, extensive troubleshooting section of *Typesetting Documents with Scientific WorkPlace and Scientific Word, Third Edition*

The Gold Standard for Mathematical Publishing

Scientific WorkPlace 5.5 makes 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* enables both professionals and support staff to produce stunning books and articles.

MacKichan SOFTWARE, INC.



Scientific Word® offers the same features as ***Scientific WorkPlace***, without the computer algebra system.

www.mackichan.com/notices
Visit our website for free trial versions of all our products.

Visit us at the Joint Mathematics Meetings in San Antonio for a demonstration

Email: info@mackichan.com • Toll-free: 877-724-9673
Fax: 360-394-6039

IMA INSTITUTE FOR MATHEMATICS AND ITS APPLICATIONS

Membership opportunities

in connection with the 2006-2007 thematic program on

APPLICATIONS OF ALGEBRAIC GEOMETRY

IMA POSTDOCTORAL FELLOWSHIPS provide an excellent opportunity for mathematical scientists near the beginning of their career who have a background in and/or an interest in learning about applied and computational aspects of algebraic geometry. IMA postdoctoral fellowships run one to two years, at the option of the holder, starting September 5, 2006.

IMA INDUSTRIAL POSTDOCTORAL FELLOWSHIPS are designed to prepare mathematicians for research careers in industry or involving industrial interaction. IMA industrial postdoctoral fellowships run two years starting September 5, 2006. They are funded jointly by the IMA and an industrial sponsor, and holders devote 50% effort to their own research and the IMA program and 50% effort working with industrial scientists.

IMA GENERAL MEMBERSHIPS provide an opportunity for mathematicians and scientists employed elsewhere to spend a period of one month to one year in residence at the IMA, and to participate in the 2006-2007 thematic program. The residency should fall in the period September 2006 through June 2007 (in special cases extending into the summer months). Logistic support such as office space, computer facilities, and secretarial support will be provided, and local expenses may be provided.

IMA NEW DIRECTIONS VISITING PROFESSORSHIPS provide an extraordinary opportunity for established mathematicians–typically mid-career faculty at US universities–to branch into new directions and increase the impact of their research by spending the 2006-2007 academic year immersed in the thematic program at the IMA. Visiting Professors will enjoy an excellent research environment and stimulating scientific program connecting algebraic geometry and related areas of mathematics with a broad range of fields of application. New Directions Visiting Professors are expected to be resident and active participants in the program, but are not assigned formal duties.

For more information and application materials see
www.ima.umn.edu/docs/membership.html or phone 612-624-6066.

The IMA is an NSF funded Institute

www.ima.umn.edu

UNIVERSITY OF MINNESOTA

NEW & NOTEWORTHY *from Birkhäuser*

Algebraic Geometry and Number Theory

In Honor of Vladimir Drinfeld's 50th Birthday

VICTOR GINZBURG, *University of Chicago, Chicago, IL (Ed.)*

This volume of invited articles by several outstanding mathematicians in algebra, algebraic geometry, and number theory is dedicated to Vladimir Drinfeld on the occasion of his 50th birthday. These surveys and original research articles broadly reflect the range of Drinfeld's work in these areas, especially his profound contributions to the Langlands program and mathematical physics.

Contributors include: **V.V. FOCK, E. FRENKEL, D. GAITSGORY, A.B. GONCHAROV, E. HRUSHOVSKI, Y. IHARA, D. KAZHDAN, M. KISIN, I. KRICHEVER, G. LAUMON, YU. MANIN,** *and* **V. SCHECHTMANN.**

2006/APPROX. 608 PP., 10 ILLUS./HARDCOVER/ISBN 0-8176-4471-7/$99.00 (TENT.)
PROGRESS IN MATHEMATICS

Number Theory

An Introduction via the Distribution of Primes

BENJAMIN FINE, *Fairfield University, Fairfield, CT;* **GERHARD ROSENBERGER**, *Universität Dortmund, Germany*

This book provides an introduction and overview of number theory based on the distribution and properties of primes. This unique approach provides both a firm background in the standard material as well as an overview of the whole discipline. All the essential topics are covered: fundamental theorem of arithmetic, theory of congruences, quadratic reciprocity, arithmetic functions, and the distribution of primes.

The book's user-friendly style, historical context, and wide range of exercises (with solutions and hints provided for select ones) make it ideal for self study as well as classroom use in upper-level undergraduate and beginning graduate-level courses.

2006/APROX. 320 PP., 10 ILLUS./HARDCOVER/
ISBN 0-8176-4472-5/$49.95 (TENT.)

Co-winner of the 2005 Ferran Sunyer i Balaguer Prize

Perturbation Methods and Semilinear Elliptic Problems on R^n

ANTONIO AMBROSETTI; ANDREA MALCHIODI, *both, SISSA, Trieste, Italy*

This monograph addresses perturbation methods in critical point theory. It particularly emphasizes applications such as semilinear elliptic problems on R^n, bifurcation from the essential spectrum, the prescribed scalar curvature problem, nonlinear Schrödinger equations, and singularly perturbed elliptic problems in domains. The book's discussion of the abstract tool of perturbation methods in critical point theory is not available elsewhere.

2006/APPROX. 196 PP./HARDCOVER/
ISBN 3-7643-7321-0/$59.95 (TENT.)
PROGRESS IN MATHEMATICS, VOL. 240

Co-winner of the 2005 Ferran Sunyer i Balaguer Prize

On the Topology of Isolated Singularities in Analytic Spaces

JOSÉ SEADE, *Universidad Nacional Autónoma de México, Cuernavaca, México*

This book offers an overview of selected topics on the topology of singularities, with emphasis on its relations to other branches of geometry and topology. The opening chapters cover complex singularities and collect a myriad of results scattered throughout the literature, including recent research. The second part of the book studies real analytic singularities which arise from the topological and geometric study of holomorphic vector fields and foliations. The book is largely self-contained and serves a wide audience of graduate students, mathematicians, and researchers interested in geometry and topology.

2006/APPROX. 256 PP./HARDCOVER/
ISBN 3-7643-7322-9/$64.95 (TENT.)
PROGRESS IN MATHEMATICS, VOL. 241

Infinite Groups

Geometric, Combinatorial and Dynamical Aspects

LAURENT BARTHOLDI, *Ecole Polytechnique Fédérale, Lausanne, Switzerland;* **TULLIO CECCHERINI-SILBERSTEIN**, *Università degli Studi del Sannio, Benevento, Italy;* **TATIANA SMIRNOVA-NAGNIBEDA**, *University of Geneva, Switzerland;* **ANDRZEJ ZUK**, *Université Pierre et Marie Curie, Paris, France (Eds.)*

This book offers a panorama of current research in the theory of infinite discrete groups, containing survey papers contributed by leading specialists in group theory and other areas of mathematics. Topics covered include amenable groups, Kähler groups, automorphism groups of rooted trees, rigidity, C*-algebras, random walks on groups, pro-p groups, burnside groups, parafree groups, Fuchsian groups, among others.

2006/APPROX. 408 PP./HARDCOVER/
ISBN 3-7643-7446-2/$109.00 (TENT.)
PROGRESS IN MATHEMATICS, VOL. 248

History of Banach Spaces and Linear Operators

ALBRECHT PIETSCH, *University of Jena, Germany*

This work, written by a distinguished specialist in functional analysis, is devoted to a comprehensive treatment of the history of Banach spaces and (abstract bounded) linear operators. It may serve as a reference and introduction for graduate students and researchers who want to learn Banach space theory with some historical flavor. While other comprehensive texts on Banach spaces focus on developments before 1950, this one is mainly devoted to the second half of the twentieth century.

2006/APPROX. 880 PP., 82 ILLUS./HARDCOVER/
ISBN 0-8176-4367-2/$104.00 (TENT.)

Vortices in Bose–Einstein Condensates

AMANDINE AFTALION, *CNRS, Laboratoire Jacques-Louis Lions, Paris, France*

One of the key issues related to superfluidity is the existence of vortices. In very recent experiments on Bose–Einstein condensates, vortices have been observed in various conditions. This monograph is dedicated to the mathematical modeling of these phenomena. The mathematical tools employed are energy estimates, Gamma convergence, and homogenization techniques. The mathematical analysis is made in the framework of the Gross–Pitaevskii energy. Results are presented and open problems related to recent experiments are explained.

2006/APPROX. 160 PP., 25 ILLUS./HARDCOVER/
ISBN 0-8176-4392-3/$79.95 (TENT.)
PROGRESS IN NONLINEAR DIFFERENTIAL EQUATIONS AND THEIR APPLICATIONS

Don't Miss the Birkhäuser Green Sale
Visit www.birkhauser.com for more details.

Recently released in the CORNERSTONES series:

Basic Real Analysis

ANTHONY W. KNAPP, *State University of New York, Stony Brook, NY*

2005/674 PP., 10 ILLUS./HARDCOVER/
ISBN 0-8176-3250-6/$69.95

Advanced Real Analysis

ANTHONY W. KNAPP, *State University of New York, Stony Brook, NY*

2005/488 PP., 6 ILLUS./HARDCOVER/
ISBN 0-8176-4382-6/$59.95

SET PRICE FOR BOTH BOOKS: $89.95/ISBN 0-8176-4407-5

Geometric Function Theory

Explorations in Complex Analysis

STEVEN G. KRANTZ, *Washington University, St. Louis, MO*

2006/328 PP., 41 ILLUS./HARDCOVER/
ISBN 0-8176-4339-7/$69.95

CALL: 1-800-777-4643 • FAX: (201) 348-4505
E-MAIL: orders@birkhauser.com • www.birkhauser.com

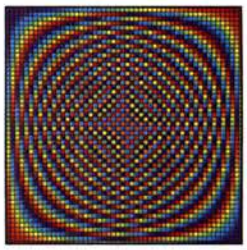
Please mention promotion **#Y8585** when ordering. Prices are valid in the Americas only and are subject to change without notice. For price and ordering information outside the Americas, please contact Birkhäuser Verlag AG by E-mail: birkhauser@springer.de
Promotion #Y11509

12/05

Birkhäuser
Boston · Basel · Berlin

Notices
of the American Mathematical Society
December 2005

Feature Articles



Communications

Commentary

Notices

of the American Mathematical Society

EDITOR: Andy Magid

ASSOCIATE EDITORS:
Susanne C. Brenner, Bill Casselman (*Graphics Editor*), Robert J. Daverman, Nathaniel Dean, Rick Durrett, Susan Friedlander, Robion Kirby, Steven G. Krantz, Elliott H. Lieb, Mark Saul, Karen E. Smith, Audrey Terras, 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, Arlene O'Sean, Karen Ouellette, Donna Salter, Deborah Smith, Peter Sykes

ADVERTISING SALES: Anne Newcomb

SUBSCRIPTION INFORMATION: Subscription prices for Volume 53 (2006) are US$430 list; US$344 institutional member; US$258 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$20; in India—US$40; expedited delivery to destinations in North America—US$35; elsewhere—US$87. 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 faxed to 401-331-3842 (indicate "*Notices* advertising" on fax cover sheet).

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: Most of this publication is 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`.

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.

Departments

From the AMS Secretary

Future High-School Math Teachers and Upper-Level Math Courses

There is considerable anecdotal evidence that high-school math teachers do not see the relevance of the upper-level math courses they took in college to the mathematics that they are teaching in high school. There are two programs at Michigan State University that have led several of us to look at this situation more closely: a Teachers for a New Era (TNE) grant whose purpose is to examine the undergraduate education of future teachers, and our senior-level capstone course for future secondary math teachers that is jointly taught by a mathematician and a math educator.

We have discovered missed opportunities for drawing connections between the math upper-level mathematics courses and high-school math. Sometimes the math is too "elementary" to be mentioned in the college course. Sometimes the topic is mentioned but not sufficiently emphasized nor connected to the high-school math, and the students forget it by time they take the capstone course. Finally some topics, such as trigonometry, have been at best briefly surveyed in post-precalculus courses. Given how important it is for us to educate future high-school teachers well, perhaps mathematics departments should encourage instructors in upper-level undergraduate math courses to include discussions about such connections.

Here are a few examples:

From complex analysis: $\sqrt{-4} \times \sqrt{-9} \neq \sqrt{36}$. This is an example of something usually considered "too elementary" to appear in a complex analysis course. But most of our future high-school teachers had not seen it before, and they were somewhat skeptical since they had grown up with $\sqrt{a} \times \sqrt{b} = \sqrt{ab}$. The explanation is likely to involve discussing $f(z) = z^2$ as a function of the unit circle to itself that wraps the circle around itself twice. Most have not seen that kind of a description of a function before.

From multivariable calculus: lines and planes in 3-space. Each is determined by a point and a vector. In both cases the point is on the object; the vector is parallel to the line or perpendicular to the plane. Lines and hyperplanes are subspaces of n-space, so they are topics of linear algebra. Their descriptions generalize the descriptions of lines and planes in 3-space. Our capstone students had forgotten essentially all of this. We designed a project for them of taking the equations for lines and planes in 3-space and restricting them to 2-space. This yields two descriptions of lines in 2-space, which the students were asked to reconcile.

From abstract and linear algebra, several topics that are important for future teachers and hence need to be emphasized by the instructors of the courses.

1. The division algorithm. They need to know this both for $\mathbb{Z}$ and for polynomials over fields. In particular they need to know why all of the hypotheses are necessary.
2. The Fundamental Theorem of Algebra and factoring of polynomials over $\mathbb{C}$ into linear factors and over $\mathbb{R}$ into linear and quadratic polynomials.
3. Using the quotient $\mathbb{R}[x]/(x^2+1)$ to explain why it is rigorous to describe addition and multiplication in $\mathbb{C}$ as "just like polynomials except that $x^2 = -1$."
4. Matrices that induce rotations and reflections in the plane.
5. The least squares problem of fitting a regression line to points in a plane.

Some general comments:

Functions. Essentially students know a function has inputs and outputs such that every input has a unique output. Several had never had to memorize a formal definition, such as "A function consists of two sets and a rule" or "A function is a set of ordered pairs...." This means that students going off to graduate school may not have either, and I have concerns about that. In any case, future high-school teachers need to know all three definitions and understand their equivalence, as all three appear in high-school math textbooks.

Trigonometry. To our surprise, most of the students had very little trig at their fingertips. Mostly, they had not seen much trig since high school, except for graphs and a few identities in calculus. In the second capstone course, we gave these students a thorough review, emphasizing things they will need to understand when they teach. But is this something we should worry about for all math majors?

Graphs. Except for functions from the reals to the reals, students may have no idea where the graph of a function lies. They can get very creative in discussing graphs of rational functions that have factors like x^2+4 in the denominator and get confused about where the asymptotes at $\pm 2i$ go.

Many people reading this will come up with other concerns both for our future high-school math teachers and for our math majors in general. It seems like a crucial time for mathematics departments to discuss these issues.

Acknowledgements. The author would like to thank Gail Burrill, Jon Hall, Peter Lappan, Thomas Parker, Jacob Plotkin, and Sharon Senk for helpful comments and suggestions.

—Richard O. Hill
Michigan State University
hill@math.msu.edu

An expanded version of this article can be found at http://www.math.msu.edu/~hill/.

Letters to the Editor

No More Homework

In the letter "Homework and Google" appearing in the December 2004, *Notices*, the author expresses concern with the availability of homework solutions on the Internet and describes methods to make posted solutions invisible to search engines.

I believe trying to do this is a waste of time. In fields such as literature, history, political science, and so on, there are already literally dozens of websites which make papers available to students for small fees. This is the present, and will continue to be the future, and I believe mathematics is not far behind, if not there already.

Attempts to thwart this phenomenon are pointless. The only way to prevent the proliferation of sites selling mathematics homework solutions, and students from purveying these sites, will be to make graded homework solutions irrelevant. What do I mean by this? Let me first describe my own background.

In the country in which I was an undergraduate, the very idea of asking university undergraduates to submit mathematics "homework" for marking (grading) was so far from the norm it would have been laughable. And I mean that literally. Laughable. No one —not one student—would have carried it out. Nor would a single instructor even have attempted to do so.

"Homework", by which was meant a written assignment for turning in and marking, was totally an elementary school or high school concept, for children only. University students were supposed to be adults, not children, and were not given "homework". This is not to say we were not given problems to do in our university courses. On the contrary, we were given many typed out pages of these. But we were never required to turn them in.

Students enrolled in mathematics courses were required to attend, once a week, what were called tutorial sessions. Attendance was taken. At these approximately two-hour sessions, 30 or 40 students would sit quietly and individually working on their problems, and professors would walk around answering questions when students had them. That's it. You could also ask your instructor for help during office hours.

Problems were for us to do if and when we wanted and however we wanted. It was assumed that university students were adults, interested in the subject they studied, and would eventually (i.e., before the final exam) do their problems. The reward was not in some artificial point grading system but in learning and succeeding in courses in which students professed to be interested. In my entire undergraduate career I can only recall turning in for grading physics and chemistry laboratory reports, and even those grades were meager in the scheme of the entire course grade. Every other grade in every other course was determined by a few exams and, most importantly, a final exam.

I am not saying what I describe above was perfect. But maybe one solution to the problem of ready availability of homework solutions on the internet is to motivate students to want to learn and to find ways to take away the incentive to plagiarize and cheat. Let the students know that you will hold them accountable for the work they are supposed to do and test them in such a way as to see if they have done it. If you want to give them homework for grading, then count it for very little in the final grade, or use it to provide verbal feedback to the students. Try to give them homework unique to your course. How to do this is our modern-day challenge.

—Manley Perkel
Wright State University
Dayton, Ohio
manley.perkel@wright.edu
(Received September 8, 2005)

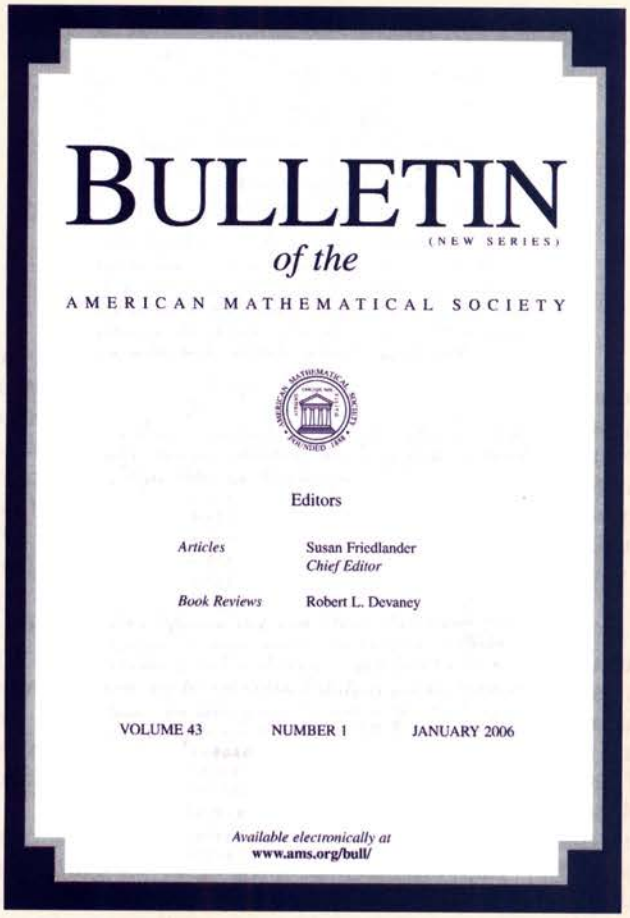
Contacting Tulane Mathematicians

Hurricane Katrina struck the Gulf South two days before the beginning of classes at Tulane. The faculty, students, and staff evacuated to hotels, shelters, and dormitories near the region, expecting to return home within a few days. After the extent of the damage became apparent, we scattered to places all over the country and are currently in the process of setting up temporary living and working arrangements. The help that we have received in these efforts from the mathematics community has been wonderful, and on behalf of the mathematics department I would like to thank all of the departments, organizations, and individuals who have been instrumental in helping us. Many departments have offered office space to displaced Tulane faculty members; I know of no department which refused such a request. In many cases the help that we received went well beyond assisting us in our professional lives. Colleagues were instrumental in helping some of us find appropriate schools for our children, in finding apartments, and in the many other tasks involved in establishing a, more or less, normal life. These were acts of genuine kindness for which we are profoundly grateful. The mathematics community extended help for our students as well. A number of departments have admitted our graduate students for the semester. At a time of such chaos and confusion, our ability to have some sort of professional life has importance to us far beyond the actual value of whatever mathematical work we produce. As we are disconnected from familiar places and routines, we can go to talks, have discussions with friends and colleagues, while waiting to return home; all the things that we do daily at Tulane.

If anyone reading this wishes to contact a Tulane mathematician, many members of the department have registered on the Tulane Survivor Network, which can be found at `http://www.tulane.edu`, where their temporary phone numbers and email addresses can be found. Members of the department have also established a discussion group at `http://groups.google.com/group/TulaneMath` where you can learn more about the status of our department.

—Morris Kalka
Chair, Mathematics Department
Tulane University
morriskalka@hotmail.com
(Received September 16, 2005)

New Look for the Bulletin of the American Mathematical Society



New Cover!

- See a different historical mathematical document replicated on the cover of each issue

New *Mathematical Perspectives* Section:

- Read short articles by influential mathematicians offering perspectives on different elements of mathematics
- View a clear reproduction of and learn about the historical document featured on the cover

Same Exceptional Content:

- Continue to stay informed with insightful expositions and timely reports on significant aspects of contemporary research and important mathematical advances

Available as a free subscription to members!

Go to www.ams.org/bull

Lifting the Curse of Dimensionality

Frances Y. Kuo and Ian H. Sloan

Introduction

Richard Bellman [1] coined the phrase *the curse of dimensionality* to describe the extraordinarily rapid growth in the difficulty of problems as the number of variables (or the dimension) increases. A common experience is that the cost of an algorithm grows exponentially with dimension, making the cost prohibitive for moderate or large values of the dimension.

In this article we consider the problem of numerical integration over the d-dimensional unit cube $[0,1]^d$. If $d = 1$ and the integrand is sufficiently smooth, then the integral can be evaluated easily by, say, Simpson's rule, in which case the error of an n-point rule, with n odd, is of order $\mathcal{O}(n^{-4})$. When d is 2 or more, the most obvious strategy is to apply a rule such as Simpson's rule in each dimension, creating what is called a *product* rule. But now we meet the curse of dimensionality: the total number of points at which the integrand must be evaluated (which we may take as the cost) is $N = n^d$. And with what error? Even if the integrand is an innocuous function of only the first component, x_1, for example x_1^4, the resulting error for the product Simpson rule is clearly still of order $\mathcal{O}(n^{-4})$, since from the point of view of this integrand the integration rule is still the n-point Simpson's rule. The essential difficulty becomes apparent when that error is expressed in terms of the total number of points N: the error is now of order $\mathcal{O}(N^{-4/d})$. Put differently, perhaps we are willing to use 11 points in each coordinate direction (i.e. $n = 11$). But if the problem is 100-dimensional (i.e., $d = 100$), then the total number of function evaluations required will be 11^{100}, and the time until the end of the universe will not suffice for this calculation. Even if we take just 2 points in each direction, the computation for $d = 100$ is impossible. Of course one can improve the one-dimensional rule (for example, by using the Gauss rule), but the essential problem remains: any product rule is prohibitively costly when d is large, because the cost for a given level of accuracy increases exponentially in d.

Nevertheless, there are other ways of tackling a high-dimensional integral, as shown in dramatic fashion in 1995, when Traub and Paskov at Columbia University successfully (but without supporting theory) treated a mathematical finance problem from Wall Street as an integration problem over the 360-dimensional unit cube.

The aim of this article is to present in a nontechnical way one strand of the story of high-dimensional numerical integration (specifically, we tell the *lattice* side of the story) as it has developed over the past half century. Part of the story is concerned with the development of a theoretical setting within which the problem is *tractable*, that is to say, loosely, a setting in which a suitably defined measure of the error does not grow with the dimension d (or perhaps grows only polynomially in d). But the arguments used in the study of tractability were until

Frances Y. Kuo is Vice-chancellor's Postdoctoral Fellow in Mathematics at the University of New South Wales, Australia. Her email address is f.kuo@unsw.edu.au.

Ian H. Sloan is Scientia Professor of Mathematics at the University of New South Wales, Australia. His email address is i.sloan@unsw.edu.au.

recently not constructive. That is to say, we knew under certain conditions that good integration rules exist for large values of d, but we had no idea how to find them. Only in the last half decade has that situation turned around with the development of very fast constructions that make feasible the tailored construction of integration rules that are of known high quality and that allow d in the hundreds (or even thousands), together with any practical number of function evaluations.

Do problems with d in the hundreds really arise in practice? This introduction concludes with a qualitative description of the 360-dimensional problem referred to above, since many features of that problem are common to problems from mathematical finance.

That problem is concerned with the valuation of a parcel of mortgage-backed securities held by a bank. In brief, customers of the bank borrow money for up to thirty years. Each month every customer has the right to repay the loan, and of course repaying the loan early will reduce its value to the bank. In a simple model, the proportion of those who choose to repay will depend on the interest rate at that time: the higher the interest rate, the more likely they are to repay the loan. The interest rate is assumed to follow a (geometric) Brownian motion. The month-by-month changes in the interest rate are random variables, so the present value of the bundle of mortgages is a (suitably discounted) 360-dimensional expected value, because there are 360 possible repayment occasions. This integral over the 360-dimensional Euclidean space is then converted into an integral over the 360-dimensional unit cube by an appropriate variable transformation. Many other high-dimensional problems in finance (including options of all varieties) are also multidimensional expected values, with the dimensionality arising either from discretization in time, as here, or because there are multiple assets with different characteristics, or both.

What Strategies Are Possible?

When d is large, we can approximate an integral over the unit cube

$$If = \int_{[0,1]^d} f(\boldsymbol{x})\,\mathrm{d}\boldsymbol{x}$$

by an integration rule of the form

$$Q_N f = \sum_{k=1}^{N} a_k f(\boldsymbol{x}_k); \tag{1}$$

that is, we sample f at N points $\boldsymbol{x}_1, \ldots, \boldsymbol{x}_N$ in the unit cube and approximate If by a weighted average of these function values.

So how can we choose these sample points? We already explained that a product rule such as the one shown in Figure 1 is too costly: the 64 points in the unit square effectively collapse down to just 8 points in each coordinate direction.

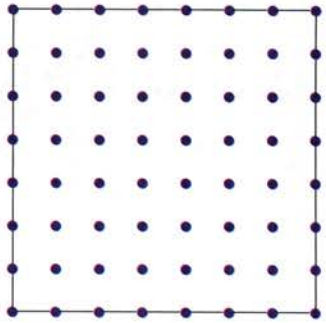


Figure 1. Product rule with 64 points.

One feasible strategy is to organize the points of a product rule in a hierarchical way and use only a few *levels* of points. This is the principle behind *sparse-grid methods*, which are generalizations of a construction first devised by Smolyak. Figure 2 shows an example of a regular sparse grid with 49 points.

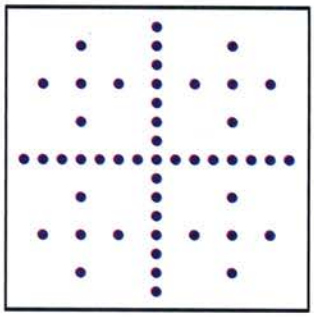


Figure 2. Sparse grid with 49 points.

Modern sparse-grid methods are dimension-adaptive: they find the important dimensions automatically and use more integration points in those dimensions. For details on sparse-grid methods, we refer readers to the recent survey article by Bungartz and Griebel [2].

Another possible strategy is the *Monte Carlo method*, the real workhorse of present-day high-dimensional integration. In its simplest form the Monte Carlo method is an equal weight rule (i.e. $a_k = 1/N$), with the points $\boldsymbol{x}_1, \ldots, \boldsymbol{x}_N$ generated *randomly* from a uniform distribution on $[0,1]^d$. Figure 3 shows 64 (pseudo) random points.

The well-known probabilistic error estimate for the Monte Carlo method is

$$\frac{\sigma(f)}{\sqrt{N}},$$

where $\sigma^2(f) = If^2 - (If)^2$ is the variance of f. Perhaps the most remarkable aspect of the Monte

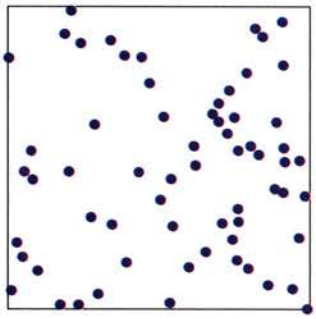


Figure 3. 64 random points.

Carlo method is that it does not suffer from the curse of dimensionality: in particular the $\mathcal{O}(N^{-1/2})$ convergence rate, while slow and erratic, does not depend on the dimension d so long as f is square integrable. Furthermore, it is cheap and easy to provide an effective error estimate, since the first term If^2 of the variance can be estimated by making use of the same function values as already used for approximating If.

Quasi-Monte Carlo methods are equal weight rules, just like the Monte Carlo method, except that the points $\boldsymbol{x}_1, \ldots, \boldsymbol{x}_N$ are now designed in a clever way to be more uniformly distributed than random points so that a convergence rate close to $\mathcal{O}(N^{-1})$ is possible. (Note, however, that the implied constant can depend exponentially on d.) Figure 4 shows the first 64 points of a 2-dimensional *Sobol′ sequence*, the first example of the now widely renowned concept of *(t, m, s)-nets and (t, s)-sequences* established by Niederreiter.

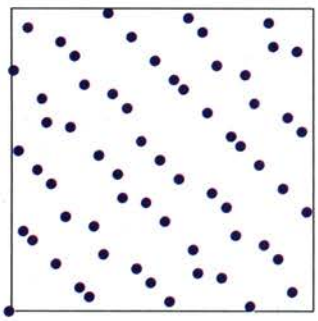


Figure 4. First 64 points of 2D Sobol′ sequence.

Informally, the basic idea is to have the right number of points in various subcubes. For example, if in Figure 4 we divide the unit square into strips of size 1 by $1/64$, then there is exactly one point in each of the 64 strips, with any point on the boundary counting toward the next strip. Similarly, if we divide the unit square into squares of size $1/8$ by $1/8$, we get exactly one point in each square. In fact, as long as we partition the unit square into 64 rectangles of the same shape and size, each rectangle will include exactly one point. Details on both theory and construction of nets and sequences can be found in the book of Niederreiter [3].

Lattice rules are a different kind of quasi-Monte Carlo method. The points $\boldsymbol{x}_1, \ldots, \boldsymbol{x}_N$ of a lattice rule are so regular that they form a group under the operation of addition modulo the integers. Figure 5 shows a lattice rule with 55 points.

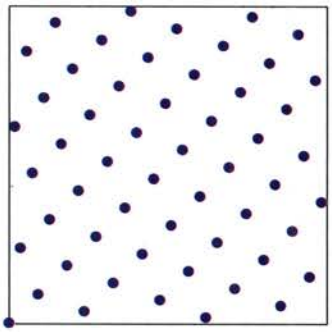


Figure 5. "Fibonacci" lattice rule with 55 points.

In this article we focus on lattice rules. Before continuing we should acknowledge a disadvantage of all deterministic methods, such as sparse-grid or quasi-Monte Carlo, when compared to the Monte Carlo method—namely, that they come without any practical information about the error. (The *a priori* estimates involving, for example, higher derivatives of f are essentially never useful for practical error estimation.) This has led to a growing interest in hybrid methods that are essentially deterministic but that also have some element of randomness, thereby seeking to capture the benefits of both approaches. We shall see an example of a hybrid method later in the article.

More on Lattice Rules

There are many kinds of lattice rules (indeed, even the product of left-rectangle rules is a lattice rule), but for our purposes it is enough to consider just the oldest and simplest kind, technically known now as a *rank-1 lattice rule*, which takes the form

$$Q_N f = \frac{1}{N} \sum_{k=1}^{N} f\left(\left\{k \frac{\boldsymbol{z}}{N}\right\}\right). \tag{2}$$

Here $\boldsymbol{z} \in \mathbb{Z}^d$ is the *generating vector*, and the braces indicate that each component is to be replaced by its fractional part in $[0, 1)$. In this case the additive group formed by the points is the cyclic group generated by $\{\boldsymbol{z}/N\}$. Without loss of generality we may restrict the components of $\boldsymbol{z}$ to the set $\{0, 1, \ldots, N-1\}$. Furthermore, we will drop 0 from this set, since if any component of $\boldsymbol{z}$ is zero, then so is the corresponding component of each integration point, which is clearly not interesting.

The lattice rule in Figure 5 is a *Fibonacci* lattice rule with $N = 55$ and $\boldsymbol{z} = (1, 34)$. (The Fibonacci lattice rule with $N = F_k$ points, where F_k is the kth number of the Fibonacci sequence $1, 1, 2, 3, 5, \ldots$, has generating vector $\boldsymbol{z} = (1, F_{k-1})$.) While the Fibonacci rules are in some sense optimal for $d = 2$, higher-dimensional generalizations, where they exist, are less persuasive.

Lattice rules were developed by number theorists, especially Hlawka and Korobov, during the late 1950s in the context of numerical integration of periodic functions. The periodicity of smooth integrands allows a convergence rate faster than $\mathcal{O}(N^{-1})$ for equal weight rules. For historical results on lattice rules applied to periodic integrands, readers are referred to the books of Niederreiter [3] and Sloan and Joe [5].

While the usefulness of lattice rules for numerical integration of periodic functions has been recognized for fifty years, their value for nonperiodic functions in high dimensions has been known only for the past half decade. That is a story to be told later in the article. The best possible convergence rate for any equal weight rule is then at best $\mathcal{O}(N^{-1})$, but that may seem like a very good rate indeed if the problem is 100-dimensional and if the implied constant is independent of d.

What makes a "good" lattice rule? This depends very much on the integrand at hand. A good lattice rule is one that is tailored to the integrand, taking into account its special features. Thus first we must consider the nature of the integrands we may encounter.

How to Model Reality—What Is Really the Dimension?

Consider a simple function

$$f(\boldsymbol{x}) = f(x_1, x_2, x_3, x_4) = x_1 \cos x_2 + x_3.$$

What is really the dimension? The nominal dimension is 4, yet clearly only the first three variables are present. Moreover, f is a sum of two terms, with each term depending on at most 2 variables. Thus we could say that the *effective dimension* of f is only 3 or even, from the point of view of each individual term, only 2.

More generally, it is possible to write any d-dimensional function f as a sum of 2^d terms, with each term depending on only a subset of variables:

$$f(\boldsymbol{x}) = \sum_{\mathfrak{u} \subseteq \{1,\ldots,d\}} f_{\mathfrak{u}}(\boldsymbol{x}_{\mathfrak{u}}).$$

Here $\boldsymbol{x}_{\mathfrak{u}}$ denotes the $|\mathfrak{u}|$-dimensional vector containing those components of $\boldsymbol{x}$ whose indices belong to the set $\mathfrak{u}$. Each term $f_{\mathfrak{u}}$ depends only on variables in $\boldsymbol{x}_{\mathfrak{u}}$, and we may say that $f_{\mathfrak{u}}$ describes the *interaction* between these variables. The terms $f_{\mathfrak{u}}$ with $|\mathfrak{u}| = \ell$ are referred to collectively as the order-ℓ terms. Note that such a decomposition of f is by no means unique. The nicest way to ensure uniqueness is to insist that for each nonempty subset $\mathfrak{u}$ we have $\int_0^1 f_{\mathfrak{u}}(\boldsymbol{x}_{\mathfrak{u}})\, dx_j = 0$ for all $j \in \mathfrak{u}$. In this case the decomposition corresponds exactly to the *ANOVA* (for analysis of variance) *decomposition* used in the statistics literature. A special feature associated with the ANOVA decomposition is that the variance of the function f is simply the sum of the variances of the individual terms $f_{\mathfrak{u}}$.

For some functions it may happen that all the terms involving variables other than, say, $x_1, \ldots, x_{10}$ are negligible, or it may be that all variables are present and equally important, but the higher-order terms are negligible compared with the lower-order ones. In these situations we can ignore the effect of variables other than $x_1, \ldots, x_{10}$ or drop unimportant higher-order terms. In both cases such functions are said to have *low effective dimension.*

The concept of effective dimension was formally introduced by Caflisch, Morokoff, and Owen in 1997. By considering the ANOVA decomposition of f and the way that the variance is allocated among the ANOVA terms, they defined two concepts of effective dimension: f has *truncation dimension* d_t if the combined variance captured by the ANOVA terms $f_{\mathfrak{u}}$ with $\mathfrak{u} \subseteq \{1, \ldots, d_t\}$ exceeds 99 percent of the total variance $\sigma^2(f)$; on the other hand, f has *superposition dimension* d_s if the combined variance captured by the ANOVA terms $f_{\mathfrak{u}}$ with order $|\mathfrak{u}| \le d_s$ exceeds 99 percent of the total variance. For the example at the beginning of this section, the truncation dimension is 3, whereas the superposition dimension is 2.

Designing the Function Spaces and Introducing Weights

Many high-dimensional problems that occur in practical applications are of low effective dimension. To model these situations, Sloan and Woźniakowski introduced in 1998 the concept of *weighted* function spaces (see [7]). They assumed the variables are ordered so that successive variables become less and less important. To be more precise, they considered a function space that is formed by taking a *tensor-product* of one-dimensional Hilbert spaces. (Loosely speaking, functions in the tensor-product space are products, sums of products, and limits of sums of products of functions from the one-dimensional spaces.) The one-dimensional building blocks for the tensor-product space are Sobolev spaces consisting of absolutely continuous functions on $[0, 1]$ with square-integrable first derivatives. The norm in the jth one-dimensional space is parameterized by a *weight* γ_j which controls the variability of f with respect to the jth variable x_j. A small value of γ_j means that f depends only weakly on x_j.

By now there are many variants of these weighted spaces. A popular variant (and the only one we consider here) is the *unanchored* Sobolev space $\mathcal{F}$ which corresponds directly to the ANOVA decomposition. If f and g have the ANOVA decompositions $f = \sum_{\mathfrak{u}} f_{\mathfrak{u}}$ and $g = \sum_{\mathfrak{u}} g_{\mathfrak{u}}$ respectively, then their inner product in $\mathcal{F}$ is given by

$$\langle f, g \rangle_{\mathcal{F}} = \sum_{\mathfrak{u} \subseteq \{1,\ldots,d\}} \langle f_{\mathfrak{u}}, g_{\mathfrak{u}} \rangle_{\mathcal{F}_{\mathfrak{u}}},$$

where

$$\langle f_{\mathfrak{u}}, g_{\mathfrak{u}} \rangle_{\mathcal{F}_{\mathfrak{u}}} = \frac{1}{\prod_{j \in \mathfrak{u}} \gamma_j} \int_{[0,1]^{|\mathfrak{u}|}} \frac{\partial^{|\mathfrak{u}|} f_{\mathfrak{u}}(\boldsymbol{x}_{\mathfrak{u}})}{\partial \boldsymbol{x}_{\mathfrak{u}}} \frac{\partial^{|\mathfrak{u}|} g_{\mathfrak{u}}(\boldsymbol{x}_{\mathfrak{u}})}{\partial \boldsymbol{x}_{\mathfrak{u}}} \, \mathrm{d}\boldsymbol{x}_{\mathfrak{u}}. \tag{3}$$

(Technically speaking, the space $\mathcal{F}$ is a direct sum of function spaces $\mathcal{F}_{\mathfrak{u}}$, with each $\mathcal{F}_{\mathfrak{u}}$ depending only on variables in $\boldsymbol{x}_{\mathfrak{u}}$ and every $f \in \mathcal{F}$ having the ANOVA decomposition $f = \sum_{\mathfrak{u}} f_{\mathfrak{u}}$, with $f_{\mathfrak{u}} \in \mathcal{F}_{\mathfrak{u}}$.)

We have described here the original idea for the weights, in which each variable x_j has associated with it a weight γ_j, and a subset of variables $\boldsymbol{x}_{\mathfrak{u}}$ is automatically assigned the weight $\prod_{j \in \mathfrak{u}} \gamma_j$. This is not always satisfactory, because the interactions between variables may not be modeled correctly. For example, for functions with low superposition dimension, it may well be that all variables are equally important but that only their lower-order interactions matter. To give more flexibility, the concept of weights has recently been generalized so that a weight $\gamma_{\mathfrak{u}}$ is associated with each subset of variables $\boldsymbol{x}_{\mathfrak{u}}$. Thus for a d-dimensional space, we have altogether 2^d weights instead of just d weights as before. The inner product for the unanchored Sobolev space with generalized weights can be obtained by replacing $\prod_{j \in \mathfrak{u}} \gamma_j$ in (3) by $\gamma_{\mathfrak{u}}$. Note that these generalized spaces are no longer tensor-product spaces. Following the generalization of weights, the traditional choice of weights, which leads to tensor-product spaces, is now referred to as the *product weights*. In some cases the interaction between variables in $\boldsymbol{x}_{\mathfrak{u}}$ depends only on the cardinality of $\mathfrak{u}$; this leads to *order-dependent weights*.

An important development is the modeling of functions with low superposition dimension by *finite-order weights* (i.e., there exists a fixed integer q such that $\gamma_{\mathfrak{u}} = 0$ for all $|\mathfrak{u}| > q$). Many practical problems do appear to be approximately of small order, for example, of order 2 or order 3.

To keep the story simple, throughout this article we shall consider only product weights.

The Magic of Reproducing Kernels

It makes sense to ask of an integration rule that it perform well not just for a single function f but rather for some family of functions. Our choice, if $\mathcal{F}$ is a Banach space, is to study the *worst-case error*: for a quasi-Monte Carlo rule Q_N and a particular space $\mathcal{F}$ with norm $\|\cdot\|_{\mathcal{F}}$, the worst-case error is defined to be the greatest error for any function f in the unit ball of $\mathcal{F}$,

$$e_N = e(Q_N, \mathcal{F}) = \sup_{\|f\|_{\mathcal{F}} \le 1} |Q_N f - I f|.$$

It is an annoying truth that the worst-case error is generally impossible to compute accurately or even to estimate other than loosely. This means that the worst-case error cannot generally be used to decide which is the better of two quasi-Monte Carlo rules. In one beautiful scenario, however, the situation is quite different, namely, when $\mathcal{F}$ is a *reproducing kernel Hilbert space* (RKHS). (In brief, the Hilbert space $\mathcal{F}$ with inner product $\langle \cdot, \cdot \rangle_{\mathcal{F}}$ is an RKHS with kernel $K(\boldsymbol{x}, \boldsymbol{y})$ if $K(\cdot, \boldsymbol{y}) \in \mathcal{F}$ for all $\boldsymbol{y}$, $K(\boldsymbol{x}, \boldsymbol{y}) = K(\boldsymbol{y}, \boldsymbol{x})$ for all $\boldsymbol{x}$ and all $\boldsymbol{y}$, and

$$\langle K(\cdot, \boldsymbol{y}), f \rangle_{\mathcal{F}} = f(\boldsymbol{y})$$

for all $f \in \mathcal{F}$ and all $\boldsymbol{y}$.) By the Riesz representation theorem, a Hilbert space is an RKHS if and only if point evaluations are bounded linear functionals in $\mathcal{F}$. The usefulness of reproducing kernel spaces in computational analysis and statistics was pointed out by Wahba fifteen years ago.

If $\mathcal{F}$ is an RKHS, then it is easy to show that the worst-case error for a quasi-Monte Carlo rule can be written explicitly in terms of the reproducing kernel. This is especially useful if the kernel is available as a simple analytic expression.

In particular, our unanchored Sobolev space is an RKHS, since point evaluations are bounded. Less obvious, perhaps, is that the kernel has the simple expression

$$K(\boldsymbol{x}, \boldsymbol{y}) = \prod_{j=1}^{d} \Big(1 + \gamma_j \Big[\tfrac{1}{2} B_2(|x_j - y_j|) + (x_j - \tfrac{1}{2})(y_j - \tfrac{1}{2})\Big]\Big),$$

where $B_2(x) = x^2 - x + 1/6$ is the Bernoulli polynomial of degree 2. For this kernel, the worst-case error of a quasi-Monte Carlo rule with points $\boldsymbol{x}_1, \ldots, \boldsymbol{x}_N$ is given by

$$e_N^2 = -1 + \frac{1}{N^2} \sum_{k=1}^{N} \sum_{\ell=1}^{N} K(\boldsymbol{x}_k, \boldsymbol{x}_\ell), \tag{4}$$

which can be computed in $\mathcal{O}(N^2 d)$ operations.

There Is Always One Choice as Good as Average

How is it possible to prove, even nonconstructively, that there exists a "good" choice of quasi-Monte Carlo points $\boldsymbol{x}_1, \ldots, \boldsymbol{x}_N$ (whatever "good" may mean)? Here we use a beautiful argument borrowed from the number theorists: there is always one choice for which the worst-case error is as

good as the average over all possible choices. As a result, it is enough to show that some average of the worst-case error has the desired property.

The simplest average to compute is

$$\overline{e}_N = \left(\int_{[0,1]^d} \cdots \int_{[0,1]^d} e_N^2 \, d\boldsymbol{x}_1 \cdots d\boldsymbol{x}_N \right)^{1/2},$$

the root mean square average of the worst-case error e_N over all possible choices for each point $\boldsymbol{x}_1, \ldots, \boldsymbol{x}_N$ in a quasi-Monte Carlo rule. An explicit formula for $\overline{e}_N$ is easily obtained if $\mathcal{F}$ is a tensor-product RKHS. In our unanchored Sobolev space the result is

$$\begin{aligned} \overline{e}_N &= \frac{1}{\sqrt{N}} \left(\prod_{j=1}^{d} \left(1 + \frac{\gamma_j}{6} \right) - 1 \right)^{1/2} \\ &\le \frac{1}{\sqrt{N}} \exp\left(\frac{1}{12} \sum_{j=1}^{d} \gamma_j \right). \end{aligned} \tag{5}$$

So if we fix d, then for each increasing value of N there exists at least one choice of points $\boldsymbol{x}_1, \ldots, \boldsymbol{x}_N$ for which the Monte Carlo rate of convergence $\mathcal{O}(N^{-1/2})$ is achieved.

Actually, we shall see that faster convergence than $\mathcal{O}(N^{-1/2})$ is possible. To set a limit to our ambition, note that we could not hope to do better than $\mathcal{O}(N^{-1})$, since that is known to be the best possible order even for $d = 1$. Thus a reasonable aim would be to obtain (for fixed d) a convergence order close to $\mathcal{O}(N^{-1})$. We shall see that this aim can be achieved, but first we need to consider the behavior of the error with increasing d.

The Tractability of Integration Depends on the Weights

Earlier we introduced *weights* into our definitions of function spaces. We did this to help model certain problems that arise, for example, in mathematical finance, but we did this without explaining very convincingly why it might be necessary to bother about this level of detail. Now we come to the key point: that *without the weights the integration problem in our function space $\mathcal{F}$ is intractable.* That is to say, if $\gamma_j = 1$ for all j, then it is impossible to choose sequences Q_N of d-dimensional N-point quasi-Monte Carlo rules in such a way that

$$e_N \le c \frac{d^b}{N^a} \tag{6}$$

for positive constants a, b, c. The claim is that such a bound is impossible no matter how large we may choose c and b nor how close to zero we may choose a.

The intractability of the unweighted problem follows from an explicit lower bound that holds for all choices of Q_N. In particular, for our unanchored space it can be shown from (4) that

$$e_N^2 \ge \frac{1}{N} \left(\frac{13}{12} \right)^d - 1. \tag{7}$$

Thus if N and d are both allowed to go to infinity, then the error is bounded away from zero unless N grows *exponentially* with respect to d. For most cases it is known, too, that allowing general integration weights a_k in rule (1) does not help to break the curse of dimensionality. For a recent survey of tractability results for integration, see the review article by Novak and Woźniakowski [4]. For the foundations of tractability and intractability, we refer readers to the book *Information-Based Complexity* by Traub, Wasilkowski, and Woźniakowski [8].

So now we come to the key role of the weights γ_j: it is a remarkable fact that the integration problem is *strongly tractable* (i.e., (6) holds with $b = 0$) if and only if the weights satisfy

$$\sum_{j=1}^{\infty} \gamma_j < \infty. \tag{8}$$

If the condition is not satisfied, then one has a lower bound similar to (7) but with $(13/12)^d$ replaced by another sequence that goes to infinity as $d \to \infty$. On the other hand, if the condition (8) is satisfied, then from (5) we know already (but not constructively) that there is some choice of quasi-Monte Carlo rule Q_N for which

$$e_N \le \frac{1}{\sqrt{N}} \exp\left(\frac{1}{12} \sum_{j=1}^{\infty} \gamma_j \right),$$

giving an error bound that is independent of d and that converges to zero with the Monte Carlo rate $\mathcal{O}(N^{-1/2})$.

An even better result is known: by exploiting a connection between nonperiodic and periodic spaces, Hickernell and Woźniakowski showed in 2000 that if the weights satisfy the stronger condition

$$\sum_{j=1}^{\infty} \gamma_j^{1/2} < \infty,$$

then there exists some quasi-Monte Carlo rule Q_N such that

$$e_N \le \frac{C_\delta}{N^{1-\delta}}, \quad \delta > 0,$$

where C_δ is independent of N and d. This rate of convergence $\mathcal{O}(N^{-1+\delta})$ is optimal in the sense of being arbitrarily close to $\mathcal{O}(N^{-1})$.

The result established by Hickernell and Woźniakowski is impressive but does not help us toward a construction. We shall say no more about it, because in fact a better result is now known—better not in the sense of order of convergence, but in the sense that the same $\mathcal{O}(N^{-1+\delta})$ can be achieved, and under the same condition, within the much more

limited class of *shifted lattice rules*. While the proofs are still nonconstructive, that topic, in the next section, will take us much closer to a construction, because the allowed set of rules is so much smaller.

Lattice Rules Can Beat the Average

Earlier we introduced the notion of a rank-1 lattice rule (2). Because we are dealing with functions that are not generally periodic, it turns out to be useful to introduce a small generalization: the *shifted rank-1 lattice rule* is defined by

$$Q_N f = \frac{1}{N}\sum_{k=1}^{N} f\left(\left\{k\frac{\boldsymbol{z}}{N}+\boldsymbol{\Delta}\right\}\right),$$

where $\boldsymbol{z}$ is the generating vector as before and $\boldsymbol{\Delta} \in [0,1)^d$ is the *shift*.

In 2001 Sloan and Woźniakowski proved a result equivalent to the following: if $\sum_{j=1}^{\infty} \gamma_j < \infty$, then for the unanchored space and for each prime N there exist $\boldsymbol{z}$ and $\boldsymbol{\Delta}$ such that

$$e_N(\boldsymbol{z},\boldsymbol{\Delta}) \le \frac{1}{\sqrt{N}} \exp\left(\frac{1}{12}\sum_{j=1}^{\infty}\gamma_j\right).$$

That is, at least for prime N one can do as well as the average quasi-Monte Carlo method even within the small class of shifted lattice rules. Moreover, they showed that the improved result of Hickernell and Woźniakowski also holds: that is, if N is prime and $\sum_{j=1}^{\infty} \gamma_j^{1/2} < \infty$, then there exist $\boldsymbol{z}$ and $\boldsymbol{\Delta}$ such that

$$e_N(\boldsymbol{z},\boldsymbol{\Delta}) \le \frac{C_\delta}{N^{1-\delta}}, \quad \delta > 0, \tag{9}$$

with C_δ again independent of N and d.

Both results were obtained by variants of the previous averaging argument. To be precise, the averaging argument proceeds in two steps. The first step is to determine the root mean square average of $e_N(\boldsymbol{z},\boldsymbol{\Delta})$ over all $\boldsymbol{\Delta} \in [0,1)^d$, which we denote by $\overline{e}_N(\boldsymbol{z})$. For the $\mathcal{O}(N^{-1/2})$ result above, the next step is to determine the root mean square of $\overline{e}_N(\boldsymbol{z})$ over all $\boldsymbol{z} \in \{1,\dots,N-1\}^d$. It turns out that both these steps can be done in a closed form for our unanchored Sobolev space. (The primality of N simplifies the argument in the second of these steps.) To obtain the improved rate of convergence, the second averaging step uses a different form of average over $\boldsymbol{z} \in \{1,\dots,N-1\}^d$, namely,

$$\left(\frac{1}{(N-1)^d}\sum_{\boldsymbol{z}\in\{1,\dots,N-1\}^d} \overline{e}_N(\boldsymbol{z})^{1/(1-\delta)}\right)^{1-\delta},$$

which after a considerable struggle can be bounded in the way indicated in (9).

To summarize the story to this point, we now know that in the worst-case setting and for suitably weighted tensor-product Hilbert spaces there exist quasi-Monte Carlo rules (and indeed even shifted lattice rules) that achieve an error bound that is independent of d and that (under suitable conditions) goes to zero with rate $\mathcal{O}(N^{-1+\delta})$ for arbitrary $\delta > 0$. But we do not yet know how to find any rules that achieve this result. That is the story of the next section.

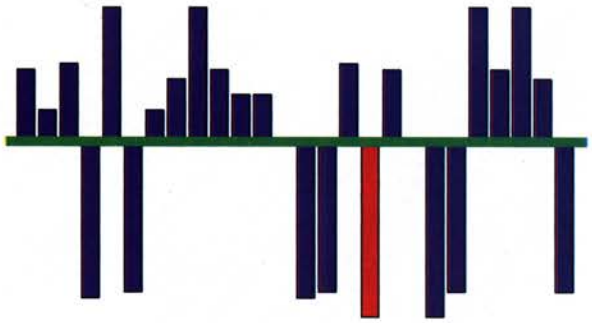
Finding a Good Lattice Rule One Component at a Time

Now the tale takes a surprising twist: what began as a theoretical study of tractability turned out, against expectation, to yield a method of construction.

Actually, all existence results of the kind reported here (asserting the existence of integration rules for which the worst-case error is smaller than some explicit upper bound) already contain within them the germ of a method of construction: one need only search among all the possible rules until one finds a rule for which the worst-case error achieves the desired bound (assuming, of course, that the worst-case error is explicitly computable). And the search can be carried out in complete confidence that it will be successful. The problem is that a full search of this kind is either impossible in principle (one cannot search over all values of a continuous variable) or else exponentially expensive (a search over all values of $\boldsymbol{z}$ in $\{1,\dots,N-1\}^d$ requires $(N-1)^d$ evaluations of the worst-case error). Somehow the cost of the search must be reduced without sacrificing the quality of the result.

We have seen already that the search can be restricted (at least if N is prime) to shifted lattice rules. There are two ways of handling the problem caused by the continuous nature of the shift $\boldsymbol{\Delta} \in [0,1)^d$. One way is to limit the components of $\boldsymbol{\Delta}$ to odd multiples of $1/(2N)$, since it can be shown that this restriction can only reduce the root mean square average of the error. The approach we prefer is to leave $\boldsymbol{\Delta}$ continuous but to treat its components as continuous random variables uniformly and independently distributed on $[0,1)$. The first advantage of using a *random* shift $\boldsymbol{\Delta}$ is that we no longer need to find the shift! The second is that, just as in the Monte Carlo method, we can obtain a probabilistic error estimate if we repeat the calculation with several independently chosen random shifts (see below). The third advantage is that we can work with the root mean square worst-case error $\overline{e}_N(\boldsymbol{z})$ defined previously, which is much easier to compute than the worst-case error $e_N(\boldsymbol{z},\boldsymbol{\Delta})$, since it involves only a single sum: explicitly, it can be shown that

$$\overline{e}_N^2(\boldsymbol{z}) = -1 + \frac{1}{N}\sum_{k=1}^{N}\prod_{j=1}^{d}\left(1+\gamma_j B_2\left(\left\{k\frac{z_j}{N}\right\}\right)\right).$$



The worst-case error for one component of the generating vector. The green line represents the average worst-case error over all choices of this component. Clearly "there is always one choice as good as average" and indeed there are many such choices. The component-by-component algorithm takes the best choice, which is typically very much better than average.

Now we need to find a good choice of $\boldsymbol{z} \in \{1, \ldots, N-1\}^d$. The question we face is how to shorten the search over the values of $\boldsymbol{z}$ yet still find a $\boldsymbol{z}$ for which the theoretical error estimate

$$\overline{e}_N(\boldsymbol{z}) \le \frac{C_\delta}{N^{1-\delta}}, \quad \delta > 0, \tag{10}$$

is achieved, assuming $\sum_{j=1}^{\infty} \gamma_j^{1/2} < \infty$.

It turns out that the following component-by-component algorithm, introduced by Sloan, Kuo, and Joe in 2002 (see [6]), achieves the desired result. In this algorithm the components of $\boldsymbol{z} = (z_1, \ldots, z_d)$ are determined successively as follows:

1. Set $z_1 = 1$.
2. For j from 2 to d, with $z_1, \ldots, z_{j-1}$ fixed, choose z_j from $\{1, \ldots, n-1\}$ to minimize $\overline{e}_N(z_1, \ldots, z_j)$.

That such a simple "greedy" algorithm can succeed is in a certain sense surprising, since in the classical literature of lattice rules it is well accepted that a good lattice rule in d dimensions does not extend to a good lattice rule in $d+1$ dimensions.

The proof that the simple algorithm achieves the desired bound (10) is, naturally enough, by induction. And as the reader will by now expect, the inductive step itself relies on an averaging argument: with the components $z_1, \ldots, z_{j-1}$ held fixed and assumed to yield the desired bound with d replaced by $j-1$, one shows that an appropriate average over all possible choices of the next component z_j satisfies the analogous bound with d replaced by j. In the original paper of Sloan, Kuo, and Joe, only a bound of order $\mathcal{O}(N^{-1/2})$ was established in this way. That the same algorithm yields the essentially optimal order of convergence in (10) was established by Kuo in 2003 by a further refinement of the averaging argument.

In the practical implementation of the rule, once we have a generating vector $\boldsymbol{z}$, we generate a number of independent random shifts $\boldsymbol{\Delta}_1, \ldots, \boldsymbol{\Delta}_m$ and form the approximations $Q_1, \ldots, Q_m$, where Q_i is the shifted lattice rule approximation to the integral If based on the generating vector $\boldsymbol{z}$ and the shift $\boldsymbol{\Delta}_i$. Then the mean

$$\overline{Q} = \frac{1}{m}(Q_1 + \cdots + Q_m)$$

is our final approximation to If. An unbiased estimate for the error of our approximation is given by

$$\sqrt{\frac{1}{m} \cdot \frac{1}{m-1} \sum_{i=1}^{m} (Q_i - \overline{Q})^2}.$$

Fast Construction of a Good Lattice Rule

The obvious implementation of the component-by-component algorithm of the last section requires $\mathcal{O}(N^2 d)$ operations to compute all components of $\boldsymbol{z} = (z_1, \ldots, z_d)$. Since this is only polynomial in d, it certainly overcomes the cost aspect of the curse of dimensionality, but it is still too expensive when N is large. In 2005 Nuyens and Cools developed a revolutionary implementation of the algorithm that reduces the computational cost to $\mathcal{O}(N(\log N)\, d)$ operations. This allows fast construction of good lattice rules with N up in the millions and brings our lattice story to a satisfying conclusion.

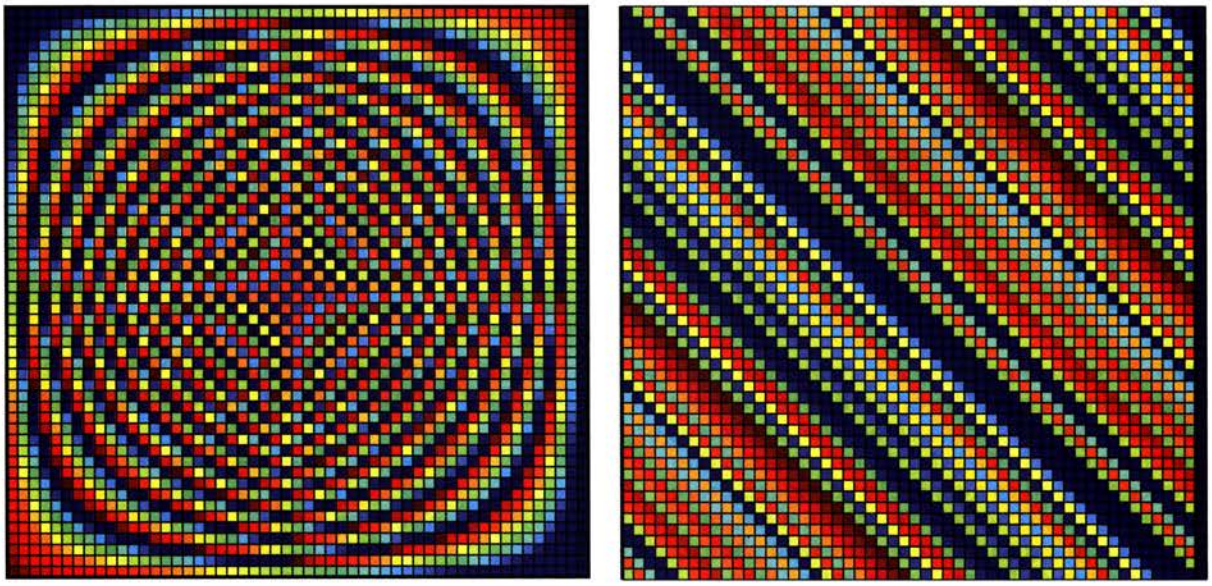
The main idea is as follows. In the jth step of the component-by-component algorithm, we need to evaluate the worst-case error with z_j taking the values $1, 2, \ldots, N-1$. This corresponds to some matrix-vector product, with the core of the matrix being (with N prime)

$$[kz \bmod N]_{\substack{1 \le z \le N-1 \\ 1 \le k \le N}}.$$

Leaving out the $k = N$ column, we can permute the rows and the columns of this matrix in such a way that we get a *circulant* matrix of order $N-1$. While a matrix-vector product in general requires $\mathcal{O}(N^2)$ operations, for a circulant matrix it can be achieved in $\mathcal{O}(N(\log N))$ operations by making use of the Fast Fourier Transform. Therein lies the secret behind the fast construction.

An Unfinished Story

The story, as told above, finishes with the development of a fast algorithm, one that yields integration rules of guaranteed quality in a specific setting (i.e., worst-case error in a specified weighted space). But many challenges remain before the resulting rules can be used sensibly for practical problems. The principal difficulty is in knowing how to choose appropriate weights for a particular



The structured matrix arising from the component-by-component algorithm and its permuted circulant form when N is prime. In its natural ordering the matrix exhibits a flower-like pattern or a wave interference effect as shown on the left. Using number theoretic permutations, this matrix can be transformed into a circulant form as shown on the right. The circulant structure means that the matrix-vector product can be computed in a fast way using the Fast Fourier Transform. When N is not prime, the same pattern shows up in multitude; see the cover and its corresponding description for N a power of 2.

problem or class of problems. That is the subject of much current research. Related problems are how best to transform a given problem to the unit cube and whether or not to use the variance reduction techniques that are familiar to the Monte Carlo community. (Practical experience suggests that variance reduction procedures are as useful as they are in the Monte Carlo method.) Much interest now lies in finding integration rules that are of acceptable quality for a range of weights. Perfection in the choice of weights is of course hard to achieve and fortunately not needed in practice, especially if we remember that the use of random shifts allows estimation of the error. (However, it is now known that the classical weights, as used implicitly for example in the book of Sloan and Joe, are much too large to yield good results.)

Many extensions have been considered by other researchers. The results have been extended to non-Hilbert space setting, to general weights, to integration over unbounded regions, and to the problem of approximation. The assumption that N is prime has been removed at the cost of complicating the analysis and slightly weakening the results.

Perhaps the most interesting extension has been the recent adaptation by Dick and Pillichshammer of the entire framework above, from the definition of weighted spaces through averaging arguments to component-by-component construction, to yield not a shifted lattice rule but rather a *digitally shifted digital net*, which is a particular kind of (t, m, s)-net. The story continues!

Acknowledgment

The support of the Australian Research Council under its Centres of Excellence Program is gratefully acknowledged.

References

[1] R. Bellman, *Dynamic Programming*, Princeton University Press, Princeton, NJ, 1957.

[2] H.-J. Bungartz and M. Griebel, Sparse grids, *Acta Numerica* **13** (2004), 147–269.

[3] H. Niederreiter, *Random Number Generation and Quasi-Monte Carlo Methods*, SIAM, Philadelphia, PA, 1992.

[4] E. Novak and H. Woźniakowski, When are integration and discrepancy tractable?, *Foundations of Computational Mathematics* (R. A. DeVore, A. Iserles, and E. Süli, eds), Cambridge University Press, Cambridge, 2001, pp. 211–266.

[5] I. H. Sloan and S. Joe, *Lattice Methods for Multiple Integration*, Oxford University Press, Oxford, 1994.

[6] I. H. Sloan, F. Y. Kuo, and S. Joe, Constructing randomly shifted lattice rules in weighted Sobolev spaces, *SIAM J. Numer. Anal.* **40** (2002), 1650–1665.

[7] I. H. Sloan and H. Woźniakowski, When are quasi-Monte Carlo algorithms efficient for high dimensional integrals?, *J. Complexity* **14** (1998), 1–33.

[8] J. F. Traub, G. W. Wasilkowski, and H. Woźniakowski, *Information-Based Complexity*, Academic Press, New York, NY, 1988.

About the Cover

The cover accompanies the article by Ian Sloan and Frances Kuo about the construction of lattice rules for multivariate integration (see page 1320). They present an algorithm, called "component-by-component construction", which by a mix of number theory and linear algebra yields some beautiful pictures.

In constructing a d-dimensional N-point lattice rule, we must choose in succession d components of its generating vector. In finding one of these, all possible choices for this component of the generating vector are considered, from among the integers in $\mathbb{Z}_N$ relatively prime to N. Multiplication modulo N for each of these choices corresponds to a certain permutation of the numbers in $\mathbb{Z}_N$.

So we can imagine making a multiplication table by considering horizontally the numbers from 0 to $(N-1)$ and vertically the numbers relatively prime to N. The bottom images of the illustrations give a visual impression of this table with the numbers from left to right and top to bottom in natural ordering. Since each row of this table corresponds to one of the permutations of the N points, there are N different colors per row. A matrix with this special structure pops up in the component-by-component algorithm and in each step a matrix-vector product has to be carried out.

Surprisingly, by just doing row and column permutations, this matrix can be brought into a form which allows for multiplication in time $O(N \log N)$ for any N. This can be done in two steps. The first step, and also the step which gives rise to the nicest images, is grouping the numbers in $\mathbb{Z}_N$ according to divisors common with N. This permutation on the columns is visualized in the middle images. If N is a power of a prime this image clearly displays a multi-resolution view of the general structure present in the first block. We have lower and lower resolution tilings of the first block on top of each other. For general N, similar but more complicated patterns appear.

In the second step we pull these smaller multiplication tables apart into multiple cyclic groups. If g is a generator for one of these cyclic groups with modulus p^α, then its elements are given by $g^k \bmod p^\alpha$ and the multiplication table has the elements $g^{k+\ell \bmod \phi(p^\alpha)} \bmod p^\alpha$, i.e., having constant anti-diagonals for k and ℓ in natural ordering. Taking $-\ell$ instead of just ℓ gives constant diagonals, making the table a circulant matrix. When we have to consider more than one generator per block then we can use the Chinese remainder theorem to obtain nested block circulant matrices. Thus by permuting the rows and the columns we can reorder the partitions so that they form nested block circulant matrices as can be seen in the top images.

It is well known that a matrix-vector product with a circulant matrix can be done in time $O(N \log N)$ using fast Fourier transforms. A similar procedure delivers a matrix-vector product with this complete matrix also in time $O(N \log N)$, being more complicated for general N than for N prime (see Nuyens and Cools in the "Dagstuhl 2004" issue of *J. Complexity*, to appear). This fast matrix-vector product is an essential ingredient for constructing large lattice rules with say $N \approx 10^8$ points.

The graphics were created using the Python package PyX .

—Dirk Nuyens
dirk.nuyens@cs.kuleuven.be

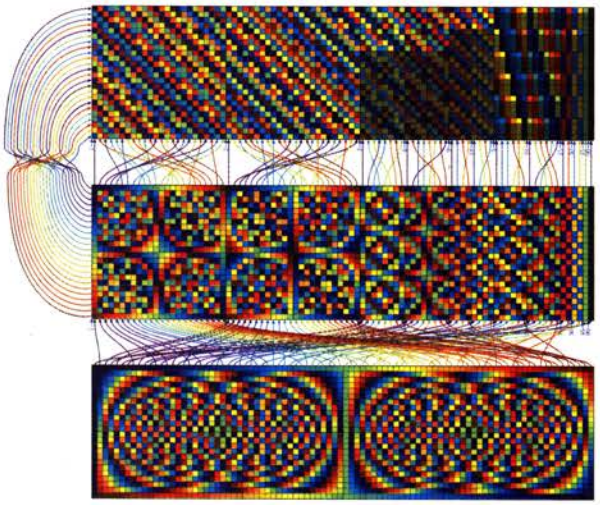


Figure 1. The three steps for $N = 2 \times 3^2 \times 5 = 90$. For general N the structure becomes more complicated. (In the top matrix the grayed out blocks denote redundancy.)

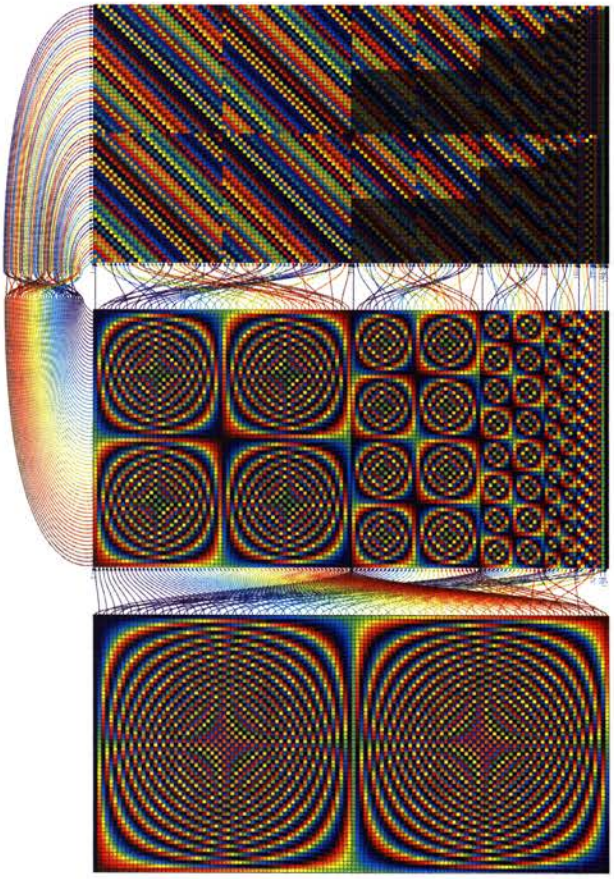


Figure 2. The three steps for $N = 2^7 = 128$. As is usual in number theory, powers of 2 (the only even prime) behave a little bit different than powers of odd primes, except for $N = 2$ and $N = 4$ which are also the usual exceptions. In this case we get an extra circulant embedding. In the top matrix the grayed out blocks denote redundancy.) Also see the cover image.

A Different Kind of Institute: The American Institute of Mathematics

Allyn Jackson

You would never think there is a math institute *here*.

Driving south along the wide, six-lane thoroughfare called El Camino Real, you pass into Palo Alto, California, from the north. The stately campus of Stanford University stretches along for a mile or two, offering a bit of elegance and greenery before the monotony of low-slung, nondescript architecture resumes. You pass the inevitable Starbucks, a few bicycle stores, and some Asian restaurants. There are few pedestrians and plenty of parking lots. After a couple of major intersections, you reach Portage Avenue, a street so small it would not merit even a stoplight were it not for the need to regulate traffic into the parking lot of the massive Fry's Electronics store that sits at the end of Portage. As you enter the Fry's parking lot, there is still no indication that a mathematics institute of international renown is located here. You mount the steps to the walkway that runs across the front of the Fry's building and wander along to the battered metal door modestly bearing the words "American Institute of Mathematics". You might then notice that the colorful mural painted on the wall next to the door has some distinctly mathematical themes.

Since its founding in 1994 the American Institute of Mathematics, known by the shorthand AIM, has become an active center for mathematical research. Its improbable location is the result of its start as a small, elite institute privately funded by the president of Fry's Electronics. The private money has been supplemented by funding from the National Science Foundation (NSF) since 2002, when AIM became one of the national mathematics institutes funded by the NSF. Among the many mathematics institutes that now dot the globe, AIM is a different kind of institute, with an unusual structure and an unusual history. And, if its plans come to fruition, AIM will become yet more distinctive when it moves into its new home, an opulent building to be constructed in the center of a golf course in a farming community about forty-five minutes south of Palo Alto.

Allyn Jackson is senior writer and deputy editor of the Notices. *Her email address is* axj@ams.org.

Adapting to Commercial Quarters

Walking into AIM, you might wonder, "*This* is a math institute?" The single-story, flat-roofed, windowless warehouse was clearly constructed with commercial purposes in mind. There is no foyer, no check-in desk, no lecture halls or administrative offices in view. After proceeding down a narrow corridor, you enter a large rectangular room with sofas and coffee tables set here and there. Soon you notice bookcases filled with mathematics monographs: AIM has purchased the entire publication list of the AMS and all mathematics books published by Cambridge University Press, Elsevier, Oxford University Press, and Springer-Verlag. Its library is 12,000 volumes strong and growing.

At this point one might notice that along the back wall of the room a mathematician stands lecturing in front of a whiteboard. Audience members move forward and listen or hang back and observe; they might get up to get a coffee or a snack, peruse the journals, leaf through handouts about current AIM

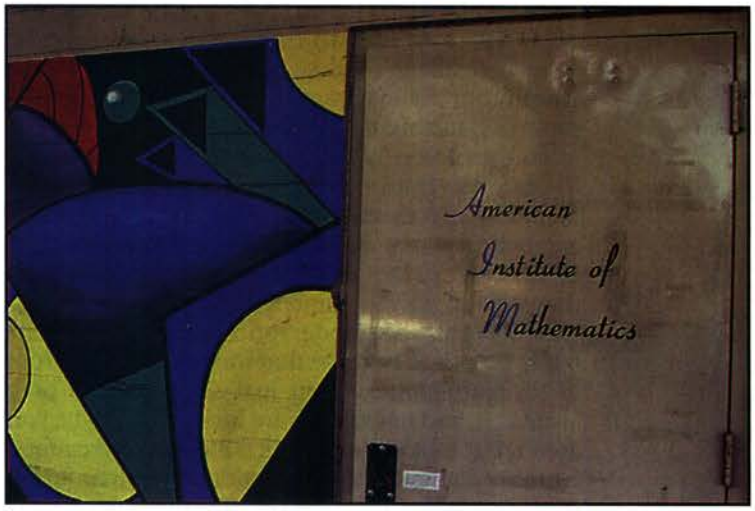
activities, and then return to the lecture—all without ever leaving the room. Take one of the chairs near the whiteboard to follow the lecture closely or perch on a stool a little distance away or sit on a sofa at the back of the room and chat with colleagues. It turns out that this odd, boxy room, which probably looked at first glance to be totally unsuited to housing a mathematics institute, has been set up in such a way that it actually works very well.

So how did a mathematics institute come to occupy this space next to Fry's Electronics? AIM is the brainchild of John Fry, president of the privately held company that runs a chain of about thirty electronics stores that now stretches across the southwestern United States. Stores recently opened in Atlanta and Chicago, and international expansion is in the works. In the 1970s Fry was a mathematics major at Santa Clara University and took courses there with Gerald Alexanderson, who remembers Fry as an outstanding student who clearly had the talent to become a mathematician if he desired. "He was terribly interested in mathematics, but he was also interested in making money," Alexanderson recalled. Fry's family owned a chain of supermarkets, and after the chain was sold Fry and his brothers decided to open supermarket-like stores selling electronics and computer equipment. Fry's Electronics stores do resemble supermarkets or perhaps Wal-Marts: they are huge and cavernous, with long shelves stuffed with goods. The stores are decorated in various whimsical themes. One sports an Egyptian motif, with wall murals depicting pharaohs doing calculations on laptops; the theme of the store next to AIM is the Wild West.

Some years after he finished college and after the electronics stores were established, Fry got back in touch with Alexanderson. In the early 1990s he asked Alexanderson to help organize a series of lectures about mathematics at the Fry's Electronics store in Sunnyvale. Among the speakers were Donald Knuth of Stanford University, Thomas Banchoff of Brown University, and Nicholas von Neumann, the brother of John von Neumann. Because they were held in the heart of Silicon Valley, the lectures sparked much interest and drew large crowds. Alexanderson recalled that at this time Fry often spoke of his desire to establish a mathematics library that would house everything ever published in the field—a contemporary version of the great library at Alexandria that was built in the third century BC and is thought to have been destroyed in a fire. A rare book collector himself, Alexanderson fully understood that it would be a herculean task to create such a library, but nothing could shake Fry's attachment to this dream. And Fry has made a start: for the past decade he has employed a part-time librarian to build his collection

One might ask, "There's a mathematics institute in *here*?"

Or say, "Wait a minute—this is an electronics store, not a math institute!"



But lo and behold, here is the door to AIM, which occupies one of the storage spaces in the building.

of rare mathematical books and has invested a couple of million dollars in it.

AIM was born in Alexanderson's living room one Sunday afternoon when Fry proposed starting a mathematics institute and persuaded Alexanderson to chair the board of trustees. Having just been named secretary of the Mathematical Association of America, Alexanderson was reluctant to take on additional responsibilities. But when it became clear that Fry was unlikely to start the institute without him, Alexanderson relented, and he has chaired the AIM board of trustees ever since. Another early key figure in the establishment of AIM is Fry's business associate, Stephen Sorenson, who is a director at Fry's Electronics. One of the people initially recruited for the AIM advisory board was Brian Conrey, then mathematics department head at Oklahoma State University. Conrey had also been a mathematics major at Santa Clara and knew Alexanderson and Fry from his student days. After serving for two years on the advisory board, Conrey was appointed as the director of AIM in 1997 and has remained in that position ever since.

Gerald Alexanderson

Although Fry continues to be deeply interested and involved in the running of AIM, particularly in its financial aspects, he stays out of the limelight. He declined to be interviewed for this article, following his policy of never granting interviews to the media. Conrey says that Fry has a deep, abiding interest in mathematics and physics and calls him a "visionary" who looks decades ahead, trying to find ways to have a positive impact on the future. As a businessman and a former college football quarterback, Fry is convinced that the team approach is the way to make progress on solving difficult problems, including in mathematics. When this approach was floated in early meetings of the AIM advisory board, the members expressed skepticism, saying that mathematicians do not operate that way. "They were still in this old paradigm that mathematicians lock themselves in a room and work on a problem until they solve it," Alexanderson recalled. "I was certainly skeptical, because that was the way I was told to do mathematics—you just sit there and plug away at it, and maybe you are lucky and maybe you aren't, but that's the way it's done." Fry envisioned a more strategic approach: pick a problem, bring together the world's experts, give them the means they need, and tell them to go at it. "And, by golly, it seems to work," said Alexanderson.

A Strategic Approach

Jonathan Mattingly of Duke University is standing in front of the whiteboard at AIM, pen in hand. The occasion is a workshop on deterministic and stochastic Navier-Stokes equations. Proving global existence of solutions to the Navier-Stokes equation in R^3 or controlling the inviscid limit of the forced equation in R^2 would be major feats, Mattingly notes. "Okay, these are the home runs—these are *Annals* papers," he says. But are there any smaller problems along the way? he asks. Are there less daunting steps that could be taken that would bring the "home runs" a little bit closer? People in the audience start suggesting problems, and Mattingly starts scribbling. This is an AIM problem session. As the moderator, Mattingly has the job of eliciting suggested problems from the audience and writing them on the board. To have your problem written on the board, you must at a minimum get Mattingly to understand it. The idea of having a moderator write the problems on the board, as opposed to having each person come up to the board to write his or her own problem, is that the moderator can distill the problem statements to make them clearer and more accessible. And the choice of a dynamic and enthusiastic moderator like Mattingly helps to get ideas flowing. This particular structure for the problem sessions is one of the hallmarks of AIM workshops.

AIM has developed various strategies for promoting interactions among researchers, with a focus on ultimate goals: solving important problems in mathematics. This approach has its roots in Fry's initial vision for AIM as a place where teams of experts would come together to focus on major problems in the field. Indeed, the very first AIM event centered on the Riemann Hypothesis, which today remains one of the major outstanding challenges in mathematics. Conrey recalls that at one of the very early advisory board meetings, when AIM existed in name only and the board was still grappling with the question of what the institute ought to do, he threw out the suggestion of having a project to attack the Riemann Hypothesis. "Everybody on the board said, 'No, no, no, that's crazy; nobody knows how to solve the Riemann Hypothesis,'" he recalled. Later that day when Conrey related this to fellow number theorist Hugh Montgomery of the University of Michigan, Montgomery noted that that particular year, 1996, was the one hundredth anniversary of the proof of the Prime Number Theorem by Jacques Hadamard and Charles Jean de la Vallée Poussin. Might it make sense to have a symposium celebrating this milestone and assessing current progress toward the Riemann Hypothesis?

Seizing on this idea, Conrey secured AIM support and organized the symposium together with Douglas Lind from the University of Washington in Seattle. The symposium was held on the Seattle cam-

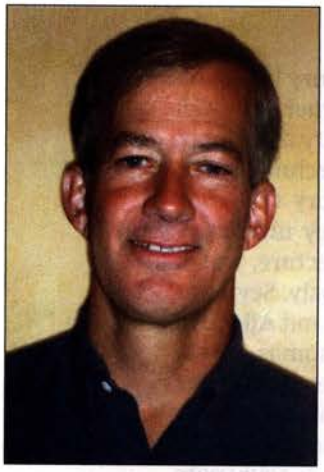
pus in August 1996 in conjunction with the MathFest. A highlight of the symposium was a rare public lecture by 1950 Fields Medalist Atle Selberg, then seventy-nine years old. In 1949 Selberg gave an elementary proof of the Prime Number Theorem and has worked on aspects of the Riemann Hypothesis throughout his long career. The symposium also included a roundtable discussion by the participants, among whom were many top experts on the problem. "Everybody sat around and talked about whether it was feasible to bring a group of people together to solve the Riemann Hypothesis," Conrey recalled. "Of course, everybody said no, but that discussion was something that I suspect nobody there had ever witnessed." It is indeed highly unusual to have a group of top mathematicians entertain the subject of how they might develop a strategy to solve such a problem. No strategy emerged for the Riemann Hypothesis, but this seems to have been a defining moment for AIM, when it cemented its identity as an institute whose goal is to identify and solve important mathematics problems.

Soon thereafter, Conrey was appointed as the director of AIM, and the institute set up shop in its Palo Alto location. Initially AIM stuck close to Fry's original vision of bringing in teams of researchers to work on specific problems. As a privately funded institute, AIM could pay full salaries and expenses for these researchers, something that cannot be done with NSF dollars. The very first mathematician funded by AIM, Frank Pacard of the Université de Paris XII, came to Palo Alto before AIM actually had a home itself; he worked in an office at Stanford University, collaborating with Stanford's Rafe Mazzeo. After AIM moved into the space next to Fry's in January 1998, it hosted three more researchers, each of whom was working with a colleague at Stanford: Ralph Greenberg of the University of Washington at Seattle, who worked with Karl Rubin on the Birch and Swinnerton-Dyer conjecture; Ib Madsen of the University of Aarhus, who worked with Gunnar Carlsson in algebraic K-theory; and Jon Wolfson of Michigan State University, who worked with Richard Schoen on the Lagrangian Plateau problem. AIM has capitalized on the strength of the Stanford mathematics department, and ties between the two have been strong from AIM's early days. Out of the nearly forty people serving on the governing boards for AIM (the board of trustees, the advisory board, and the scientific board), four are Stanford mathematicians.

One project that AIM counts as one of its big success stories focused on the strong perfect graph conjecture, a forty-year-old problem considered to be one of the most important in graph theory. (The conjecture states that a graph is perfect if and only if it contains no odd graph hole and no odd graph antihole.) On the advice of Peter Sarnak of Princeton University, AIM's scientific advisory board invited Princeton's Paul Seymour, together with Neil Robertson of the Ohio State University and Robin Thomas of the Georgia Institute of Technology, to propose a problem from graph theory that they could work on together at AIM. They ultimately chose the strong perfect graph conjecture, which none of them had worked on previously. Seymour received release time from Princeton, and AIM paid the full salaries of Robertson and Thomas for six months and then paid part-time salaries for another six months. "So they spent a year, eight hours a day or whatever, just talking to each other and working on this problem," Conrey said. "Well, four years later, with the addition of Maria Chudnovsky, Paul Seymour's graduate student, they solved the problem." The solution drew heavily on the ideas and methods developed during the time AIM supported Robertson and Thomas.

It was in 1997 that the NSF announced a new competition for grants for national mathematics institutes. At the time, the two existing institutes were the Institute for Mathematics and its Applications at the University of Minnesota and the Mathematical Sciences Research Institute in Berkeley, and they were forced to compete anew for continued funding. AIM submitted a massive, US$30-million proposal that outlined a plan for pooling funds from Fry, the NSF, and a network of eight mathematics departments across the nation that would form the nodes of a "distributed institute". The proposal was turned down for various reasons, including its size and some skepticism on the part of the NSF about Fry's financial commitment.

After that, AIM took a more incremental tack with the NSF and began submitting a series of smaller proposals for individual projects, including some conferences and workshops. AIM also became the sponsor for a Focused Research Group (FRG) grant from the NSF, for which Conrey was one of the principal investigators (AIM has since served as a sponsor for three other FRGs). By the time the NSF announced yet another institute competition in 2000, AIM had gained experience not only in dealing with the NSF but also in organizing activities other than the small groups with which it had started, and it used this experience as the basis for a new institute proposal. When that proposal was approved in 2002, AIM became one of the seven NSF-funded mathematics institutes that exist today. Formally, the NSF-funded portion of AIM is called the AIM Research Conference Center (ARCC). The main activity of ARCC is weeklong workshops with thirty-two participants apiece. Since it was established in the fall of 2002, ARCC has held over forty workshops across a wide spectrum of mathematical areas, pure and applied.



AIM Director Brian Conrey.

Codirector Helen Moore.

Codirector David Farmer.

The AIM Workshop Style

It is 9:00 p.m., and a group of mathematicians is sitting in front of the whiteboard at AIM. One of the participants is Dennis Sullivan of the City University of New York, whose energy and enthusiasm is the driving force behind this late-night meeting. He has asked some of the other participants to explain certain ideas to him, and most of the rest of the workshop group is all too happy to listen in. As a succession of speakers give short explanations, Sullivan cuts in, asking questions and requesting clarifications that others were no doubt also wondering about, albeit silently. At some point the AIM cleaning crew shows up and quickly withdraws, not wanting to disturb the mathematicians. After someone tells the crew it is okay to come in, the mathematicians continue their discussion into the night as the trash cans are emptied and the vacuum cleaners whirr. Because AIM is close to many restaurants and because the hotel it uses to house visitors is within walking distance, spontaneous after-dinner sessions like this one are not uncommon.

The evening session initiated by Sullivan took place during a workshop on the topology and geometry of the moduli space of algebraic curves organized by Ulrike Tillmann of the University of Oxford and Ravi Vakil of Stanford University. The purpose was a common one for AIM workshops: to foster communication between two groups that have common interests but that do not usually talk to each other. Topologists and algebraic geometers are both interested in the moduli space of curves but for different reasons and from different perspectives, and the goal of the workshop was to get them to exchange ideas. At one point the participants broke up into three "camps": a topology camp, an algebraic geometry camp, and a "miscellaneous" camp. Each one came up with a list of questions it would like to ask of one of the other camps, and the three lists were compiled, printed out, and distributed to the workshop participants. There was also a problem session, led by Jordan Ellenberg, who at the time was an assistant professor at Princeton University and is now at the University of Wisconsin at Madison.

Activities like breaking into small groups and holding interactive problem sessions are characteristic aspects of the AIM style of workshop. Another is the small number of formal lectures, no more than three per day. For many AIM workshops, only the first day's lectures are scheduled in advance, and others are set up during the course of the workshop as the organizers find out what participants are interested in hearing about. As a result there is a good deal of unstructured time for informal discussions and impromptu talks. This fluidity is reflected in the physical setup of AIM, which allows many simultaneous activities to be going on at once: as one person lectures, some will sit near the whiteboard and listen, small groups will move to the back to engage in discussion, and individuals might park themselves on a sofa to read a journal for a while before going back to the lecture. A constant supply of drinks, snacks, and coffee keeps participants together in the room for the entire day, and when wine is uncorked at five o'clock, they often remain in discussion before ambling off to dinner at a restaurant.

Despite the seeming looseness of the structure, a good deal of planning and management goes into the AIM workshops. Mathematicians submit workshop proposals to AIM, and once a proposal is selected by the AIM Scientific Board, Conrey gets on the phone with the organizers. "I explain to them in great detail that [the AIM workshops] really are different, that the ARCC staff is very hands-on and very involved with what goes on," Conrey explained. "I give them the opportunity at that point, if they are not comfortable with this, to say so right then so we don't go any further, because in order to be able to do this, they absolutely have to buy into what [AIM does] and be willing to try this different style. It's true that it flies in the face of conventional thought about mathematics, but we think it's an interesting alternative."

In addition to director Conrey, AIM has two codirectors, Helen Moore and David Farmer. Well before a workshop takes place, the directors hold a series of three, hour-long conference calls with the workshop organizers to discuss the structure of the workshop. Each call begins with a question to the

organizers: What are the goals of the workshop? The AIM directors help the organizers to articulate, refine, and shape the goals to ensure that they are clear and realistic. They also describe typical AIM activities and discuss how they can be structured in pursuit of the workshop's goals.

Of the thirty-two workshop participants, the organizers invite twenty-four, and the other eight slots are filled by open applications. The AIM directors help the organizers cull through the applications and choose appropriate participants. One of Moore's main responsibilities is to increase diversity among participants, and for this purpose AIM has assembled a database of mathematicians from underrepresented groups, together with information about their research specialties. When a workshop fits with the mathematical interests of a person in the database, Moore encourages him or her to apply. The organizers are also told that the initial list of invited participants should include members of underrepresented groups, and sometimes the organizers request AIM's help in finding appropriate people to invite. As a result of these careful and sustained efforts, the AIM workshops have had about 20 percent women participants, and 6 percent have been from underrepresented minorities. AIM has been so effective in this regard that other mathematics institutes have begun asking for Moore's help in finding appropriate participants from underrepresented groups for their own activities.

The American Institute of Mathematics
360 Portage Avenue
Palo Alto, CA 94306-2244
http://www.aimath.org

After the participants are invited but well before the workshop is held, they are asked to submit statements about the workshop topic: they might suggest problems, describe what they are working on, pose questions they are curious about, supply ideas for references, and so forth. As the director of AIM Web programming, Farmer creates for each workshop its own Web page, accessible only to that workshop's participants. The participants' statements are made available on this Web page and are also handed out when the workshop actually starts. The organizers recruit some of the junior participants to act as scribes during the workshop and in particular to record the suggestions made during the problem sessions. The material so generated is also posted on the workshop's Web page. In addition, AIM asks all participants to send a full collection of reprints of their papers and adds them to its sizeable reprint library, which has been built primarily through donations of collections of papers. During the workshop the AIM directors check in regularly with the organizers to monitor how things are going and to offer advice on what activities could be scheduled for the rest of the meeting. They also try to circulate among the participants to gauge their responses to the workshop; based on this feedback, they might work with the organizers to adjust the workshop plans accordingly. At the end of each workshop the AIM directors conduct a final "debriefing" meeting with the organizers, and they also collect written evaluations from participants.

Reactions to the AIM style of workshop vary. One participant in a recent workshop raved about the more open, interactive format and relished the emphasis on tackling difficult problems and trying to move the field forward. Another participant in the same workshop was perplexed at the request before the workshop for suggestions of topics and problems to be covered and at the lack of a set schedule for lectures: to this individual, it all looked a bit disorganized. To some, the windowless quarters are drab and uninviting, while others find that interactions are enhanced by having the workshop participants basically spend a week together in one room. (AIM's few individual offices are reserved for staff and long-term visitors; as the AIM directors say, workshop participants have no offices and therefore have "nowhere to hide"). Some people find the targeting of goals and problems to be stimulating and motivating, while others express skepticism that such a strategic approach can work in mathematics, a field where it is often the unexpected side trips that lead to the most fruitful results.

AIM has gained a reputation for having adopted a "business-model" approach to mathematics. Indeed, during a recent AIM workshop a joke floated among the participants that if they didn't prove any theorems, they would have to give AIM its money back. But this reputation might not be entirely deserved. Vakil said he has heard people rail against the notion that AIM's goal is to have immediate results during its weeklong workshops, a goal that he called "idiotic." However, he said, "I didn't get the sense during our workshop, or the previous workshop that I attended, that AIM actually had this intent." He was initially skeptical about the AIM problem sessions, which he assumed were intended to isolate key problems to be solved during the workshop, which is unrealistic. Instead, he found that the problem sessions opened a window for him on what other people found interesting in the field and why. "It gave me a sense of the flavor of the field: what's known, what we really should want to know, and what sorts of methods are out there," he remarked. "This 'big picture' is something you tend not to get from a series of narrow research

Morgan Hills, CA, golf course, location of future AIM.

talks." Jeroen Demeyer, a graduate student at the University of Ghent in Belgium who attended a recent AIM workshop, also noted that the problem sessions are especially helpful for graduate students who are looking for ideas about what to work on.

Another aspect of AIM that might give the impression of a "business-model" approach is the hands-on style of the AIM directors. Moore noted that this style has sometimes elicited reactions from workshop organizers along the lines of "I have been organizing math meetings for thirty years, and who are you to tell me how to run my workshop?" However, this reaction is uncommon, she says, and most organizers, especially junior ones, are willing to experiment with activities and approaches suggested by the AIM directors. Many organizers have become converts to the AIM way of doing things. As Farmer says, "It is extremely common—certainly over 80 percent of the time—that someone starts out very unhappy and skeptical, [but later] says, 'You know, you really have something here, and we are happy we did it this way.' The more we hear that, the more we just keep pressing."

One aspect of AIM that resembles a business is the flexibility it has in spending money—a flexibility that derives from its private funding. For example, not long ago a prominent mathematician explained to AIM that she could not attend a workshop because she has two small twins and cannot travel without her nanny. AIM dipped into its private funds and paid for the nanny's travel too, and the mathematician was able to attend the workshop. Typically AIM provides full travel and housing support for all workshop participants. It is able also to offer modest financial incentives for the work associated with organizing and carrying out the workshops. For example, the students and postdocs enlisted to take notes and to maintain the workshops' Web pages are paid US$1,000 for this work. Workshop organizers split an honorarium of US$2,000.

Conrey says that to his mind the main difference between AIM workshops and typical mathematics meetings is that AIM workshops look to the future. "Imagine a typical conference or workshop: everybody presents what they've done, the theorems they've proved," he said. "Whereas the whole concept of the AIM workshops is to look to the future. What are the problems that we don't know? Is there a possibility for how we might solve these? What are the priorities? What kind of agenda do we have? How can we bring people together and get them excited about working on these problems? How can we bring new people into the field?" The AIM style of workshop may not work for every mathematical topic and may not suit every organizer, but it seems to have been successful in many cases. As Vakil noted, "It has its place in the mathematical universe."

Alhambra Look-alike

Morgan Hill, California, population 36,000, lies about twelve miles south of San Jose and about fifteen miles inland from the Pacific coast, nestled in a valley between the Santa Cruz and Diablo mountain ranges. It is a world away from the bookstores and theaters, the stylish shops and restaurants, and the world-class universities of the Bay Area proper. Driving through the outskirts of Morgan Hill to reach the golf course owned by John Fry, you pass fields of crops, perhaps a clutch of chickens scratching the dry dirt. With its ponds and flowers and meandering streams, the golf course is an inviting green oasis amid the gently rolling hills that, as everywhere in this part of California, remain golden brown for most of the year. On entering the golf course, you are likely to wonder, "*This* will be a mathematics institute?" In fact, assuming that all goes according to plan, it will be something yet more unusual: a mathematics institute *and* a golf course.

In 2005 AIM cleared the final legal and zoning hurdles to begin construction of a new building that will be its headquarters and will also, as something of a sideline, serve as a clubhouse for golfers. Right now the course is not open to the public and is used by just a few people, most of them friends and business associates of Fry's. Once the new clubhouse is in place, golfers' use of the building will be limited to six months out of the year, but it is possible that tournaments would be held there. AIM will use the building year-round for workshops as well as for small groups of mathematicians working together over longer periods and perhaps for new activities that are not possible in its current, very limited Palo Alto facilities. AIM will most

Artist's rendering of the proposed new AIM headquarters in Morgan Hill, CA.

likely keep the Palo Alto quarters after its move to Morgan Hill, which is tentatively scheduled for August 2007.

There are a couple of existing buildings on the golf course, some of which will be torn down to make way for the AIM building. One that will remain is the "Octagon Building", so named because of its octagonal shape. The building has been renovated in opulent style—the extraordinary stone sinks in the bathrooms testify to the expense lavished on the decor—and AIM has held several dinners and other events there. Conrey hints that the new AIM building will have a level of luxury similar to that of the Octagon Building. What is more, the design of the new building is modeled on the legendary Alhambra in southern Spain, which is renowned for its splendid fountains and courtyards and intricate mosaics. The cost of the 177,000-square-foot building is currently estimated at US$50 million. Fry will donate a large chunk of the funds, and a fundraising campaign is being planned.

AIM will try to recreate in its Morgan Hill location some of the successful features of its current home in Palo Alto, including a large open area for the workshops. There will be only a few private offices, to be used by staff and long-term visitors. Like the mathematics institute in Oberwolfach, Germany, the AIM building will have on-site accommodations for workshop participants and visitors, as well as a dining hall with a professional kitchen. There will also be a 150-seat lecture hall. Conrey notes that because the Morgan Hill location, like Oberwolfach, is somewhat isolated, a top-notch library is essential, and plans are under way to establish one. There will also be a rare documents room to house Fry's collection of rare mathematics works. The golf course is adjacent to the 87,000-acre Henry Coe State Park, which is the largest state park in northern California and offers hiking possibilities.

According to Conrey, Fry's ambitions for supporting research extend beyond AIM and the new building. Conrey predicts that Fry's business will eventually become a multibillion-dollar enterprise with hundreds of stores worldwide. "If only a small percentage of that goes to mathematics, that would be great," he says. "I want to be there when it happens." He speculates that AIM may one day have a permanent research faculty, in the style of the Institut des Hautes Études Scientifiques in Paris, and noted that Fry has dreamed of starting a physics research institute.

Aside from grants held by the AIM directors for their own research (all of them remain active in research), the budget for AIM is around US$2 million per year, about half of which comes from Fry. The NSF institute funding, which supports the AIM workshops, comes to a little more than US$1 million per year and is supplemented by cost-sharing from Fry. (Right now, AIM is running only workshops and not the small-group research activities of its early days, though it will likely return to funding small groups again in the future, especially after it moves to Morgan Hill.) Most of the rest of the AIM budget goes toward staff salaries and library and administrative costs, as well as the elite AIM Five-Year Fellowship, which is given each year and pays a generous salary to a new doctorate, who can take the fellowship anywhere. In addition, AIM sponsors a few outreach activities, such as local mathematics competitions and a yearly meeting of women mathematicians in the area.

Fry has not set up an endowment for AIM, preferring instead to fund the institute on an ongoing basis. Still, his consistent support for AIM over the past eight years, together with his plans for the building, seem to indicate he is in it for the long haul. As long as his business does well, the future looks bright for AIM. The more immediate challenge for AIM will likely not be a financial one, but rather the task of transplanting the traditions it has built up in Palo Alto to its new, and very different, location in Morgan Hill. But AIM has shown itself to be an adaptable and innovative institute despite having only a small staff and less-than-ideal facilities. When it moves into its new home, perhaps AIM will find that it finally has a building to match its ambitions.

ADVERTISERS' FORUM

AMS
American Mathematical Society

Index of Advertisers

Book Review

Saunders Mac Lane: A Mathematical Autobiography and *A^3 & His Algebra: How a Boy from Chicago's West Side Became a Force in American Mathematics*

Reviewed by Lance W. Small

Saunders Mac Lane: A Mathematical Autobiography
Saunders Mac Lane
A K Peters, Ltd., May 25, 2005
354 pages, US$39.00
ISBN: 1568811500

A^3 & His Algebra: How a Boy from Chicago's West Side Became a Force in American Mathematics
Nancy E. Albert
iUniverse, Inc., January 18, 2005
366 pages, US$23.95
ISBN 0595328172

(Abraham) Adrian Albert and Saunders Mac Lane were two of the most prominent American algebraists of the twentieth century. Their contributions extend beyond their mathematics, and they are representative of the "public" scientist that appeared after World War II. Their careers were parallel in many ways; they both spent many years at the University of Chicago, and both served as AMS president. The books under review, a biography of Albert by his daughter Nancy and the autobiography of Mac Lane, present a picture of the evolution of mathematics, mathematicians, and their work in the last century.

Saunders Mac Lane, who died April 14, 2005, at 95, remains well-known for his seminal work in category theory, homological algebra, algebraic topology, etc. and was active in mathematics and public service until late in his life. Adrian Albert, who died in 1972, though well-known to algebraists in the areas of finite-dimensional division algebras and nonassociative algebras, seems to have receded somewhat from the general view of many, especially younger, mathematicians. Albert was born in 1905 and Mac Lane in 1909; the four-year age difference turns out, however, to be almost a generation mathematically. Albert was a student of L. E. Dickson who was a student of E. H. Moore, the founding chairman of the Chicago department. Albert received his Ph.D. in 1928 at the age of 22. The principal result of his thesis is still striking: a division algebra of dimension 16 over its center is a crossed product. In subsequent years, Albert would develop, almost in isolation, the theory of finite-dimensional central simple algebras that would extend this result to finite-dimensional division algebras over number fields. Indeed, he certainly deserves a portion of what is commonly referred to as the Brauer-Hasse-Noether theorem (on the South Side of Chicago, the Albert-Brauer-Hasse-Noether theorem). Albert would win the AMS Cole Prize in algebra for work on Riemann matrices in 1939.

Lance W. Small is professor of mathematics at the University of California, San Diego. His email address is lwsmall@ucsd.edu.

Albert's mathematical style may be described as one of extended calculation. To this day, his books and papers often leave the reader gasping for inspiration. Nancy Albert relates Dan Zelinsky's account of the following encounter between Albert and Mac Lane in a 1950s seminar.

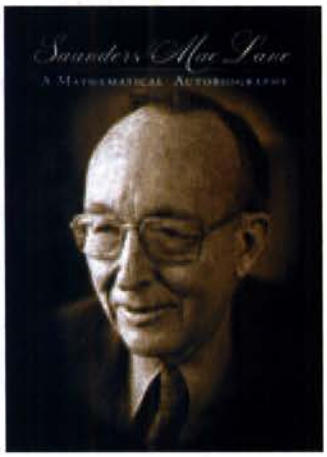
> Professor Saunders Mac Lane jumped up and demanded to know, "Why *do* the results turn out that way?" Adrian stood silent, wearing a sphinxlike [sic!] smile. Mac Lane, furious, pounded on the table. "Adrian knows, but he won't tell us!"

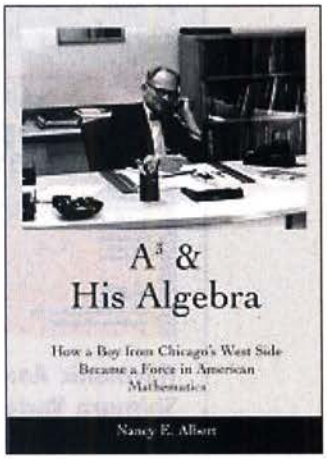
Indeed, Ms. Albert continues that her father "could not explain how he arrived at his results—they sprang from an intuition he could not put into words."

Mac Lane, on the other hand, was a talented, even great, expositor who attempted to explain what was behind results. Surely, one of Mac Lane's greatest and most lasting achievements, in exposition, is *A Survey of Modern Algebra*, written with Garrett Birkhoff. This book, first published in 1941, has had a lasting impact on the undergraduate algebra curriculum. There's really little reason not to use it today. Sure, mappings are written on the right—this might even be popular nowadays—and the vocabulary is a little too rich for current students, but the book presents the material clearly, with good examples and exercises. It even begins with the integers and rings—more familiar and intuitive than groups.

Mac Lane points out that Birkhoff and he expended a considerable effort in writing the book, but that it didn't "weigh against me at Harvard" when his promotion to tenure was being considered, unlike the current situation where "the time taken from their research would negatively affect their chances for promotion."

Mac Lane returned to Chicago, for good, after the war (he had been there several times previously in various roles), recruited by his former Harvard colleague Marshall Stone. The story of the "Stone Age" in the Chicago mathematics department has been told many times, so we won't go into it here. Mac Lane succeeded Stone as chairman in 1952, and Albert followed Mac Lane in 1958. The department during the late 1950s suffered some severe losses: Weil went to the Institute in Princeton, Chern and Spanier to Berkeley. Mac Lane also tells a revealing story about an attempted hire early in his term. The department proposed Felix Browder for an assistant professorship that was turned down by the administration. The reason, though not explicitly stated, was that Browder's father Earl had been the head of the Communist Party of the USA. Mac Lane considered resigning in protest, but Stone persuaded him not to. Browder eventually did go to Chicago and served a couple terms as chair.





Mac Lane and Albert devoted substantial effort to public service. Albert played an important role in the early days (the early to middle 1950s) of the National Security Agency (NSA) and its predecessor, the Armed Forces Security Agency (AFSA); in the founding of the Institute of Defense Analyses (IDA); and, more generally, in the country's efforts in cryptology. In particular, he directed some of the early summer programs, SCAMPs, where academic mathematicians and mathematicians from IDA and NSA collaborated on cryptological problems. No one seems to know for sure what SCAMP stands for. It could be Southern California Applied Mathematics Project, as Nancy Albert would have it, or Special Committee Advising in Mathematics with a "P" added for, ah, euphony. SCAMP continues to this day.

The importance of mathematicians in cryptology is nowadays taken for granted; this was not always the case. It was the work of mathematicians during World War II that made it clear that mathematics was indispensable in cryptology. Albert made important contributions during the 1950s to shift register algebra (linear recursive sequences)—and he showed the engineers a thing or two! The theory that developed from this, over the years, can be seen in spread spectrum cell phone technology, for example.

Mac Lane concentrated his efforts on the National Academy/National Research Council where, among other activities, he was deeply involved in ensuring that NRC reports were accurate and of high quality. In later years, he cast a skeptical eye on current academic fads like the drive to linearly order institutions, faculty, departments, etc. through "studies" and "surveys."

This reviewer was a student at Chicago from 1959–1965. Albert was, during this time, already chair and then dean of the Division of Physical Sciences—he was "Aleph, Aleph, Aleph—the Cardinal of Eckhart". (Eckhart was home to both the mathematics department and the Divisional offices.) Mac Lane, however, was still deeply involved with teaching at all levels. Remarkably, he made time even for the occasional confused undergraduate like me. He cared.

At some point, Norman Steenrod was visiting Chicago for a quarter and observed that we students

were taught lots of mathematics but only rarely how to go about research. Steenrod organized a series of talks by faculty on how they attacked a problem. There was one ground rule: no faculty could attend any other faculty member's talk without permission. I recall the talks of Steenrod, Kaplansky, Herstein, Calderon, and, of course, Mac Lane. Mac Lane emphasized hard work (he'd work through the night with Eilenberg sometimes!). Someone, somewhere, has sketchy notes of these talks.

Both books are marred by errors in chronology, spelling, and grammar. A good editor would have served both authors well. Some fact checking would have been useful as well. Too often both books lapse into a sort of expanded CV/Christmas letter mode. The most serious, and misleading, mistake is in Nancy Albert's book: she writes that Nathan Jacobson didn't receive an offer from Chicago in the late 1950s/early 1960s because of questions about area and religious background. Jacobson was, in fact, offered a job, but after much consideration decided to stay at Yale. The bad old days—that gave Albert so much grief—were gone!

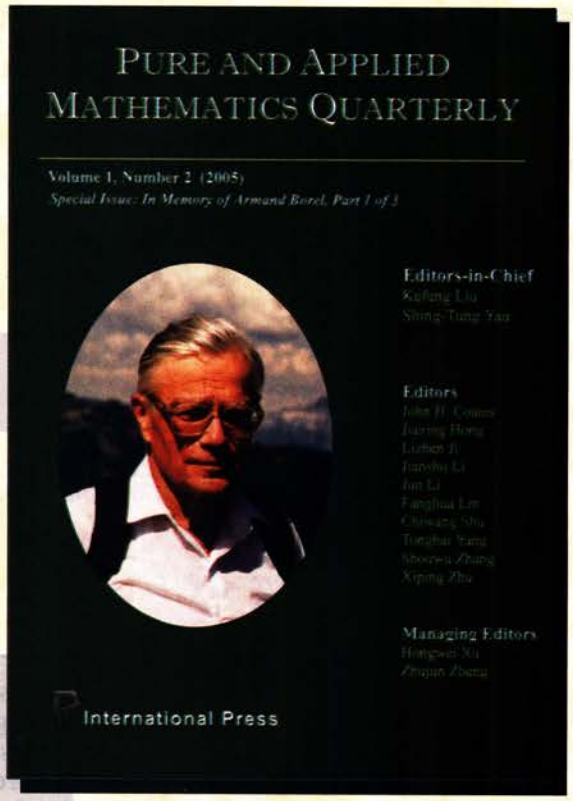
With the caveats mentioned above, I'd recommend both volumes to mathematicians, especially algebraists, who would like to see how algebra in the U.S. developed in the twentieth century and how mathematicians became increasingly involved with public policy.

One cannot read a biography without recalling the first sentence of *David Copperfield*: "Whether I shall turn out to be the hero of my own life, or whether that station will be held by anybody else, these pages must show." Adrian Albert and Saunders Mac Lane were the heroes of their own lives.

International Press

Publishing high-quality, peer-reviewed mathematics and physics journals at affordable prices since 1992

Pure and Applied Mathematics Quarterly



With the rapid development of mathematics in China, International Press is proud to announce the **debut of a premium journal** based in China. Previously named the *Quarterly Journal of Pure and Applied Mathematics* published by International Press, the *Mathematics Quarterly* publishes high-quality, original papers in all fields of mathematics. To facilitate fruitful interchanges between mathematicians from different regions and specialties, and to effectively disseminate new breakthroughs in mathematics, the journal also welcomes submissions of well-written survey articles in significant areas of research. The editors are committed to promoting the highest in mathematical scholarship.

With strong endorsement and support of mathematicians around the world, *Mathematics Quarterly* is currently preparing special issues in honor of A. Borel, J.P. Serre, F. Hirzebruch, J. Tate, F. Bogomolov, J.H. Coates, R. MacPherson, G. Margulis, and L. Simon.

Papers Published in PAMQ Include:

B.Sturmfels & S.Sullivant:	Combinatorial Secant Varieties
C.-L. Chai & F.Oort:	Hypersymmetric abelian varieties
D.Gross:	On the value of Artin L-functions
H.Jacquet:	Kloosterman integrals for GL(2, R)
H.Fan & J.Jost:	Conley Index Theory and Novikov-Morse Theory
F.Hirzebruch:	The projective tangent bundles of a complex three-fold
P.Hu & I.Kriz:	On Modular Functors and the Ideal Teichmuller Tower
T.Kobayashi & T.Yoshino:	Compact Clifford-Klein forms of Symmetric Spaces -- Revisited
W.Lueck:	The Burnside Ring and Equivariant Cohomotopy for Infinite Groups
M.Shubin & T.Sunada:	Geometric Theory of Lattice Groups
A.Schwarz & I.Shapiro:	Some remarks on Gopakumar-Vafa invariants
F.Shahidi:	Infinite Dimensional Groups and Automorphic L Functions
R.Sjamaar & V.Guillemin:	Convexity Theorems for Varieties Invariant under a Borel Subgroup
A.Lubotzky:	Finite Presentations of Adelic Groups, the Congruence Kernel and Cohomology of Finite Simple Groups
Neil S Trudinger:	On Hessian measures for non-commuting vector fields.
Claire Voisin:	A generalization of the Kuga-Satake construction

Subscriptions: $330
Issues: 4/year

Special: Mention this ad when you order all 14 International Press journals, including the new *Pure and Applied Mathematics Quarterly*, and pay only $2,195, $200 less than the regular package price.

Visit ***http://www.intlpress.com/*** for more information and ways to save.

International Press, P.O. Box 43502, Somerville, MA 02143 USA Tel: (617) 623-3601 FAX: (617) 623-3101

Science in the Looking Glass: What Do Scientists Really Know?

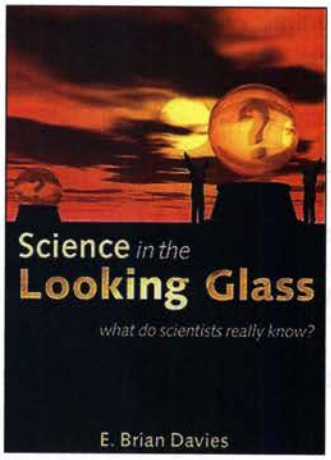
Reviewed by Martin Gardner

Science in the Looking Glass: What Do Scientists Really Know?
E. Brian Davies
Oxford University Press, 2003
288 pages, US$29.95
ISBN 0198525435

I'm not sure exactly what Brian Davies, a distinguished mathematician at King's College, London, intended the title of his fifth book to suggest. Reflect like a mirror the history and nature of science? Perhaps he also thought of his book as leading readers into a dreamlike universe as fantastic as the world Alice first entered through a rabbit hole and later through a looking glass. Whatever the intent, it is a brilliant work, beautifully written, and brimming with surprising information and stimulating philosophical speculations.

Before turning to my one caveat—unlike Davies I'm an unabashed realist who believes that mathematical objects and theorems are "out there" with a peculiar kind of reality that is independent of minds and cultures—let me go over some of the book's highlights.

Davies begins with a discussion of the uncertainties of perception. Errors of seeing are demonstrated with two amazing optical illusions. One is a ring of slash strokes that seems to rotate as the page is shifted forward and back. It is impossible, viewing the other illusion, not to be sure that one square of a checkerboard is darker than another when both are actually the same shade. Language too can be misleading. Davies does not buy Noam Chomsky's claim that there is a genetically transmitted deep "universal grammar". Interaction with environment is sufficient to account for the ability to speak. Apes failed to speak because their throats lacked the apparatus necessary for producing a great variety of sounds.



Descartes's famous effort to separate mind from body is thoroughly discredited. On the other hand, although Davies is convinced that consciousness—the awareness that one exists and has free will—is a function of a material brain, it is still a total mystery. He agrees with Roger Penrose, Oxford's mathematical physicist, that no computer made with wires and switches will ever become aware of what it is doing. Assuming that we are no more than an enormously complex pattern of molecules, Davies speculates on the possibility that our pattern could someday be scanned and transmitted to another place like the up and down beaming of characters in *Star Trek*. Can a simpler pattern, such as an apple, be so translocated?

Martin Gardner is the author of more than sixty books and wrote the "Mathematical Recreations" column for Scientific American *magazine for 25 years. He lives in Norman, Oklahoma.*

Physicists are hard at work trying to accomplish just such a feat and have actually succeeded in teleporting an atom. Transmitting a human, however, as Davies recognizes, raises profound questions about identity. After being "beamed down", would a translocated person be the same person or merely a replica? What if the technique produces two identical persons? Philosophers, notably Locke, have agonized over just such thought experiments. Hundreds of science-fiction tales have considered such possibilities. Penrose, by the way, has argued that if even an apple is transmitted, laws of quantum mechanics require total destruction of the original. When the captain of the Enterprise is beamed down to a planet, he cannot leave himself behind.

Davies's chapters on pure mathematics cover a wide range. He deals with imaginary and complex numbers and the difficulties that arise with rational numbers when they are enormously large or small. "Hard" problems like the four-color-map theorem have finally been proved, but by such monstrous computer printouts that the proof can be checked only by another computer. Goldbach's still unsettled conjecture that every even number greater than four is the sum of two odd primes has now been confirmed for numbers up to 10^{14}. This, Davies adds, "would be sufficient evidence for anyone except a mathematician."

A page is devoted to the notorious Collantz conjecture. Start with any number above 1. If even, halve it. If odd, replace it with $3n+1$. Continue doing this. If the procedure ends with 1, stop. The conjecture is that it will always stop. So far it has stopped for all n up to 10^{12}, but a proof remains elusive.

Davies reports the sensational discovery a few years ago by Manindra Agrawal and his two young assistants in Kampur, India, of a simple rapid method of testing whether a huge number is or isn't prime. The algorithm doesn't generate factors, but merely tests for primality, and does so in polynomial time! "Such discoveries," Davies writes, "are among the things which make it a joy to be a mathematician."

Several pages concern the innocent-seeming little problem of the three doors, which created such a stir when Marilyn vos Savant published it in her weekly *Parade* column. Modeled with playing cards it goes like this. Smith places three cards face down on a table. Only one card is an ace. You are asked to guess where the ace is by placing a finger on a card. Clearly the probability you guess right is $1/3$. Smith, who knows where the ace is, now turns face up a card that is *not* an ace. Two cards remain face down. Does not the probability your finger is on the ace go up to $1/2$? It does not! It remains $1/3$. If you now move your finger to the other card, the probability it rests on the ace rises to $2/3$! Savant gave a correct solution, but thousands of mathematicians who should have known better wrote angry letters attacking the solution. The event even made the front page of the *New York Times*.

Davies's chapters on the physical and biological sciences are as broad in scope and as illuminating as his chapters on mathematics. We learn about the mind-bending paradoxes of relativity and quantum mechanics, about chaos theory, continental drift, the ever-changing conjectures of cosmology, the anthropic principle, Thomas Kuhn's shaky views about science revolutions and paradigm shifts, and a hundred other topics on the frontiers of modern science.

A lengthy chapter on evolution rips apart the currently fashionable claim by defenders of "intelligent design" that the "irreducible complexity" of even the simplest life forms could not have evolved without the guidance of an intellgent designer, namely God. Davies ticks off a variety of facts that support the randomness of mutations. Why should a competent designer, he asks, bother to produce millions of dinosaurs only to allow them to vanish except for some small ones that turned into birds?

The world's vast amount of evil and suffering is evidence, Davies is convinced, that there is no transcendent deity supervising evolution. As Marlene Dietrich once remarked (my quote), "If there is a God, he must be crazy." Davies reproduces a lovely photograph of a snow crystal as evidence that natural laws combined with chance can produce intricate complexity.

I have touched on only a small fraction of the myriad of colorful accounts that Davies provides about today's science and mathematics. Let me now turn to my reasons for not accepting a basic theme of Davies's book. I refer to his constant bashing of mathematical realism, especially the vigorous Platonism of Penrose and Kurt Gödel.

First of all, I prefer the term realism to Platonism. Why? Because it avoids all the dismal controversies over such universals as goodness, beauty, chairness, cowness, and so on, that so agitated the minds of the medieval scholastics. No modern realist believes for a moment that numbers and theorems "exist" in the same way that stones and stars exist. Of course mathematical concepts are mental constructs and products of human culture. Everything persons think and do is part of culture. To say that numbers are mental constructs is to say something trivial—something no realist denies. The deeper question is whether these constructs have a peculiar, dimly understood kind of reality embedded in the universe in a way that is not mind-dependent. No human is needed to establish the fact that the geometrical shape of Aristotle's vase is inseparable from the vase. A spiral is inseparable from a spiral galaxy. The four corners of a cube can no more be detached from a physical model of a

cube than from an ideal cube. The existence of optical illusions doesn't prevent one from seeing eight corners. You can close your eyes and feel the corners.

To a realist it is a misuse of language to say that primitive humans invented integers. What they did was invent *names*, later symbols, for properties of sets of discrete things such as fingers, pebbles, and elephants—things "out there", independent of human minds. Later they discovered the laws of arithmetic because that was how pebbles behaved when manipulated. They didn't invent the Pythagorean theorem. They found it, out there, when they measured the sides of material right triangles.

If one is a theist, believing as Paul Dirac did that God is a great mathematician, or even in the pantheistic deity of Spinoza and Einstein, then the locus of mathematical reality moves to a transcendent realm outside Plato's cave. The big debate between realism and constructivism evaporates. Paul Erdős liked to refer to God's *Book* in which all the most elegant proofs are recorded. From time to time mathematicians are permitted brief glimpses into one of the Book's infinity of pages.

In a curious way, numbers may be *more* real than pebbles. Matter first dissolved into molecules, then into atoms, then into particles, which are now dissolving into vibrating loops of string or maybe into Penrose's twistors. And what are strings and twistors made of? They are not made of anything except numbers. If so, the numbers are as much "out there" as molecules. They could be the *only* things out there. As a friend once said, the universe seems to be made of nothing, yet somehow it manages to exist. As Ron Graham remarked, mathematical structure may be the fundamental reality.

No anti-realist such as Davies, and Reuben Hersh whom he admires, thinks the moon vanishes when no one, not even a mouse, is observing it. If the moon is "out there", why not admit that the moon's circumference, divided by its diameter, is a close approximation of π even before mathematicians were around to say it and will be true if humans became as extinct as dinosaurs?

To an anti-realist, π doesn't really exist outside the minds of sentient creatures. A sequence in π's decimal expansion, such as ten sevens in a row, isn't "there" until a computer calculates it. Davies tells an amusing story about how, in his book's first draft, he wondered whether a computer would ever find the sequence 0123456789 in π. To Davies's astonishment he later discovered that this sequence actually had been found. In the unlikely case that readers would like to know, the run starts at π's $17,387,594,880^{\text{th}}$ digit.

Davies takes up the question of whether one is allowed to say that somewhere in π is a run of a thousand sevens. In talking about such things, Davies, like all anti-realists, slips into the language of realism. He writes, "we can estimate how long it would take to *find* the first occurrence" (italics mine) of a run of a thousand sevens. Again: The time it would probably take "to *find* the sequence" would be "vastly longer than the age of the universe". The word "find" of course implies that the run already exists. Davies is usually careful to avoid the word "find" because it gives the game away. "A Platonic mathematician would say that either there exists [such a run] ... or there does not. This is certainly psychologically comfortable, but it is not necessary to accept it in order to be a mathematician." So comfortable, in fact, that anti-realists seldom hesitate to speak of "finding" (i.e., discovering) something when they really mean constructing it.

William James somewhere speaks of digits as "sleeping" in π until some mathematician wakes them up. It is a striking metaphor. A sleeping cat, however, has to sleep somewhere. To Davies and Hersh the uncalculated digits of π sleep nowhere. They just pop into reality when a computer "constructs" them.

Bertrand Russell, a firm realist, once wrote that $2+2=4$ even in the interior of the sun. As I have often said, if two dinosaurs met two other dinosaurs in a clearing there would have been four there even if no humans were around to observe them. The equation $2+2=4$ is a timeless truth, valid in all logically possible worlds because it is what philosophers since Kant have called *analytic*. Given the axioms of arithmetic $2+2=4$ can be translated into a string of symbols which, assuming the axiomatic system's formation and transformation rules, arrive at $A=A$. Two plus two is four for the same reason that there are three feet in a yard.

Like many anti-realists, Davies drifts close to a kind of social solipsism in which even the external world fades into a hazy construction of our brains. He quotes favorably from Donald Hoffman's book *Visual Intelligence: How We Create What We See*. "Why," Hoffman asks, "do we all see the same things?" Why for instance, do we all see the same moon? Everyone I know would at once answer, "Because the moon doesn't change." Not Hoffman. His reason, so help me, is "because we all have the same rules of construction." We are not seeing a moon, out there, independent of us. We are seeing our constructions of the moon!

This is far more extreme than the opinion that $2+2=4$ because we all construct numbers the same way. To suppose that people see the same cow because they have constructed the cow by the same rules boggles my mind. They see the same cow because it *is* the same cow. "Realism," I once heard Russell say in a lecture, "is not a dirty word."

Anti-realists are fond of claiming that mathematics, like science, is never certain. Morris Kline even wrote a book titled *Mathematics: The Loss of Certainty*. On the contrary, mathematics (including formal logic) is the *only* place where there is no loss of certainty. In his book *What is Mathematics, Really?*, Hersh argues that even laws of arithmetic are uncertain by considering a hotel that is missing a thirteenth floor. Take an elevator up eight floors, then go five floors more, and you reach floor fourteen. Hersh apparently thinks this violates the equation $8 + 5 = 13$. What he has done, of course, is jump from pure arithmetic to applied arithmetic, where applications are often uncertain.

Two beans plus two beans make four beans only if you assign to beans what Rudolf Carnap called a correspondence rule. In this case the rule is that each bean corresponds to 1. In the case of Hersh's elevator, if you assume that every floor corresponds to 1, then 8 floors plus 5 floors is sure to make 13 floors. Without correspondence rules, applications of mathematical truths are indeed uncertain. Two drops of water added to two drops can make a single drop. Hersh and Philip J. Davis, in their book *The Mathematical Experience*, give an even funnier example. A cup of milk, they inform us, added to a cup of popcorn doesn't make two cups of the mixture.

Euclidean geometry is not rendered uncertain because space-time is non-Euclidean. The Pythagorean Theorem is absolutely certain within the formal system of plane geometry. There is not the slightest doubt that the angles of a Euclidean triangle add to 180 degrees. Science, on the other hand, is corrigible. Decades before Karl Popper, Charles Peirce coined the term fallibilism, and awareness that science is fallible goes back to the ancient Greek skeptics. As Hume taught us, there is no *logical* reason why the sun must rise tomorrow. For all we know there might be an unknown law of inertia that would suddenly stop the earth from rotating. This is in stark contrast with mathematics, where the uncertainty of science is incapable of inflicting injuries.

But enough about the tiresome, never-ending debate between the small minority of anti-realists and the vast majority of mathematicians, including the greatest, who take realism for granted. They do their work without the slightest anxiety over the philosophical foundations of their craft.

What I admire most about Davies is his awe before the terrible mystery of time and why the universe, as Hawking recently wondered, "bothers to exist." He is aware of how little we understand the workings of Einstein's Old One. To answer his book's subtitle, scientists "really know" a great deal but what they don't know is even vaster. Here is how this book ends:

> The full complexity of reality is far beyond our ability to grasp, but our limited understanding has given us powers which we had no right to expect. There is no reason to believe that we are near the end of this road, and we may well hardly be past the beginning. The journey is what makes the enterprise fascinating. The fact that the full richness of the universe is beyond our limited comprehension makes it no less so.

The conflict between realists and their critics may come down finally to the choice of a language that is the least confusing. As President Clinton famously said, it all depends on what the meaning of *is* is.

WHAT IS . . .

a Random Matrix?

Persi Diaconis

When I became a professor at Harvard, David Kazhdan was running a "basic notions" seminar—things every graduate student (and perhaps also faculty member) should know. He asked me to give a talk on "what is a random variable." Since a random matrix is a random variable taking values in the space of matrices, perhaps it's good to start with random variables.

I was surprised by Kazhdan's request since "everybody knows" that a random variable is just a measurable function

$$X(\omega) \text{ from } \Omega \text{ to } \mathcal{X}.$$

He answered "yes, but that's not what it means to people working in probability" and of course he was right. Let us consider the phrase

Pick a random matrix from Haar measure on the orthogonal group O_n

Here O_n is the group of $n \times n$ real matrices X with $XX^T = id$. Most of us learn that O_n has an invariant probability measure μ, that is, a measure on the Borel sets A of O_n such that for every set A and matrix M

$$\mu(A) = \mu(MA),\ \mu(O_n) = 1.$$

Let me tell you how to "pick X from μ." To begin with, you will need a sample Y_{ij} of picks from the standard normal density (bell-shaped curve). This is the measure on the real line with density $\frac{e^{-x^2/2}}{\sqrt{2\pi}}$. Even if you don't know what it means to "pick Y_{ij} from the normal density," your computer knows. You can just push a button and get a stream of independent normal picks.

Now things are easy. Fill up an empty $n \times n$ array with Y_{ij}, $1 \le i, j \le n$. Turn this into an orthogonal matrix by applying the Gram-Schmidt algorithm; make the first row have norm one, take the first row out of the second row and then make this have norm one, and so on. The resulting matrix X is random (because it was based on the random Y_{ij}) and orthogonal (because we forced it to be). Using the orthogonal invariance of the normal distribution it is not hard to prove that X has the invariant Haar measure

$$\text{probability}(X \in A) = \mu(A).$$

Let us now translate the algorithmic description of a random orthogonal matrix into random variable language. Let $\Omega = \mathbb{R}^{n^2}$. Let $\mathcal{X}$ be the orthogonal group. The Gram-Schmidt algorithm gives a map $X(\omega)$ from almost all of Ω onto $\mathcal{X}$. This $X(\omega)$ is our random variable. To prescribe its probability distribution, put product measure of $\frac{e^{-x^2/2}}{\sqrt{2\pi}} dx$ on $\mathbb{R}^{n^2}$. The push forward of this measure under the map X is Haar measure μ.

Often, one is interested in the eigenvalues of the matrix. For orthogonal matrices, these are n points on the unit circle. Figure 1a shows the eigenvalues of a random 100×100 orthogonal matrix. While there is some local variation, the eigenvalues are very neatly distributed. For contrast, Figure 1b shows 100 points put down independently at random on the unit circle. There are holes and clusters that do not appear in Figure 1a. For details, applications and a lot of theory supplementing these observations, see Diaconis (2003).

So far, I have answered the question "what is a random orthogonal matrix?" For a random unitary matrix replace the normal distribution on $\mathbb{R}$ with the normal distribution on $\mathbf{C}$. This has density $\frac{e^{-|z|^2}}{\pi} dz$. We choose a random complex normal variable Z on a computer by choosing real independent normals Y_1 and Y_2 and setting

Persi Diaconis is the Mary V. Sunseri Professor of Statistics and Mathematics at Stanford University.

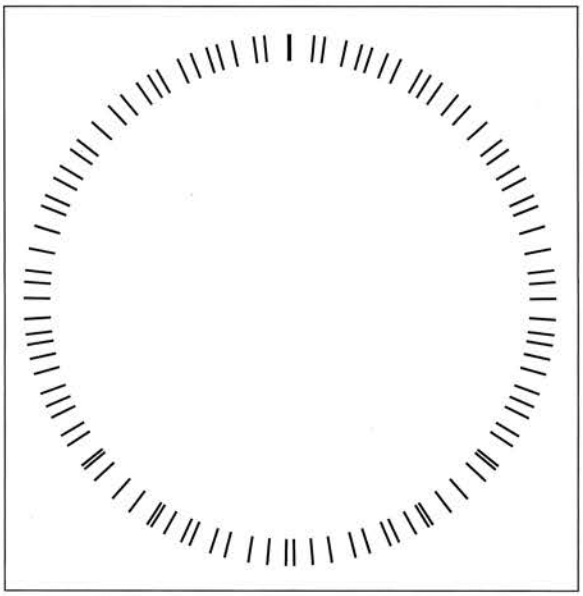


Figure 1a. Eigenvalues of a random orthogonal matrix.

Figure 1b. Random points on the circle.

$Z = \frac{1}{2}Y_1 + i\frac{1}{2}Y_2$. For a random symplectic matrix, use the quaternions and $Z = \frac{1}{4}(Y_1 + iY_2 + jY_3 + kY_4)$. Random matrices in orthogonal, unitary, and symplectic groups are called the classical circular ensembles in the physics literature.

There are also noncompact ensembles; to choose a random Hermitian matrix, fill out an $n \times n$ array by putting picks from the standard complex normal above the diagonal, picks from the standard real normal on the diagonal, and finally filling below the diagonal by using complex conjugates of what is above the diagonal. This is called GUE (the Gaussian unitary ensemble) in the physics literature because the random matrices have distribution invariant under multiplication by the unitary group. There are other useful ensembles considered in the classical book by Mehta (2004). One of the interesting claims argued there is that only three universal families (orthogonal, unitary, and symplectic) need be considered; many large n problems have answers the same as for these families, no matter what probability distribution governs the matrices involved.

Historically, random matrix theory was started by statisticians studying correlations between different features of a population (height, weight, income...). This led to correlation matrices with (i, j) entry the correlation between the ith and jth features. If the data was based on a random sample from a larger population, these correlation matrices are random; the study of how the eigenvalues of such samples fluctuate was one of the first great accomplishments of random matrix theory. These values and the associated eigenvectors are a mainstay of a topic called "principle components analysis". This seeks low-dimensional descriptions of high-dimensional data; it is widely used across applied areas from psychology to oceanography and is a crucial ingredient of search engines such as Google. See Diaconis (2003) for more details.

Physicists began to study random matrix theory in the 1950s as a useful description of energy differences in things like slow neutron scattering. This has grown into an enormous literature which has been developed to study new materials (quantum dots) and parts of string theory. There have also been wonderful applications of random matrix theory in combinatorics and number theory. One can find the literature on all of these topics by browsing in Forrester et al (2003).

Returning finally to random matrices as mathematical objects, the reader will see that we have been treating them as "real" rather than as abstract mathematical objects. From a matrix one passes to the eigenvalues and then perhaps to a spectrum renormalized to have average spacing one and then to the histogram of spacings. All of this is mechanically translatable to the language of measurable functions. However, this is a bit like working in assembly language instead of just naturally programming your Mac. Random matrix theory has evolved as the high order descriptive language of this rich body of results.

References

P. Diaconis, Patterns in Eigenvalues: The 70th Josiah Willard Gibbs Lecture, *Bull. Amer. Math. Soc.* **40**, 155–178 (2003).

P. Forrester, N. Snaith, and V. Verbaarschot, Introduction Review to Special Issue on Random Matrix Theory, *Jour. Physics A: Mathematical and General* **36**, R1–R10 (2003).

M. Mehta, *Random Matrices*, 3rd Edition, Elsevier, Amsterdam. (2004).

Whither Mathematics?

Brian Davies

Introduction

During most of the twentieth century there was remarkable agreement about the right way to present results in (pure) mathematics. The subject consisted of a list of theorems, each of which was proved from an underlying set of axioms using what were called rigorous arguments. In a few cases, such as Peano arithmetic, the truth of the axioms seemed self-evident, but in many cases they simply defined the domain of discourse. For mathematicians, talking as mathematicians rather than as amateur philosophers, philosophical distinctions between the invention and discovery of new concepts did not affect the way they practised their subject.

In this paper we will argue that developments of the classical Greek view of mathematics do not adequately represent current trends in the subject. It proved remarkably successful for many centuries, but three crises in the twentieth century force us to reconsider the status of an increasing amount of current mathematical research.

The apparent consensus among mathematicians *as mathematicians* stands in stark contrast to the disagreements between those studying the philosophy of mathematics. This subject has been dominated by a single issue. This concerns the peculiar status of mathematical objects: if one maintains that they exist in some Platonic realm, it seems impossible to give any account of how we, as creatures embedded in space and time, can come to know about them. The argument that we may have no access to these objects but can nevertheless work out what they are like by the use of our reasoning powers is unconvincing for the following reason (among others): we could apparently follow exactly the same lines of reasoning about the properties of and relationships between mathematical entities even if the Platonic realm did not exist. Whole books have been devoted to the discussion of the relationship between ontology and epistemology in mathematics, but it is fair to say that agreement about its solution is not imminent [5], [6], [25], [26].

Brian Davies is professor of mathematics at King's College London. His email address is E.Brian.Davies@kcl.ac.uk.

Mathematicians as amateur philosophers are no more agreed about the status of their subject than are philosophers. As representatives of many others we cite Roger Penrose as a committed realist (i.e., Platonist) [20], [21] and Paul Cohen as an anti-realist [12], [13]. Einstein was clear that mathematics was a product of human thought and that, as far as the propositions of mathematics are certain, they do not refer to reality [16]. The author of the present article has always been critical of Platonism [14]; he now fully accepts the existence of mathematical entities, but only in the Carnapian sense [15]. This allows mathematical theories to be products of the human imagination, but nevertheless to have definite properties just as chess and Roman law do; it also allows numbers to exist in the same sense as the black king does in chess. Fortunately mathematicians *as mathematicians* do not need to refer to their philosophical beliefs, and hence can achieve a large degree of agreement amongst themselves. This agreement is, however, not total: constructivists adopt a strict, algorithmic notion of existence that is more acceptable to applied mathematicians, numerical analysts, and logicians than it is to most pure mathematicians [7], [8], [9], [15].

Kurt Gödel's astonishing insights in the 1930s created the first of the three crises to which we refer. He demonstrated that within any sufficiently rich axiomatic system there must exist certain statements that cannot be proved or disproved. He also established that the consistency of arithmetic was not provable. There have been many discussions of his work, but these frequently involve implicit philosophical assumptions on the part of the writer. For example, the belief of Gödel himself that the continuum hypothesis must be either true or false independently of whether we can prove this fact reveal his wholehearted commitment to Platonism in mathematics. Gödel's theorems are technical in nature and do not establish that there is a fundamental distinction between truth and provability in mathematics without the insertion of extra philosophical assumptions.

It might be thought that Gödel's attitude towards his own results must be of great significance, but he was a somewhat eccentric figure; his argument that one can have the same confidence in mathematical intuition as in sense perception does not sit happily with the consensus of psychologists that sense perception is heavily dependent on constructions within the human mind [11], [14, p. 38]. Other giants in the field have taken quite different attitudes. For example, Paul Cohen, who eventually proved the independence of the continuum hypothesis, did not share Gödel's views, believing that set theory was no more than an axiomatic structure: it was not the partial description of an external entity [12], [13].

In spite of the enormous literature emphasizing the importance of Gödel's work for the foundations and philosophy of mathematics, it had very little effect within mathematics itself for several decades, excepting logic, regarded as one among many fields of mathematics. Its relevance within mainstream mathematics only emerged when it was discovered that the word problem and the isomorphism problem for finitely presented groups were algorithmically insoluble and, as a consequence, the homeomorphism problem for 4-manifolds was also insoluble. Gradually more and more such issues have been revealed, but in spite of this, most mathematicians ply their trade exactly as they would have done if Gödel had never existed.

Since 1970 two other crises have arisen in mathematics, neither of which was anticipated, just as Gödel's work had not been. Both involve the issue of complexity: proofs that are too long and complex for anyone to be able to assert with total confidence that the theorems claimed are certainly true. These crises have not been discussed much in the philosophical literature, even though both are starting to have more impact on the way that mathematicians think about their subject than Gödel's work ever has. In October 2004 the Royal Society held a two-day discussion meeting in London on "The Nature of Mathematical Proof" to discuss possible ways of responding to them; see [10]. The meeting provided a variety of insights into the issues involved but no solutions. There was evidence of a serious communication problem between the mathematicians and computer scientists present.

At first sight it seems obvious that the "crises of complexity" that we will describe are epistemological in character and say nothing about the ontology of mathematics. On the other hand some mathematicians prefer to think of mathematics as involving a process of creation rather than discovery, just as in architecture. One is free to pursue many different ideas as long as one follows certain basic rules and need not accept that distinctions between ontology and epistemology are relevant. The crises may simply be the analogy of realizing that human beings will never be able to construct buildings a thousand kilometres high and that imagining what such buildings might "really" be like is simply indulging in fantasies.

Computer-Assisted Proofs

The first example of a major mathematical theorem that depended on computer assistance was the four-colour theorem, proved by Appel and Haken in 1976 [1], [2]. It caused great uneasiness among some mathematicians for two reasons. One was that it was considered that one could not be *certain* that a machine had performed a calculation correctly if one could not check every line of the proof by hand. At that time "proper" theorems had proofs that were agreed to be unassailable. Mistakes might occasionally occur, but they could and would be rectified with the passage of time. The other issue was that some mathematicians considered that they were not interested in *whether* theorems were true but *why* they were true. A proof that did not generate understanding was of no interest to them.

The four-colour theorem did not have any very important applications, and for a considerable time it was possible to regard it as an aberration. Perhaps it was not really very interesting after all and had only acquired fame because it was easily stated. However, as time has passed, and computers have become more available, the number of computer-assisted proofs has slowly grown. It would serve no useful purpose to enumerate all such cases, so we turn to the most recent example.

The Kepler problem is to determine the best way of packing identical solid spheres in three-dimensional space, so as to maximize their average density. The expected solution has been known for many years, and involves packing the spheres exactly as oranges are displayed in every grocer's shop. In 1998 Tom Hales announced the rigorous solution of this problem using a combination of geometrical analysis and heavy computer calculations. *Annals of Mathematics* solicited his paper and set up a team of twenty of the top experts in the field to referee the work. They started by holding a conference in Princeton to decide their strategy. As the years passed referees gradually left the team, and early in 2004 the effort of refereeing the paper had to be discontinued. The *Annals* editors decided to publish the "theoretical part" of the paper and send the computer-based part to a more appropriate journal for publication. One of the *Annals* editors, Robert MacPherson, admitted that the (unpublished) policy of the *Annals* editors for such papers had failed; see [18].

At the Royal Society meeting there were lively discussions about whether formal proofs of the correctness of programs could have made a contribution to the refereeing process. According to

MacPherson the panel did not have any member who understood the technology of program correctness proofs, so this way of increasing confidence in the computer-assisted part of the proof was not considered. The programs had not been written with the possibility of formal verification in mind, and it is generally recognized that this greatly impeded any attempt to apply such methods.

Another possibility would be to write a totally new program that implemented the ideas in the theoretical part of the proof. This was dismissed as being too much to demand of any group of referees, a statement that shows how little mathematicians appreciate the labour involved carrying through projects to completion in other areas of science, for example the Cassini space probe to Saturn. Also relevant is the fact that as the refereeing process continued it became apparent that the computations were so specific to the particular problem that they provided few insights that could be applied to other similar problems.

The Kepler problem is closely related to finding the ground state energy of a large assembly of bodies, which may have a variety of shapes and ways of interacting with each other. There is a huge number of similar minimization problems, and it is infeasible to understand the field by solving them one at a time by highly specific computations. If there is no other way perhaps most of these problems are not so interesting after all. However, the Kepler problem itself has connections with several other issues of known importance, including the theory of error-correcting codes.

On the positive side I must mention the steadily increasing use of computers, which are transforming the work of pure mathematicians. Here are a few randomly chosen examples, which fall into several different categories. Computer algebra can transform hopelessly lengthy calculations and has been used extensively in various fields. The investigation of chaotic dynamical systems could not have progressed without the possibility of numerical experimentation; it is true that the existence of chaotic phenomena was discovered by Henri Poincaré at the end of the nineteenth century, but progress in understanding the subject had to wait for the development of computers. The enormous differences between the spectral behaviour of self-adjoint and non-selfadjoint matrices came to light as a result of numerical experiments and has spawned the new field of pseudospectra, which is now being studied as an area of rigorous mathematics in its own right [28].

Controlled numerical calculations are also playing an essential role as intrinsic parts of papers in various areas of pure mathematics. In some areas of nonlinear PDE, rigourous computer-assisted proofs of the existence of solutions have been provided; [22] and [23] provide typical examples. These use interval arithmetic to control the rounding errors in calculations that are conceptually completely conventional. The key is to provide a rigourous proof of an inequality that is then used as a vital ingredient in the proof of the theorem. In principle the calculations could be done by hand, but in practice this would be quite impossible.

Formal Verification of Proofs

Anyone who has written even short computer programs knows that they are much less forgiving than mathematics. Tiny errors of syntax are caught by the compiler and stop the program completely. The multiple uses of variable labels do not stop the program running, but they are usually easily detected by the fact that the output is rubbish. Mathematical errors are often detected by running the program on a very simple problem of the same type, to which the solution is already known. Varying the parameters of the problem allows one to check that the effects are as expected. Possible errors or inaccuracies in standard routines built into a software package are more difficult to detect, since the effects are likely to be small or infrequent. Nevertheless programs of only a few hundred lines in length can be extremely powerful aids to mathematicians, and experience shows that they can be made to function as expected after some debugging. The real problems occur with *much* bigger programs and are a major problem: the British Civil Service recently had to resolve a flawed software upgrade that stopped the work of an entire department for almost a week.

The formal verification of software packages is simultaneously an area of applied logic and a business. The increased reliability of Windows XP has been achieved with the aid of powerful program analysis tools, which are themselves based on the mathematics of program correctness which was originally explored with the goal of formal verification. However, in some respects the problem faced by computer scientists is quite unlike that faced by mathematicians. The specification of some software, such as Java, may run to more than a hundred pages, far longer than would be acceptable for the statement of a theorem. It is not clear in some cases whether unexpected behaviour of a software package should be called a bug or a feature. Crashes, often caused by buffer overflows, are clearly the consequences of design faults, but one cannot say the same of the refusal of LaTeX to allow the user to do something that the designers never thought of. Inadequate specifications of large software projects are a much more common cause of commercial disasters than incorrect implementations of the specifications.

The proven value of formal proofs of correctness in the software context has encouraged some computer scientists to try to apply the same methods to mathematics, but this is, at present, an immature field. The following comments indicate that there are likely to be serious difficulties in implementing formal proofs of correctness in my area of analysis. They may well not be so relevant to other fields, such as logic or algebra, but I leave such judgements to others. I give some details in order to provide some feeling for the issues, but these are not essential. Almost every proof of a theorem in analysis alludes to external facts that are frequently not spelled out because they are assumed to be a part of the background of the reader. A paper might well start by stating that it intends to study the spectral theory of the Laplacian on a bounded Euclidean region subject to Dirichlet boundary conditions. There are hundreds, possibly thousands, of papers even on this tiny subject, and the writer will assume a familiarity with a substantial part of the literature. On some occasions he will refer to papers containing recent results that he considers the reader might not know about, but in many cases he will use older results without reference, confident that almost everyone who is well enough educated to want to read the paper will already know these.

There are real traps into which one can fall, and people sometimes do fall into them. When using a particular result it is possible to forget that there are often many versions of a theorem in analysis, with similar conclusions, but depending on different technical hypotheses. Monographs often make standing hypotheses, which are mentioned at the start of some section or chapter, but not anywhere near the statement of the theorem being quoted.

It is commonplace to justify a step in a proof by reference to some classical result for which no reference is given. I was challenged recently by one of my students in relation to Mercer's theorem. Mercer's original version referred to kernels on a one-dimension interval, but I was using a more general version of the theorem without explanation. When he asked me to justify my comment I was unable to find a statement of the theorem in the literature that was sufficiently general to cover the application that I was making. After looking through a half dozen books I eventually decided to write out the proof. It was obvious to me, and would have been to anyone who had read the original proof in sufficient detail, that the classical restriction to an interval was unnecessary, but it nevertheless took me four pages to describe and prove a sufficiently general form of the result. I did not regard this as a serious gap, in the sense that I was confident throughout that the result needed was correct, and that it would be obtained by extracting the core of Mercer's argument. The student ended up satisfied.

It seems that mathematics is carried in people's heads, and that it is malleable in the sense that experts "know" almost instinctively whether it is possible to modify standard theorems to fit the context being discussed; perhaps this is the definition of an expert. Every now and again someone summons up the energy to write out a fairly comprehensive account of a field as a monograph. This provides a huge service, by giving a systematic account of a field to which one can then refer. Very frequently it also misrepresents the literature somewhat, because an author is almost bound to adopt a particular, uniform context in his monograph, and many of the theorems that he proves will be true under weaker conditions.

Finite Simple Groups

The third crisis that we discuss is also one concerning complexity, but it is in some ways more serious. Since it does not involve computers, we cannot dismiss it simply by declaring computer-assisted proofs illegitimate, i.e., not a part of what we call pure mathematics. In addition, the example that I will describe involves one of the most central concepts in mathematics: group theory.

During the 1970s more than a hundred group theorists came together in a consortium devoted to classifying all finite simple groups. The task was a massive one and provided what is still the only example of industrial scale pure mathematics. Under the leadership of Daniel Gorenstein the problem was broken up into smaller packages that were entrusted to various groups around the world. Intensive work over ten years led to a complete list of all finite simple groups: three infinite families, together with twenty-six sporadic (i.e., exceptional) groups. The existence of the largest of these, the so-called Monster, was only proved with the aid of a computer. Fortunately we can discuss the crisis surrounding this problem without knowing what the classification is, and without even knowing what a finite simple group is.

What happened after 1980 has been as interesting as the classification itself. One positive development in this period was the discovery of a method of avoiding the use of computers in the proof of the existence of the Monster. It was appreciated that the work of the different groups needed to be integrated into a single coherent account, but attempts to do this led to the discovery of many gaps in the proofs. Many of these were patched up, but one seemed very serious, and in 1990 claims that the classification was complete had to be reconsidered. Eventually this gap was also filled by Aschbacher and Smith and, once again, it seems likely that the proof is sound [3]. However only about five out of the twelve volumes of the

final proof have been published, almost twenty-five years after the theorem was "proved"; see [3], [27] for details. Michael Aschbacher, one of the people most heavily involved in the project, admits the possibility that a new finite simple group might one day be discovered. If that group has characteristics sufficiently similar to the others, this might not be too disturbing, but he accepts that the discovery of a new finite simple group quite different from the others would throw the problem wide open again; see [4]. Note that Jean-Pierre Serre is also very cautious about accepting the proof [24].

Aschbacher has noted that the proof seems to be robust. By this he means that every gap so far discovered can be plugged with only a moderate amount of extra work, leaving the main lines of the proof unaffected. Unfortunately, this does not imply that the result is correct. A chain is as strong as its weakest link, and the fact that every faulty link has so far been replaced by a sound one provides no guarantee that it will remain so. If one thinks that the proof is more like a web, in which flaws in many threads would not jeopardize the integrity of the whole, then it is possible that the web contains a large enough hole for a fly to escape through it. Most flies might be caught by the web, but not necessarily all.

The idea of comparing mathematical knowledge to a web of interrelated facts de-emphasizes the role of linear logic in favour of the confidence associated with a highly redundant structure. This is not a new idea, but it has not been emphasized by mathematicians much until recently. Aschbacher uses a related analogy in [4], invoking the paradigm of biology as an information-rich subject in which there is an overabundance of different ways of organizing the data, and contrasting this with "classical mathematics".

The completion of the classification project (in the sense of the publication of a connected account of the entire calculation) is threatened by the attrition of the leading players by death and retirement. Within ten years most of them may have stopped working, and there may well be too few left with the necessary deep understanding of the subject to complete the task. Even if the project is brought to a conclusion, it is likely that fewer than a dozen mathematicians will be able to claim a reasonably comprehensive understanding of the main lines of the proof.

We have thus arrived at the following situation. A problem that can be formulated in a few sentences has a solution more than ten thousand pages long. The proof has never been written down in its entirety, may never be written down, and as presently envisaged would not be comprehensible to any single individual. The result is important, and has been used in a wide variety of other problems in group theory, but it might not be correct.

It is of course possible that a much simpler approach to this particular classification problem will one day be discovered, but it is equally possible that it will not. Aschbacher is pessimistic about the existence of a moderately simple proof, observing that the estimated overall length of the (still unwritten) proof has not decreased much over the last quarter century. It follows from Turing's work that there are theorems whose proofs are far longer than their statements: indeed the ratio of the two lengths can be arbitrarily large. According to Cohen "the vast majority of even elementary questions in number theory, of reasonable complexity, are beyond the reach of any reasoning" [13]. So we have to anticipate that more and more such results will be discovered as time passes.

The Consistency of Arithmetic

In this section we argue that the existence of simple statements that have extraordinarily long proofs may be of great importance. Gödel taught us that it is not possible to prove that Peano arithmetic is consistent, but everyone has taken it for granted that *in fact* it is indeed consistent.

Platonistically-inclined mathematicians would deny the possibility that Peano arithmetic could be flawed. From Kronecker onwards many consider that they have a direct insight into the natural numbers, which guarantees their existence. If the natural numbers exist and Peano's axioms describe properties that they possess then, since the axioms can be instantiated, they must be consistent. Often this is dressed up with references to the expected or intended model of Peano's axioms, but expectations or intentions do not by themselves settle anything.

When we delve into history we see many reasons for doubting claims for certainty, even in mathematics. For many centuries it was thought self-evident that Euclidean geometry necessarily provided the correct description of space, but eventually Riemann and then Einstein proved this wrong. The status of the axiom of choice is usually regarded as unproblematical nowadays, but there was a vigorous debate early in the twentieth century about its acceptability. Even its inventor, Zermelo, eventually agreed that the most compelling reason to accept it was the fact that without it mathematicians could not prove large numbers of results that they needed; see Maddy [19, p. 56]. These doubts have not been resolved, but merely forgotten, by most of the community. We finally mention that Hilbert's confidence about the possibility of resolving all mathematical problems was shared by most of his contemporaries, until Gödel showed that it was unfounded.

It is, in fact, logically possible that Peano arithmetic is internally inconsistent. There is no evidence for this, and we do not claim that it is likely to be

inconsistent, only that it is possible. To investigate this idea further we consider an example from group theory. Consider the following list of axioms.

(1) G is the set of elements considered, and it is supposed that the elements obey the group axioms.

(2) G is supposed to be finite but not isomorphic to any of the known list of finite simple groups.

(3) G is supposed to be simple. In other words, if N is a subset that has a certain list of properties (those of a normal subgroup other than the trivial subgroup), then $N = G$.

These axioms can be compared to those of Peano arithmetic. The last is similar in form to the induction axiom (or axiom schema in first order logic) in that it refers to an unspecified set with certain properties, and concludes that it is equal to G (we assume that one can switch back and forth between subsets and predicates). Although G is assumed to be finite, its size is not specified, so one cannot simply enumerate all objects of the above type, however long the time given: the only way of understanding the axiom system is via proofs.

The fact that an axiom scheme so similar to Peano arithmetic might require such a long proof of its inconsistency (if indeed it is inconsistent, as most group theorists believe) provides a reason why we cannot be absolutely sure of the consistency of Peano arithmetic itself. Perhaps the shortest proof of an inconsistency in Peano arithmetic is one hundred million pages long, and we will never discover it. If we were never led into a contradiction, would the inconsistency matter? We could continue to prove theorems and derive interesting interconnections between ideas without ever suspecting the awful truth.

Such a situation need not imply that our efforts were worthless. There are many examples in the past in which contradictions in axiom systems, or counterexamples to theorems, once pointed out, have been rectified. A famous book of Imre Lakatos is a celebration of the ability of mathematicians to respond to counterexamples to a sequence of flawed statements of Euler's theorem [17]. The most famous inconsistency was in Frege's foundations of mathematics, to which Bertrand Russell found a paradox. Within twenty years the ZFC set theory removed these particular problems, although at some cost in terms of elegance. Interesting mathematics (certainly in the field of analysis) is remarkably tolerant of changes in the axiomatic framework, and can often be rescued from technical errors, possibly after changing or increasing the number of assumptions.

Discussion

It seems to the author that the prospects for a complete proof of the Kepler problem are better than they are for the classification of finite simple groups. One day the programs may be rewritten in a form that permits a formal proof of the correctness of Hales' theorem. In the Royal Society meeting some mathematicians repeated the well-known argument that this would still not be satisfactory, because computer programs are fallible, computer hardware is fallible, and anyway the computer might be hit by a cosmic ray during the computation. These statements are obviously correct, but it would be absurd to think that similar criticisms do not apply to human-generated proofs, particularly in the light of the finite simple group experience. All one can ask of the formal computer verification of proofs is that they perform better than human beings, in the sense that they find mistakes in proofs that humans have missed and that humans recognize once they are pointed out. In the field of software and chip design verification this has already happened, and it is to be expected that it will become more common in mathematics itself.

A number of mathematicians are very concerned about where this revolution is leading us. If the goal of mathematics is understanding, then one cannot deny that computer-assisted proofs do not supply it in full measure. But neither does the proof of the classification of finite simple groups. In both cases the proofs are only locally checkable, and this provides no guarantee of global correctness. Many mathematicians find the prospect of losing this understanding abhorrent, and their best remedy is to stick to fields in which such methods are not yet needed. Fortunately there are vast swathes of the subject that remain ripe for development by traditional methods, so they need not worry too much that their contribution will become unnecessary within the foreseeable future.

Taking an historical perspective, we can see that once the number of mathematicians became large enough, they were almost bound to start producing a quantity of mathematics that could only be validated at a collective level. Combine this with the development of ever more sophisticated computer software, and the possibility of individuals being able to understand all aspects of a complex proof was certain to vanish. The twentieth century provided both of these conditions for the decisive and irreversible change in the nature of mathematical research. Pure mathematics will remain more reliable than most other forms of knowledge, but its claim to a unique status will no longer be sustainable. It will be seen as the creation of finite human beings, liable to error in the same way as all other activities in which we indulge. Just as in engineering, mathematicians will have to declare their degree of confidence that certain results are reliable, rather than being able to declare flatly that the proofs are correct. Hilbert's goal of achieving perfect certainty by the laying of firm foundations

died with Gödel's work, but the problem of complexity would have killed his dreams with equal finality fifty years later.

We finally ask if there are further crises still to be faced. One possibility is the discovery of a contradiction in a mathematical argument whose complexity is beyond any yet contemplated. One might imagine that the contradiction is the result of a mistake that is too deep for us to be able to locate it, even with the aid of computers. This may seem farfetched, but a somewhat similar problem has already arisen in computer chess programs, which occasionally make moves for which the best chess grandmasters can find no rationale. The computer can, of course, only declare that the said move yielded the highest score out of billions of combinations that it had considered. This does not imply that the move is indeed the best in the given position, because the method of scoring positions is derived from human advice. If such a scenario materializes, we may finally have to admit to limits on what our species can aspire to in the mental realm, as well as in other types of activity.

Whether or not these prognostications prove correct, the future of pure mathematics is certain to be very different from its past. In 1875 every sufficiently able mathematician could fully absorb the proof of most theorems that existed within a few months. By 1975, a year before the four-colour theorem was proved, this was not even close to being true, but it was still the case that some mathematicians fully understood the proof of any known theorem. By 2075 many fields of pure mathematics will depend upon theorems that no mathematician could fully understand, whether individually or collectively. Many mathematicians will still prove theorems by traditional methods, but these will stand out as landmarks in a much broader subject. Formal verifications of complex proofs will be commonplace, but there will also be many results whose acceptance will owe as much to social consensus as to rigorous proof. Perhaps by then the differences between mathematics and other disciplines will be so much reduced that philosophical discussions of the unique status of mathematical entities will no longer seem relevant.

Acknowledgements

I should like to thank M. Aschbacher and C. A. R. Hoare for valuable advice.

References

[1] K. Appel and W. Haken, Every planar map is four colorable. Part I, Discharging, *Illinois J. Math.* **21** (1977), 429–490.

[2] ——, Every planar map is four colorable. Part II, Reducibility, *Illinois J. Math.* **21** (1977), 491–567.

[3] M. Aschbacher, The status of the classification of the finite simple groups, *Notices Amer. Math. Soc.* **51** (2004), 736–740.

[4] ——, Highly complex proofs and implications of such proofs, in [10].

[5] J. Azzouni, *Deflating Existential Consequence*, Oxford Univ. Press, Oxford, 2004.

[6] M. Balaguer, *Platonism and Anti-Platonism in Mathematics*, Oxford Univ. Press, Oxford, 1998.

[7] E. Bishop, *Foundations of Constructive Analysis*, McGraw-Hill, 1967.

[8] ——, Schizophrenia in contemporary mathematics (Errett Bishop: Reflections on him and his research), M. Rosenblatt, ed., Contemporary Mathematics, vol. 39, Amer. Math. Soc., Providence, RI, 1985, pp. 1–32.

[9] E. Bishop and D. Bridges, *Constructive Analysis*, Grundlehren der math. Wiss. vol. 279, Springer-Verlag, Heidelberg, 1985.

[10] A. Bundy, D. MacKenzie, M. Atiyah, and A. MacIntyre, eds., The nature of mathematical proof, Proceedings of a Royal Society discussion meeting, *Phil. Trans. R. Soc. A*, **363** (2005), to appear.

[11] C. S. Chihara, *Constructibility and Mathematical Existence*, Clarendon Press, Oxford, 1990.

[12] P. J. Cohen, Comments on the foundations of set theory, in *Axiomatic Set Theory*, Proc. Symp. Pure Math. vol. XIII, Part I, Amer. Math. Soc., Providence, RI, 1967, pp. 9–15.

[13] ——, Skolem and pessimism about proofs in mathematics, in [10].

[14] E. B. Davies, *Science in the Looking Glass*, Oxford Univ. Press, 2003.

[15] ——, A defence of pluralism in mathematics, *Phil. Math.* to appear.

[16] A. Einstein, Lecture delivered to the Prussian Academy of Sciences, January, 1921, *Ideas and Opinions*, Crown Publ. Inc., New York, 1982, p. 233.

[17] I. Lakatos, *Proofs and Refutations: The Logic of Mathematical Discovery*, Cambridge Univ. Press, Cambridge, 1976.

[18] R. MacPherson, Machine computation and proof, in [10].

[19] P. Maddy, *Naturalism in Mathematics*, Clarendon Press, Oxford, 1997.

[20] R. Penrose, *The Emperor's New Mind*, Oxford Univ. Press, Oxford, 1989.

[21] ——, *Shadows of the Mind*, Oxford Univ. Press, Oxford, 1994.

[22] M. Plum, Computer-assisted enclosure methods for elliptic differential equations, *Lin. Alg. Appl.* **324** (2001), 147–187.

[23] M. Plum and C. Wieners, New solutions of the Gelfand problem, *J. Math. Anal. Appl.* **269** (2002), 588–606.

[24] M. Raussen and C. Skau, Interview with Jean-Pierre Serre, *Notices Amer. Math. Soc.* **51** (2004), 210–214. Reprinted from *European Mathematical Society Newsletter*, September 2004, pp. 18–20.

[25] M. D. Resnik, *Mathematics as a Science of Patterns*, Clarendon Press, Oxford, 1997.

[26] ——, Structuralism and the independence of mathematics, *Harvard Rev. Phil.* **12** (2004), 40–52.

[27] R. Solomon, On finite simple groups and their classification, *Notices Amer. Math. Soc.* **42** (1995), 231–239.

[28] L. N. Trefethen and M. Embree, *Spectra and Pseudospectra*, Princeton University Press, 2005, to appear.

The Mathematics Survey Project

Jim Pitman and David Aldous

Electronic journals, arXiv, Google Scholar, MathSciNet, and Wikipedia are just some of the existing venues for electronic publishing and searching of mathematics. But the level between graduate textbooks and research papers is not well served at present. We propose two parallel initiatives: creation of a network of open access survey journals across all areas of mathematics and creation of a network of websites on particular topics (e.g., bottom-level MSC topics), with each site maintained by an expert editor using the ease of modern software tools to provide both an "encyclopedia entry" for the topic and updated links to electronic resources. An initial journal, *Probability Surveys,*[1] is already in operation.

Mathematical Publication Today

Textbooks and monographs on one side and peer-reviewed research journals on the other side are the most familiar categories of mathematical publication. They have not changed in essence for 50 or 100 years and likely will not change much in the near future—the transition of journals from paper to electronic format facilitates physical access without changing the roles of authors, referees, and editors and (as yet) without resolving contentious issues of price. But cyberspace provides the opportunity for a much broader spectrum of types of publication. One can already find online, for instance:

- unreviewed preprints;
- peer-reviewed research papers;
- peer-reviewed survey papers;
- monographs and polished lecture notes;
- lectures recorded by slide presentations, scribe notes, and videos;
- literature databases;
- retroactive digitization of old print literature;
- descriptions by individuals or groups of their ongoing research activities;
- encyclopedias at an elementary level.

We applaud this variety of content, but find three unsatisfactory features of its structure.

Cost of Journals. Commercial publishers impose ever-increasing subscription costs on their ejournals, thereby restricting access, with negligible compensating advantages.

Fragmentation. The totality of mathematical material in cyberspace is at present neither well linked together nor intelligently searchable. Seeking a readable account of Topic X, one could use a search engine like Google or MathSciNet. But Google treats a mathematics page as just another page on the Web, having no conception of the logical interrelationships of mathematics. The new Google Scholar service restricts the search to the scholarly literature, accessing the content of many copyrighted books and journals as well arXiv and other open access sources. But it is not easy to restrict such a search to expository material. MathSciNet and Zentralblatt MATH enable basic searches like "find papers by author A in subject S". But there is no resource currently available for a search like "find a survey on topic X accessible to a first-year graduate student". Designing a system which can respond to such queries seems to require more human intervention. As another instance, when you post your lecture notes on subject S, you currently have no systematic way of providing links

Jim Pitman and David Aldous are professors in the Department of Statistics, University of California, Berkeley. Their email addresses are pitman@stat.berkeley.edu *and* aldous@stat.berkeley.edu *or* mathsurv@ stat.berkeley.edu.

[1] http://projecteuclid.org/ps

to your material which make it easily accessible to someone searching for material on subject S.

Compartmentalization

Research progress continually increases the gap between research frontiers and first-year-graduate-textbook level material, and the gaps between different disciplines. Monographs help fill these gaps but we see an increasing need for survey papers. At present, writing expository survey papers carries insufficient prestige and such papers are often scattered in hard-to-find conference proceedings and expensive handbooks. Writing high-quality surveys should be encouraged to help organize mathematical knowledge in accessible form and to facilitate interdisciplinary work.

The Project

Instead of tackling each of these three difficulties separately, we have a bold proposal which attempts directly to solve the problems of fragmentation and compartmentalization, and indirectly to reduce the cost of commercial journals by promoting the value of openly accessible content. We propose the formation of a large collection of open access electronic survey journals in mathematics with articles indexed by subject for ease of access. We expect the main organization of survey journals to correspond to the different branches of mathematics, but we hope that national mathematics societies may contribute to the effort by supporting open access publishing of high-quality survey papers in all fields of mathematics.

The authors work in the field of probability, which (as measured by papers in *Math Reviews*) is about 1/25 of mathematics. We describe our plan to survey the field of probability and stochastic processes with the idea that its structure may be copied (and tinkered with) about 25 times to cover all of mathematics. The *Mathematics Survey* is our vision of such a system of surveys, one for each major branch of mathematics.

As the foundation for a survey of probability and stochastic processes, we have started the new open access electronic journal *Probability Surveys*, with support from the Institute of Mathematical Statistics and the Bernoulli Society. This is a peer-reviewed electronic journal with a basic user interface similar to that of existing ejournals such as *Geometry and Topology* and *The Electronic Journal of Probability*. Survey articles can be of various size and scope, ranging, say, from a five-page write-up of a conference talk on recent developments (or a five-page account of some unjustly neglected classical topic) to a several-hundred-page monograph. They are posted on the Web as accepted, with bundling into volumes of convenient size for Web display. Papers are to be kept in a format like PDF or its successors and are intended to be printed for reading rather than read onscreen. We note that if high-quality survey papers are provided an open access electronic outlet, they should be widely cited and hence appear near the top of a citation ranked search of scholarly articles such as now provided by Google Scholar. An open access survey journal which already exists in another branch of mathematics is *Living Reviews in Relativity*,[2] supported by the Max Planck Institute. We plan to promote the development of such journals in all branches of mathematics with the help of various organizations.

As a second *encyclopedia layer* of a survey of probability and stochastic processes, we plan to exploit the structure of the 2000 Math Subject Classification (MSC), much like David Rusin's Mathematical Atlas,[3] but eventually may allow finer subclassifications and new overlapping classifications. For instance, topics such as

- 60J: Markov processes,
- 60J80: branching processes,
- 60J80-brw: branching random walk

would conceptually be nodes of the encyclopedia layer. Initially, we imagine this to be just a tree-structured index like that provided by MPRESS[4] for preprints, which would allow the reader to easily browse lists of survey articles and other open access material classified by subject. The structure of such an index is technically quite light: a Web page for each node of the MSC can easily be generated by a script with some human-specified links, and the rest can be done by automated pointers to e.g., MathSciNet, Zentralblatt MATH, and Google Scholar. A prototype for such a distributed system of scripted Web pages, with authors instead of subjects and navigation by the author collaboration graph instead of a more complex graph describing interrelations between subjects, is provided by the BibServer[5] system. A typical subject node would initially be generated by scripted links to existing resources. As the content at a subject node expands, we intend that control over its arrangement be provided by one or more associate editors who should develop a website devoted to that subject. Such sites already exist for a relatively small fraction of subjects, and their maintainers should for the most part be willing to maintain content consistently with requirements of the navigation system. The value of such sites should be obvious enough that they will be created in areas where there is need. These sites and their maintainers would serve three interrelated purposes. First, the site would contain original content designed to be read onscreen—minimally a one page "encyclopedia entry" describing the subject, but this could be

[2] http://relativity.livingreviews.org/

[3] http://www.math.niu.edu/~rusin/known-math/

[4] http://MathNet.preprints.org/msc2000/

[5] http://bibserver.berkeley.edu/

expanded arbitrarily according to the energy of contributors. Second, the site would assemble links to related content available on the Web, including relevant papers in the survey journal and subject bibliographies. Third, the maintainers of subject specific sites would typically be willing to serve as associate editors of the survey journal.

Once this structure is set up, we expect it to quickly and automatically become the canonical place to look for links to graduate and research level mathematics: people who post material on the Web are *ipso facto* wanting others to be able to look at their material and will be happy to take one minute to transmit the link to the associate editor of the relevant node. The kind of material on the existing Probability Web[6]—links to personal home pages of probabilists, journals, conferences, etc.—would become part of the material associated with the top-level (60: Probability) node. Along with the link structure, it should be straightforward to search the collection of all sites linked to the Survey.

Is the Project Feasible?

Consider email, TEX/LATEX, and the Web. Each started with individuals yet became indispensable because their usefulness was obvious and because enough people were motivated to help implement them. Similarly, the usefulness of a *Mathematics Survey* is (we hope) obvious. But why do we expect people to contribute to it?

1. By emphasizing survey papers, for which few publication venues exist, we expect that *Probability Surveys* will quickly become the definitive place for authors to publish survey papers in probability.

2. Joining the project doesn't require a huge commitment of time or effort. If you are an active researcher, then you typically are an expert on some subject node. All that is needed to get started as an associate editor maintaining a subject site is to write a one-page description of that subject, insert it into a suitable template, and insert links to and brief descriptions of other online material on that subject. But these are all things you already know—it's just one afternoon's work.

3. Continuing this theme, most people are happy to write about their research speciality, so we hope that eventually a large proportion of active researchers will participate as subject node associate editors and will contribute occasional survey articles. Indeed, provided the quality of the survey journals is well maintained, as is in the obvious interest of the profession, being invited to edit a subject node should convey the prestige of being "an established research mathematician" akin to receiving tenure. We envisage dynamic interaction with one's professional work, in that on the occasions when one needs to write research overviews—as part of organizing a workshop, planning a monograph, assembling a research group, making a grant proposal, or giving a talk—one takes the opportunity to make the intellectual content be openly available on the Web rather than hidden in private documents.

Why This Particular Approach?

Let us imagine three different projects:
(i) a survey ejournal of mathematics,
(ii) an online encyclopedia of mathematics,
(iii) a site which indexes and searches online mathematics.
In our opinion, each project is in one sense "too big" —it's too difficult to cover all of mathematics under any centralized scheme—while being in another sense "too small", in that it would just add an extra category to the existing categories of mathematical publication in cyberspace. We are ambitious in that we are proposing all three projects at once. But we hope that the obvious synergy between these projects will sustain self-reinforcing growth into a new feature in the landscape of online mathematics. We start with probability as a demonstration because there is a reasonably small, tightly knit community of probabilists with a strong sense of the identity and importance of their subject in the larger scheme of mathematics and science (exemplified by specialist societies such as the Bernoulli Society and the Institute of Mathematical Statistics).

We think it essential that the project be perceived as being run by the mathematical community as a whole, so we expect that individuals' involvement in the project should be largely self-organizing with only a small degree of hierarchical structure. Perhaps controversially, we regard it as undesirable for the project to be controlled by any single scholarly society for three reasons. Existing mathematical societies (AMS, SIAM,...) comprise geographically- and subdiscipline-bounded subsets of the very broadly defined mathematical sciences community, and such boundaries are anachronistic in cyberspace. Societies have bureaucratic structures, which make them slow to innovate or create. And most of them derive revenue from existing publications, causing a perceived conflict of interest with the principle of free access underlying our concept. We do appreciate however that AMS has encouraged authors and editors to use its extremely useful MR Lookup[7] and MRef[8] facilities by pledging to maintain these services on an open access basis. This and other developments, such as the general support for open access provided by the European Mathematical Society through EMIS[9] and by the International Mathematical Union through

[6] http://mathcs.carleton.edu/probweb

[7] http://www.ams.org/mrlookup

[8] http://www.ams.org/mref

its CEIC[10] and Math-Net,[11] offer hope that within a few years' time a significant fraction of the mathematical literature may be navigable on the Web without gates or tolls. The mathematics survey project could only ever represent a tiny proportion of all journal publication, so it would not directly ameliorate the systemic problem of journal costs. But every successful open access project is progress toward the tipping point when expensive journal subscriptions become unsustainable.

More About the Project

1. The survey journal is intended to be noncompetitive; any submission reaching the required standard of scholarship will be accepted. Refereeing is intended to improve quality of exposition and to ensure that the paper does a reasonably complete job of surveying the subject (whether broad or narrow) that it claims to survey.

2. The encyclopedia layer is not enslaved to the MSC classification. If an individual perceives some topic as an interesting research area and can articulate that perception clearly, then he or she can create a new node for that topic in the encyclopedia layer. Indeed, as one of many barely-foreseeable side benefits of the project once established, a listing of recently-created nodes may become the best list of "hot topics" in mathematics.

3. Obviously it will be necessary to provide some technical organization of format for Web pages and the survey journal and their cross-links, but that sort of thing is becoming easier and easier to automate on a wide scale. Moreover, Web crawlers such as CiteSeer and Google Scholar do much to compensate for lack of uniformity of various sites. We seek to minimize requirements for administration of people. Being an editor of *Probability Surveys* or a sibling survey journal may entail effort and responsibility comparable to being an editor of a major research journal. We expect these sibling editors to communicate, but a formal structure seems unnecessary.

4. There is little hope for any human endeavor predicated upon 100% altruism and 0% self-interest. But with regard to self-interest, we have already mentioned prestige, added to which there is the opportunity to publicize one's own view of a mathematical area. Another aspect (addressed to U.S. readers but surely with analogs elsewhere) is that NSF (National Science Foundation) funding programs increasingly seek a "contribution to infrastructure" for individual, group, interdisciplinary and VIGRE-type grants. Involving postdocs and advanced graduate students in the writing of encyclopedia entries and survey papers can perhaps be counted as contributing to the "informational infrastructure" of the *Mathematics Survey*, as well as to "human infrastructure" in that we are training them to write well.

How to Help

The first volume of *Probability Surveys* was posted online in 2004. We hope to launch the encyclopedia layer soon. We would appreciate technical assistance with design and content management for a generic subject site. We encourage mathematicians in other fields to take the initiative of starting up sister survey journals in their fields, and we will do what we can to facilitate this process. Please contact us at `mathsurv@stat.berkeley.edu` and see `http://mathsurvey.org/` for more information about the project.

Note: A talk based on this article was given by Jim Pitman at the Special Session on Electronic Publications at the Joint AMS-SMM International Meeting, Houston, May 13, 2004. The article appears also in the volume *New Developments in Electronic Publishing of Mathematics* edited by Hans Becker, Kari Strange and Bernd Wegner, and published by Fiz Karlsruhe, 2005.

[9] `http://www.emis.de/`

[10] `http://www.ceic.math.ca/`

[11] `http://www.math-net.de/`

Coming soon

■ Automorphic Representations, L-Functions and Applications: Progress and Prospects

Proceedings of a conference honoring Steve Rallis on the occasion of his 60th birthday, The Ohio State University, March 27-30, 2003

Ed. by James W. Cogdell / Dihua Jiang / Stephen S. Kudla / David Soudry / Robert J. Stanton

October 2005. Approx. 440 pages. Cloth.
€ [D] 148.00 / sFr 237.00 / *US$ 168.00
ISBN 3-11-017939-3
(Ohio State University Mathematical Research Institute Publications 11)

The continuing vigor and diversity of research on automorphic representations and their applications to arithmetic are clearly reflected in this volume. The depth and breadth of Rallis's influence are also discussed.

The papers in this volume represent many of the most recent developments and directions.

■ Projective Varieties with Unexpected Properties

A Volume in Memory of Giuseppe Veronese. Proceedings of the international conference ‚Varieties with Unexpected Properties', Siena, Italy, June 8—13, 2004

Ed. by Ciro Ciliberto / Antony V. Geramita / Brian Harbourne / Rosa Maria Mirò-Roig / Kristian Ranestad

November 2005. Approx. XX, 380 pages. Cloth.
€ [D] 148.00 / sFr 237.00 / *US$ 168.00
ISBN 3-11-018160-6

This volume contains refereed papers related to the lectures and talks given at a conference held in Siena (Italy) in June 2004. The topic of secant varieties and the classification of defective varieties is central and ubiquitous in this volume. Besides the intrinsic interest of the subject, it turns out that it is also relevant in other fields of mathematics like expressions of polynomials as sums of powers, polynomial interpolation, rank tensor computations, Bayesian networks, algebraic statistics and number theory.

Hellmuth Kneser

■ Gesammelte Abhandlungen / Collected Papers

Hrsg. v. Gerhard Betsch / Karl Heinrich Hofmann

November 2005. Ca. XVI, 923 Seiten. 3 Abb. Gebunden.
€ [D] 248.00 / sFr 397.00 / *US$ 298.00
ISBN 3-11-016653-4

Hellmuth Kneser (1898-1973) was a mathematician of extraordinarily broad vision and insight and thus contributed to many mathematical fields of pure and applied mathematics including foundations, differential equations, operations research, and mathematics education. With the exception of two papers written in French, all of his articles were written in German. Experts in various areas have written English commentaries on aspects of Hellmuth Kneser's work, summarizing what he accomplished, describing the context of his work, and giving outlooks on its aftereffects.

Mathematics People

Bos Awarded 2005 May Prize

The International Commission for the History of Mathematics (ICHM) has awarded the 2005 Kenneth O. May Prize and Medal to HENK BOS of the University of Utrecht. The May Prize honors outstanding contributions to the history of mathematics. According to the prize citation, Bos's studies of the work of Descartes and his contemporaries and predecessors are "an exploration of what counted as good mathematics in a particular period...Henk Bos has, through his deep and insightful research, fundamentally shaped present-day understanding of the mathematics of the seventeenth century...Bos gives to this seventeenth-century material the kind of careful attention it was given by the experts when it was new." His other writings, including a collection of essays on the history of mathematics, have "effectively extended Bos's audience beyond the community of historians of mathematics to the international mathematical community as a whole."

Kenneth O. May (1915–1977) was the founding chair of the ICHM and the founding editor of the international journal *Historia Mathematica.* Born in the United States, he studied mathematics at the University of California at Berkeley but spent most of his career teaching history of mathematics at the University of Toronto, Canada. After his death, the Institute for History of Science and Technology at the University of Toronto and the International Commission on History of Mathematics honored his memory with an international prize to be awarded every four years to scholars who had made significant lifetime contributions to the history of mathematics. The award consists of a certificate and a medal cast in bronze.

Previous recipients of the Kenneth O. May Prize and Medal are: Dirk J. Struik and A. P. Youschkevitch (1989); Christoph J. Scriba and Hans Wussing (1993); René Taton (1997); and Ubiratàn D'Ambrosio and Lam Lay Yong (2001).

—Karen Parshall, University of Virginia, on behalf of ICHM

Heinrich and Liu Receive 2005 CMS Awards

The Canadian Mathematical Society (CMS) has awarded the 2005 Adrien Pouliot Award to KATHERINE HEINRICH of the University of Regina, Saskatchewan, and the 2005 G. de B. Robinson Prize to YU-RU LIU of the University of Waterloo.

The Adrien Pouliot Award is given to individuals or teams of individuals who have made significant and sustained contributions to mathematics education in Canada. Heinrich originated the Canadian Mathematics Education Forum in 1995 as a venue for people interested in mathematics education at all levels to meet and discuss issues of common interest and has been involved in the promotion of mathematics and mathematics education throughout her career.

The G. de B. Robinson Award recognizes high-quality papers published in the *Canadian Journal of Mathematics* and the *Canadian Mathematical Bulletin.* Liu was honored for her papers "A Generalization of the Turàn Theorem and its Applications" and "A Generalization of the Erdős-Kac Theorem and its Applications", both published in the *Canadian Mathematical Bulletin* in 2004.

—From a CMS announcement

NDSEG Fellowships Awarded

Thirteen young mathematicians have been awarded National Defense Science and Engineering Graduate (NDSEG) Fellowships by the Department of Defense (DoD). As a means of increasing the number of U.S. citizens trained in disciplines of military importance in science and engineering, DoD awards fellowships to individuals who have demonstrated ability and special aptitude for advanced training in science and engineering. The fellowships are sponsored by the United States Army, Navy, and Air Force.

Following are the names of the fellows in mathematics, their institutions, and the offices that awarded the fellowships: JEFFREY ARISTOFF (Massachusetts Institute of Technology), Air Force Office of Scientific Research (AFOSR); ETHAN ATKINS (Rensselaer Polytechnic Institute), AFOSR; REID BARTON (Massachusetts Institute of Technology), Army Research Office (ARO); DAMIAN BURCH (University of California at Los Angeles), AFOSR; MARGARET DOIG (University of Notre Dame), ARO; DAVID FREEMAN (University of California at Berkeley), ARO; WEI HO (Princeton University), Office of Naval Research (ONR); KENNETH KAMRIN (Massachusetts Institute of Technology), AFOSR; MICHAEL LESNICK (Brown University), AFOSR; ERIC MALM (Harvey Mudd College), ARO; HARRIS NOVER (University of Wisconsin, Madison), ONR; MELANIE WOOD (Princeton University), ONR; and BRIAN WYMAN (University of Richmond), ARO.

—From an NDSEG announcement

National High School Calculus Award

SAM BECK, a ninth-grade student at Jackson Preparatory High School, Jackson, Mississippi, has won the fifth annual National High School Calculus Student Award. In three consecutive years, Beck achieved the highest score in the state of Mississippi on the American Mathematics Competition (AMC-12). He won first place on the calculus written exam and in advanced ciphering in the 2005 state Mu Alpha Theta competition. He again placed first on the written and ciphering exams in the 2005 Mississippi School of Mathematics and Science Tournament. In academic competition sponsored by the Mississippi Private School Education Association, he won first place in algebra II (2002–2003), first place in calculus (2003–2004), and first place in history (2004–2005). He is also a violist with the Mississippi Youth Symphony Orchestra.

The National High School Calculus Student Award is a US$1,000 prize awarded by calculus.org, based at the University of California at Davis, Williams College, and Wake Forest University.

—calculus.org

Pi Mu Epsilon Student Paper Presentation Awards

Pi Mu Epsilon (PME), the U.S. honorary mathematics society, makes annual awards to recognize the best papers by undergraduate students presented at a PME student-paper session. This year, the PME held a session in conjunction with the MAA MathFest in Albuquerque, New Mexico, August 4–6, 2005. Each awardee received a prize of US$150.

The Pi Mu Epsilon awards for best presentations are sponsored by the AMS. Eight students were chosen to receive these awards. Their names, institutions, and titles of their talks follow: JASON BRINKER, St. Norbert College, "Let Me Do a Little Number"; JENNIFER CARMICHAEL, Western Oregon University, "Can You or Can't You Count Cantor?"; STEPHANIE DEACON, University of Texas at San Antonio, "Key Generation of a Group-Oriented, Threshold Cryptosystem"; DAVID GOHLKE, Youngstown State University, "Modeling Bacterial Growth in the Presence of Toxins"; ANGELA HICKS, Furman University, "Applications of Lie Symmetry Groups to Minimal Surfaces"; DAVID MARTIN, Youngstown State University, "An Alternate Demonstration of Euler's Formula"; MARIA SALCEDO, Youngstown State University, "An Introduction to Knot Theory"; and TINA SMITH, McNeese State University, "Exploring Groups with Perfect Order Subsets".

The prize for best research presentation, sponsored by the Council on Undergraduate Research, was awarded to CHANTEL BLACKBURN, Andrews University, for her paper "Finite and Infinite Configurations in the Hausdorff Metric Geometry".

—Elaine Kehoe

B. H. Neumann Awards Given

The B. H. Neumann Awards for 2005 have been awarded by the Board of the Australian Mathematics Trust to RUSSELL COAD, Australian Mathematics Competition; GEORGE HARVEY of St. Clare's College, Canberra; and ANDREI STOROZHEV of the Australian Mathematics Trust. The awards, named for Bernhard H. Neumann, are presented each year to mathematicians who have made important contributions over many years to the enrichment of mathematics learning in Australia and its region.

—Board of the Australian Mathematics Trust

Mathematics Opportunities

NRC-Ford Foundation Diversity Fellowships

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

Approximately sixty predoctoral fellowships will be awarded for 2006. The awards provide three years of support and are made to individuals who, in the judgment of the review panels, have demonstrated superior academic achievement, are committed to a career in teaching and research at the college or university level, show promise of future achievement as scholars and teachers, and are well prepared to use diversity as a resource for enriching the education of all students. The annual stipend is US$19,000, with an institutional allowance of US$3,000. The deadline for applying online is **November 17, 2005**.

Approximately thirty-five dissertation fellowships will be awarded for 2006 and will provide one year of support for study leading to a Ph.D. or D.Sc. degree. The stipend for one year is US$21,000. The deadline for applying online is **December 1, 2005**.

The postdoctoral fellowship program offers one year of postdoctoral support for individuals who have received their Ph.D.'s no earlier than January 1998 and no later than January 15, 2005. The stipend is US$40,000, with an employing institution allowance of US$1,500. Approximately twenty-four postdoctoral fellowships will be awarded for 2006. The deadline for applying online is **December 15, 2005**.

More detailed information and applications are available at the website `http://www7.nationalacademies.org/fellowships/`. The postal address is: Fellowships Office, GR 346A, National Research Council of the National Academies, 550 Fifth Street, NW, Washington, DC 20001. The telephone number is 202-334-2872. The email address is `infofell@nas.edu`.

—From an NRC announcement

EDGE Summer Program

The Enhancing Diversity in Graduate Education (EDGE) Program is a postbaccalaureate summer enrichment program designed to strengthen the ability of women and minority students to successfully complete graduate programs in the mathematical sciences.

The summer program consists of two core courses in analysis and algebra/linear algebra, a minicourse in a current area of mathematical research, short-term visitors from academia and industry, guest lectures, graduate student mentors, and problem sessions. In addition, a follow-up mentoring program and support network will be established with the participants and their respective graduate programs.

Applicants to the program should be women who either (1) have been accepted to a graduate program in the mathematical sciences or (2) have just completed their first year of graduate school in the mathematical sciences. All applicants should have completed standard junior- or senior-level undergraduate courses in analysis and abstract algebra and have a desire to earn the doctorate degree. Women who have taken time away from formal education as well as women from minority groups who fit into one

of the above two categories are especially encouraged to apply. Final acceptance to the program is contingent on acceptance to a graduate program in the mathematical sciences.

The ninth summer session of the EDGE Program will be held at the New College of Florida, Sarasota, Florida. The dates for the program are June 12 through July 7, 2006. It will be codirected by Sylvia Bozeman (Spelman College), Rhonda Hughes (Bryn Mawr College), and local program coordinator Eirini Poimenidou (New College of Florida). A stipend of US$2,000 plus room and board will be awarded to participants. Applicants chosen to participate in the program will be notified by April 14, 2006.

Applications should consist of the following: (1) a completed application form; (2) a statement describing the expected value of this program to the applicant's goals; (3) two letters of recommendation from mathematical sciences faculty familiar with the applicant's work; (4) a transcript and current resume; and (5) a list of graduate programs to which the applicant has applied, together with a ranked list of her two or three top choices.

The deadline for applications is **March 1, 2006**. Applications should be sent to: EDGE Program, P.O. Box 63, Swarthmore, PA 19081. The EDGE Program is funded by the Andrew W. Mellon Foundation. For more information visit the program's website at `http://www.edgeforwomen.org/`.

—From an EDGE Program announcement

Newton Fellowship Program

The Math for America Foundation (MfA) sponsors the Newton Fellowship Program, which trains mathematically talented individuals to become high school mathematics teachers in New York City. The fellowship provides an aggregate stipend of US$90,000 over five years; a full-tuition scholarship for a master's-level teaching program at one of MfA's partner universities; and ongoing support mechanisms, including mentoring and professional development.

Candidates should hold a bachelor's degree with substantial coursework in mathematics and should be able to demonstrate a strong interest in teaching. Applicants must be willing to commit to a five-year fellowship term in New York City. Individuals who are currently teaching, are certified to teach, or who have completed an education degree program are not eligible. Candidates must be U.S. citizens or permanent residents of the United States. The deadline for applications is **February 10, 2006**. For more detailed information, see the website at `http://www.mathforamerica.org/`.

—From an MfA announcement

News from the CRM Montreal

The Centre de Recherches Mathématiques (CRM) in Montreal, Canada, has announced its thematic program for the spring semester of 2006. The theme of the academic year is analysis in number theory; the spring semester, running from January to May 2006, will focus on classical analysis and analytic number theory. The organizers of the thematic year are Henri Darmon (McGill University), Chantal David (Concordia University, Montreal), and Andrew Granville (University of Montreal).

The following workshops will be held: *February 13–18, 2006*: L-Functions and Related Themes; Organizers: Chantal David (Concordia University) and Ram Murty (Queen's University). *March 13–17, 2006:* Anatomy of Integers; Organizers: Jean-Marie de Koninck (University of Laval) and Andrew Granville (University of Montreal). *April 6–12, 2006:* Additive Combinatorics; Organizers: Jozsef Solymosi (University of British Columbia) and Andrew Granville (University of Montreal). *May 13–18, 2006:* Analytic Methods for Diophantine Equations; Organizers: Andrew Granville (University of Montreal), Yuri Tschinkel (University of Göttingen), Michael Bennett (University of British Columbia), Chantal David (Concordia University), and Bill Duke (University of California at Los Angeles). In addition, a summer workshop on Singularities in PDE and the Calculus of Variations will be held from July 17–21, 2006. Organizers are P. Sternberg, L. Bronsard, and S. Alama.

The CRM-Clay School on Additive Combinatorics will be held March 30–April 5, 2006, organized by David Ellwood (Clay Mathematics Institute), Jozsef Solymosi (University of British Columbia), and Andrew Granville (University of Montreal). Lecturers include Ben Green (University of Bristol), Bryna Kra (Northwestern University), Terence Tao (University of California at Los Angeles), and Van H. Vu (University of California at San Diego). Guest lecturers include Tim Gowers (University of Cambridge) and Imre Ruzsa (Alfréd Rényi Institute).

A conference in honor of the sixtieth birthday of Peter Shalen will be held from June 12–14, 2006. The organizers are S. Boyer, D. Canary, M. Cullen, N. Dunfield, and B. Farb.

The Aisenstadt Lecturers will be Manjul Bhargava of Princeton University (March 15–April 15, 2006), Kannan Soundararajan of the University of Michigan (January–June, 2006), and Terence Tao of the University of California at Los Angeles (March 30–April 12, 2006).

Support is available for visitors, graduate students, and postdoctoral fellows to attend the various events. For more information, see `http://www.crm.umontreal.ca`.

—From a CRM announcement

For Your Information

Three NSF Institutes Pass Five-Year Renewal

In 2005 three of the U.S.-based mathematics institutes funded by the National Science Foundation (NSF) cleared a major midterm funding hurdle and had their grants renewed for another five years. The three institutes are the Institute for Mathematics and its Applications (IMA) at the University of Minnesota, the Institute for Pure and Applied Mathematics (IPAM) at the University of California, Los Angeles, and the Mathematical Sciences Research Institute (MSRI) in Berkeley. Despite budgetary pressures on the NSF's Division of Mathematical Sciences (DMS), all three institutes received increases.

IMA and MSRI were the two original institutes funded by the DMS back in 1982. In 1999, the DMS opened a new competition for institute proposals. IMA and MSRI were required to compete anew to retain their grants, and they were successful in gaining renewal funding. The DMS also chose at that time to launch IPAM. The three institutes were put on a ten-year funding cycle, with a major review scheduled for 2005, the halfway point in the cycle.

Starting in 2000, the DMS budget began an ascent that led to a 72-percent increase (in constant dollars) over five years. In this positive budget climate, the division issued in 2001 another call for proposals for mathematics institutes and in 2002 funded three additional institutes: the American Institute of Mathematics Research Conference Center in Palo Alto, the Mathematical Biosciences Institute at the Ohio State University, and the Statistical and Applied Mathematical Sciences Institute in Research Triangle Park. At the same time the NSF also made a large continuing award to the School of Mathematics at the Institute for Advanced Study.

Further large increases were planned for the DMS, but those plans fell by the wayside as the NSF budget flattened, due to increased pressures on the federal budget overall. In fiscal year 2005 the NSF actually took a cut in budget, and the DMS received a zero increase. When fiscal year 2005 began in the fall of 2004, rumors circulated that the DMS might eliminate one of the institutes, but that danger seems to have passed for now. Nevertheless, the bleak outlook for the NSF budget as a whole means that the budget stringency in the DMS is not likely to be relieved soon. The DMS has therefore begun to examine more closely everything that it funds, including the institutes.

The DMS has called upon the institutes to make greater efforts to ensure participation in their programs by a broad swath of the mathematics community. This means including not only more women and members of minority groups, but also more mathematicians from non-elite institutions. As DMS director William Rundell explained it, there is no way that the DMS, with its present budgetary outlook, can hope to give individual grants to a sizeable fraction of all the mathematicians who are doing quality research. But the DMS can offer a broader segment of this group the possibility of participation in institute activities. (Additional details about the future of the NSF-funded institutes may be found in "The Mathematical Science Institutes" by William Rundell, *Notices*, October 2005, pages 1052–1054.)

IMA received a renewal grant totaling US$19.5 million over five years, which is the largest single research grant in mathematics ever made by the NSF. With this renewal, the IMA's annual budget will rise 77 percent, to US$3.9 million. Rundell explained that the IMA has been highly successful and was "clearly underfunded". IPAM also saw a sizeable rise in its annual budget, from US$2.2 million to US$3.4 million, an increase of 55 percent. MSRI's budget increased slightly, from US$3.4 million to US$3.5 million annually. At the same time as these renewals were made, the DMS renewed a grant that provides partial support, US$0.5 million per year, for the Banff International Research Station in Banff, Canada.

—Allyn Jackson

Inside the AMS

AMS Assists Mathematicians Affected by Hurricane

Mathematicians in New Orleans may be away from their regular work environment for many months. The AMS is therefore providing alternative access to MathSciNet and AMS journals during this time. If you are a mathematician at one of the eight universities in New Orleans (University of New Orleans, Tulane University, Loyola University, Xavier University of Louisiana, Southern University at New Orleans, Our Lady of the Holy Cross College, Dillard University, and Delgado Community College) you are eligible for this alternative access until your institution is able to reactivate its service. Please call the AMS at 800-321-4267 for more details. If you are at another institution affected by the hurricane, please call the above number to let us know.

In the months ahead, mathematicians at institutions closed by Hurricane Katrina will be seeking places to work temporarily, either as visiting faculty or as adjuncts. Several departments around the country have already offered to host some faculty. The AMS would like to help in matching displaced mathematicians with host departments by sharing information.

If you are a mathematician displaced by hurricane Katrina and you are seeking a temporary place to work, or if you represent a mathematics department that might have available space for a mathematician, please call 800-321-4267 and ask for "Katrina Relief". You will be asked for only basic information and further contact information. Neither mathematicians nor departments are making any commitment by giving us this information. The AMS will *not* make assignments of any kind. Our job is to help mathematicians and departments connect in order to allow each to make decisions.

Information is available on the AMS website at `http://www.ams.org/ams/katrina-help.html`.

—From AMS announcements

Deaths of AMS Members

THOMAS BETH, University of Karlsruhe, Germany, died on August 17, 2005. Born on November 16, 1949, he was a member of the Society for 30 years.

PAMELA A. FERGUSON, professor, Grinnell College, IA, died on April 24, 2004. Born on May 5, 1943, she was a member of the Society for 29 years.

GEORGE SZEKERES, professor emeritus, University of New South Wales, Australia, died on August 28, 2005. Born on May 29, 1911, he was a member of the Society for 55 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

November 17, 2005: Applications for NRC-Ford Foundation Diversity Predoctoral Fellowships. See "Mathematics Opportunities" in this issue.

November 30, 2005: Nominations for Alan T. Waterman Award. See http://www.nsf.gov/nsb/awards/waterman/waterman.htm.

December 1, 2005: Applications for NRC-Ford Foundation Diversity Dissertation Fellowships. See "Mathematics Opportunities" in this issue.

December 1, 2005: Applications for AMS Centennial Fellowships. See http://www.ams.org/employment/centflyer.html; contact Membership and Programs Department, American Mathematical Society, 201 Charles Street, Providence, RI 02904-2294; email: prof-serv@ams.org; telephone 401-455-4107.

Where to Find It

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

AMS Bylaws—*November 2005, p. 1239*

AMS Email Addresses—*December 2004, p. 1365*

AMS Ethical Guidelines—*June/July 2004, p. 675*

AMS Officers 2004 and 2005 (Council, Executive Committee, Publications Committees, Board of Trustees)—*May 2005, p. 564*

AMS Officers and Committee Members—*October 2005, p. 1073*

Conference Board of the Mathematical Sciences—*September 2005, p. 892*

Information for *Notices* Authors—*June/July 2005, p. 660*

Mathematics Research Institutes Contact Information—*August 2005, p. 770*

National Science Board—*January 2005, p. 76*

New Journals for 2004—*June/July 2005, p. 662*

NRC Board on Mathematical Sciences and Their Applications—*March 2005, p. 361*

NRC Mathematical Sciences Education Board—*April 2005, p. 465*

NSF Mathematical and Physical Sciences Advisory Committee—*February 2005, p. 261*

Program Officers for Federal Funding Agencies—*October 2005, p. 1069 (DoD, DoE); November 2005, p. 1223 (NSF)*

Stipends for Study and Travel—*September 2005, p. 900*

December 2, 2005: Submissions for Ferran Sunyer i Balaguer Prize. See http://www.crm.es/FSBPrize/fsb2005prize.htm.

December 9, 2005: Applications for visiting and postdoctoral positions at the Fields Institute. See http://www.fields.utoronto.ca/proposals/visitors.html or http://www.fields.utoronto.ca/proposals/postdoc.html.

December 10, 2005: Applications for East Asia and Pacific Summer Institutes. See http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5284&org=NSF.

December 15, 2005: Applications for NRC-Ford Foundation Diversity Postdoctoral Fellowships. See "Mathematics Opportunities" in this issue.

December 15, 2005: Applications for AMS Epsilon Fund. See http://www.ams.org/outreach/epsilon.html, or contact Membership and Programs Department, AMS, 201 Charles Street, Providence, RI 02904-2294; telephone 800-321-4267, ext. 4170; email: prof-serv@ams.org.

December 31, 2005: Supporting references for Alan T. Waterman Award. See http://www.nsf.gov.

December 31, 2005: Applications/nominations for AIM Five-Year Fellow. See http://www.aimath.org/fellows/.

January 1, 2006: Submissions for Competition 2006 of the European Mathematical Society. See http://www.mat.dtu.dk/people/V.L.Hansen/rpa/secondartcomp.html.

January 1, 2006: Applications for ICM 2006 Travel Grants. See http://www.icm2006.org or email: grants@icm2006.org.

January 10, 2006: Applications for AAUW Educational Foundation Fellowships and Grants. See http://www.aauw.org/fga/fellowships_grants/selected.cfm or contact the AAUW Educational Foundation, 1111 Sixteenth St. N.W., Washington, DC 20036; telephone 800-326-2289 (AAUW); fax 202-872-1425; email: info@aauw.org.

January 15, 2006: Applications for AMS-AAAS Mass Media Fellowships. See http://ehrweb.aaas.org/massmedia.htm; contact Stacey Pasco, Manager, Mass Media Program, AAAS Mass Media Science and Engineering Fellows Program, 1200 New York Avenue, NW, Washington, DC 20005; telephone 202-326-6441; fax 202-371-9849; or see the AMS website at http://www.ams.org/government/massmediafellowaward.html; or contact the AMS Washington Office, 1527 Eighteenth Street, NW, Washington, DC 20036; telephone 202-588-1100; fax 202-588-1853; email: amsdc@ams.org.

January 27, 2006: Proposals for Partnerships for Adaptation, Implementation, and Dissemination Awards of the NSF ADVANCE Program. See the website http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5383.

January 31, 2006: Applications for postdoctoral fellowships at the Institut Mittag-Leffler. See the website http://www.mittag-leffler.se/grants.

February 1, 2006: Applications for AWM Travel Grants and Mentoring Travel Grants. See http://www.awm-math.org/travelgrants.html; telephone 703-934-0163; email: awm@math.umd.edu; or contact Association for Women in Mathematics, 11240 Waples Mill Road, Suite 200, Fairfax, VA 22030.

February 10, 2006: Applications for Math for America Foundation Newton Fellowships. See "Mathematics Opportunities" in this issue.

March 1, 2006: Applications for EDGE Program. See "Mathematics Opportunities" in this issue.

March 31, 2006: Nominations for Third World Academy of Sciences Prizes. See http://www.twas.org/.

May 1, 2006: Applications for AWM Travel Grants. See http://www.awm-math.org/travelgrants.html; telephone 703-934-0163; email: awm@math.umd.edu; or contact Association for Women in Mathematics, 11240 Waples Mill Road, Suite 200, Fairfax, VA 22030.

October 1, 2006: Applications for AWM Travel Grants. See http://www.awm-math.org/travelgrants.html; telephone 703-934-0163; email: awm@math.umd.edu; or contact Association for Women in Mathematics, 11240 Waples Mill Road, Suite 200, Fairfax, VA 22030.

International Mathematical Union

The International Mathematical Union (IMU) is an international nongovernmental and nonprofit scientific organization that has the purpose of promoting international cooperation in mathematics. The IMU Executive Committee consists of nine voting members elected for four-year terms: the four officers (president, two vice presidents, and secretary), and five other members. The retiring president is an ex officio member of the Executive Committee without a vote for a period of four years. The current members (terms January 1, 2003, to December 31, 2006) of the IMU Executive Committee are:

President
John M. Ball, United Kingdom

Vice Presidents
Jean-Michel Bismut, France
Masaki Kashiwara, Japan

Secretary
Phillip A. Griffiths, United States

Members at Large
Martin Grötschel, Germany
Zhi-Ming Ma, China
Ragni Piene, Norway
Madabusi S. Raghunathan, India
Victor A. Vassiliev, Russia

Ex Officio Member
Jacob Palis, Past President, Brazil

Contact: Phillip A. Griffiths, Secretary
International Mathematical Union
Institute for Advanced Study
Einstein Drive
Princeton, NJ 08540, USA
Fax: 609-683-7605
Email: imu@ias.edu
http://www.mathunion.org/index.html

For the United States, the adhering organization to the IMU is the National Academy of Sciences (NAS). The U.S. National Committee for Mathematics (USNC/Math), a committee of the NAS, represents the United States

in the International Mathematical Union (IMU) and promotes the advancement of the mathematical sciences. The committee members are:

Salah Baouendi, Chair
University of California San Diego

Lawrence Brown
The Wharton School,
University of Pennsylvania

Tony Chan
University of California
at Los Angeles

Ruth M. Charney
Brandeis University

Jennifer Chayes
Microsoft Corporation

C. Herbert Clemens
Ohio State University

Raymond Johnson
University of Maryland

Joseph Kohn
Princeton University

Kenneth Ribet
University of California at Berkeley

David O. Siegmund
Stanford University

Philippe Tondeur
University of Illinois, Urbana-
Champaign

Ex-Officio Members

Phillip A. Griffiths
Institute for Advanced Study
Secretary, IMU

David W. McLaughlin
New York University
Chair, Board on Mathematical
Sciences and Their Applications
National Research Council

Hyman Bass
University of Michigan
President, International
Commission on Mathematical
Instruction

Michael Clegg
University of California Irvine
Foreign Secretary, NAS

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.

13: The Story of the World's Most Popular Superstition, by Nathaniel Lachenmeyer. Thunder's Mouth Press, October 2004. ISBN 1-568-58306-0.

1089 and All That. A Journey into Mathematics, by David Acheson. Oxford University Press, July 2002. ISBN 0-19-851623-1. (Reviewed February 2005.)

Action This Day, edited by Michael Smith and Ralph Erskine. Random House of Canada, February 2003. ISBN 0-593-04910-1.

Alfred Tarski: Life and Logic, by Anita Burdman Feferman and Solomon Feferman. Cambridge University Press, October 2004. ISBN 0-521-80240-7.

Beyond Reason: Eight Great Problems That Reveal the Limits of Science, by A. K. Dewdney. Wiley, April 2004. ISBN 0-471-01398-6.

A Brief History of Infinity, by Paolo Zellini. Penguin Books (paperback), March 2005. ISBN 0-141-00762-1.

**A*^{3} *& His Algebra: How a Boy from Chicago's West Side Became a Force in American Mathematics*, by Nancy E. Albert. iUniverse, Inc., January 2005. ISBN 0-595-32817-2. (Reviewed in this issue.)

The Calculus Gallery: Masterpieces from Newton to Lebesgue, by William Dunham. Princeton University Press, December 2004. ISBN 0-691-09565-5.

Chance: A Guide to Gambling, Love, the Stock Market and Just About Everything Else, by Amir D. Aczel. Thunder's Mouth Press, October 2004. ISBN 1-56858-316-8. (Reviewed August 2005.)

**Coincidences, Chaos, and All That Math Jazz: Making Light of Weighty Ideas*, by Edward B. Burger and Michael Starbird. W. W. Norton, August 2005. ISBN 0-393-05945-6.

The Colours of Infinity: The Beauty and Power of Fractals, by Michael Barnsley, Nigel Lesmoir-Gordon, Benoit B. Mandelbrot, Ian Stewart, Gary Flake, Robert Prechter, and Arthur C. Clarke. Clear Press, March 2004. ISBN 1-904-55505-5.

Complexities: Women in Mathematics, edited by Bettye Anne Case and Anne M. Leggett. Princeton University Press, January 2005. ISBN 0-691-11462-5.

Converging Realities: Toward a Common Philosophy of Physics and Mathematics, by Roland Omnes. Princeton University Press, November 2004. ISBN 0-691-11530-3.

The Curious Incident of the Dog in the Nighttime, by Mark Haddon. Vintage, May 2004. ISBN 1-400-03271-7.

Dark Hero of the Information Age: In Search of Norbert Wiener, by Flo Conway and Jim Siegelman. Basic Books, December 2004. ISBN 0-738-20368-8.

The Equation That Couldn't Be Solved (How Mathematical Genius Discovered the Language of Symmetry), by Mario Livio. Simon and Schuster, September 2005. ISBN 0-743-25820-7.

The Essential Turing, edited by B. Jack Copeland. Oxford University Press, September 2004. ISBN 0-198-25080-0.

Experimentation in Mathematics: Computational Paths to Discovery, by Jonathan Borwein, David Bailey, and Roland Girgensohn. A K Peters, March 2004. ISBN 1-56881-136-5. (Reviewed September 2005.)

**The Fermat Diary*, by C. J. Mozzochi. AMS, August 2000. ISBN 0-8218-2670-0.

**The Fermat Proof*, by C. J. Mozzochi. Trafford Publishing, Inc., February, 2004. ISBN 1-412-02203-7.

From Eudoxus to Einstein: A History of Mathematical Astronomy, by C. M. Linton. Cambridge University Press, August 2004. ISBN 0-521-82750-7.

Geometry and Meaning, by Dominic Widdows. Center for the Study of Language and Information, November 2004. ISBN 1-575-86448-7.

The Golden Ratio: The Story of Phi, the World's Most Astonishing Number, by Mario Livio. Broadway Books, September 2003. ISBN 0-7679-0816-3. (Reviewed March 2005.)

Graphic Discovery: A Trout in the Milk and Other Visual Adventures, by Howard Wainer. Princeton University Press, October 2004. ISBN 0-691-10301-1.

The Heart of Mathematics: An Invitation to Effective Thinking, by Edward B. Burger and Michael Starbird. Key College Publishing (Springer-Verlag), April 2000. ISBN 0-555953-407-9. (Reviewed February 2005.)

Incompleteness: The Proof and Paradox of Kurt Gödel, by Rebecca Goldstein. W. W. Norton, February 2005. ISBN 0-393-05169-2.

The Infinite Book: Where Things Happen That Don't, by John D. Barrow. Jonathan Cape, February 2005. ISBN 0-224-06917-9.

Introducing Game Theory and its Applications, by Elliott Mendelson. CRC Press, July 2004. ISBN 1-584-88300-6.

János Bolyai, Euclid, and the Nature of Space, by Jeremy J. Gray. MIT Press, May 2003. ISBN 0-262-57174-9. (Reviewed October 2005.)

John Pell (1611–1685) and His Correspondence with Sir Charles Cavendish: The Mental World of an Early Modern Mathematician, by Noel Malcolm and Jacqueline Stedall. Oxford University Press, second edition, January 2005. ISBN 0-198-56484-8.

Kepler's Conjecture: How Some of the Greatest Minds in History Helped Solve One of the Oldest Math Problems in the World, by George G. Szpiro. Wiley, January 2003. ISBN 0-471-08601-0. (Reviewed January 2005.)

The Knot Book: An Elementary Introduction to the Mathematical Theory of Knots, Colin C. Adams. AMS, September 2004. ISBN 0-8218-3678-1. (Reviewed September 2005.)

Knots and Links, by Peter R. Cromwell. Cambridge University Press, October 2004. ISBN 0-691-10301-1.

The Liar Paradox and the Towers of Hanoi: The Ten Greatest Math Puzzles of All Time, by Marcel Danesi. Wiley, August 2004. ISBN 0-471-64816-7.

Luck, Logic, and White Lies: The Mathematics of Games, by Jörg Bewersdorff. Translated by David Kramer. A K Peters, November 2004. ISBN 1-568-81210-8.

Math and the Mona Lisa: The Art and Science of Leonardo da Vinci, by Bulent Atalay. Smithsonian Books, April 2004. ISBN 1-588-34171-2.

The Math Instinct: Why You're a Mathematical Genius (Along with Lobsters, Birds, Cats, and Dogs), by Keith Devlin. Thunder's Mouth Press, March 2005. ISBN 1-560-25672-9.

Math Magic: How to Master Everyday Math Problems, by Scott Flansburg. Perennial Currents, revised edition, August 2004. ISBN 0-060-72635-0.

**Mathematical Adventures for Students and Amateurs*, David F. Hayes and Tatiana Shubin, editors. Mathematical Association of America, 2004. ISBN 0-88385-548-8.

Mathematical Illustrations: A Manual of Geometry and PostScript, by Bill Casselman. Cambridge University Press, December 2004. ISBN 0-521-54788-1.

A Mathematician at the Ballpark: Odds and Probabilities for Baseball Fans, by Ken Ross. Pi Press, July 2004. ISBN 0-131-47990-3.

Mathematicians under the Nazis, by Sanford L. Segal. Princeton University Press, July 2003. ISBN 0-691-00451-X. (Reviewed April 2005.)

Mathematics: A Very Short Introduction, by Timothy Gowers. Oxford University Press, October 2002. ISBN 0-192-85361-9. (Reviewed February 2005.)

Mathematics by Experiment: Plausible Reasoning in the 21st Century, by Jonathan Borwein and David Bailey. A K Peters, December 2003. ISBN 1-56881-211-6. (Reviewed September 2005.)

Mathematics in Nature: Modeling Patterns in the Natural World, by John A. Adam. Princeton University Press, November 2003. ISBN 0-691-11429-3. (Reviewed June/July 2005.)

The (Mis)Behavior of Markets: A Fractal View of Risk, Ruin and Reward, by Benoit Mandelbrot and Richard Hudson. Basic Books, August 2004. ISBN 0-465-04355-0.

More Damned Lies and Statistics: How Numbers Confuse Public Issues, by Joel Best. University of California Press, August 2004. ISBN 0-520-23830-3.

More Mathematical Astronomy Morsels, by Jean Meeus. Willmann-Bell, 2002. ISBN 0-943396-743.

Musings of the Masters: An Anthology of Miscellaneous Reflections, edited by Raymond G. Ayoub. Mathematical Association of America, 2004. ISBN 0-88385-549-6.

The Newtonian Moment: Isaac Newton and the Making of Modern Culture, by Mordechai Feingold. New York Library and Oxford University Press, December 2004. ISBN 0-195-17735-5.

Number Theory from an Analytic Point of View, by Badih Ghusayni. Komati, December 2003. ISBN 9953-0-0282-7.

Numbers, the Language of Science, by Tobias Dantzig. Pi Press, fifth edition, March 2005. ISBN 0-131-85627-8.

The Oxford Murders, by Guillermo Martínez. Abacus, January 2005. ISBN 0-349-11721-7. (Reviewed November 2005.)

The Pea and the Sun: A Mathematical Paradox, by Leonard M. Wapner. A K Peters, April 2005. ISBN 1-568-81213-2.

R. L. Moore: Mathematician and Teacher, by John Parker. Mathematical Association of America, 2004. ISBN 0-88385-550-X.

Reality Conditions: Short Mathematical Fiction, by Alex Kasman. Mathematical Association of America, May 2005. ISBN 0-88385-552-6.

The Road to Reality: A Complete Guide to the Laws of the Universe, by Roger Penrose. Knopf, February 2005. ISBN 0-679-45443-8.

**Saunders Mac Lane: A Mathematical Autobiography*, by Saunders Mac Lane. A K Peters, Ltd., May 2005. ISBN 1-568-81150-0. (Reviewed in this issue.)

**Science in the Looking Glass*, by E. Brian Davies. Oxford University

Press, August 2003. ISBN 0-19-852543-5. (Reviewed in this issue.)

Sneaking a Look at God's Cards: Unraveling the Mysteries of Quantum Mechanics, by Giancarlo Ghirardi, translated by Gerald Malsbary. Princeton University Press, revised edition, January 2005. ISBN 0-691-12139-7.

Spaceland, by Rudy Rucker. Tor Books, June 2002. ISBN 0-765-30366-3. (Reviewed August 2005.)

Stalking the Riemann Hypothesis: The Quest to Find the Hidden Law of Prime Numbers, by Dan Rockmore. Pantheon, April 2005. ISBN 0-375-42136-X.

A Tour through Mathematical Logic, by Robert S. Wolf. Mathematical Association of America, January 2005. ISBN 0-88385-036-2.

Towards a Philosophy of Real Mathematics, by David Corfield. Oxford University Press, April 2003. ISBN 0-521-81722-6.

The Transformation of Mathematics in the Early Mediterranean World: From Problems to Equations, by Reviel Netz. Cambridge University Press, June 2004. ISBN 0-521-82996-8.

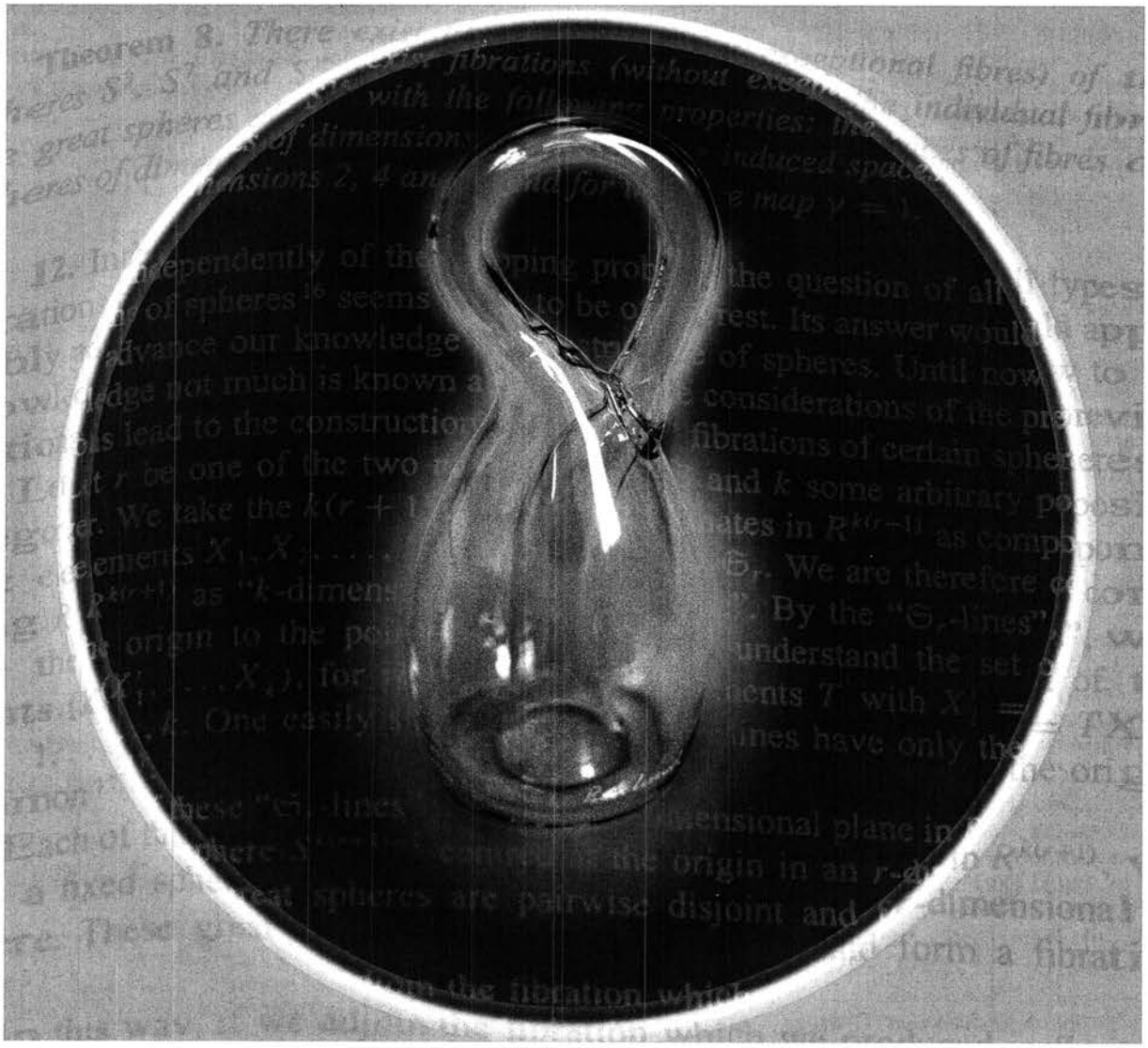
The Universal Book of Mathematics: From Abracadabra to Zeno's Paradoxes, by David Darling. Wiley, July 2004. ISBN 0-471-27047-4.

Using the Mathematics Literature, by Kristine K. Fowler. Marcel Dekker, June 2004. ISBN 0-824-75035-7.

The Works of Archimedes: Translation and Commentary. Volume I: The Two Books *On the Sphere* and *The Cylinder*. Edited and translated by Reviel Netz. Cambridge University Press, April 2004. ISBN 0-521-66160-9. (Reviewed May 2005.)

A World without Time: The Forgotten Legacy of Gödel and Einstein, by Palle Yourgrau. Basic Books, January 2005. ISBN 0-465-09293-4.

You Can Do the Math: Overcome Your Math Phobia and Make Better Financial Decisions, by Ron Lipsman. Praeger Publishers, November 2004. ISBN 0-275-98341-2.



The Department of Mathematics of ETH Zurich

invites applications for several

Heinz Hopf Lectureships

beginning 1st of October 2006 or earlier. The positions are awarded for a period of 3 years, with the possibility of an extension by 1 year.

Duties of Heinz Hopf lecturers include research and teaching in mathematics. Together with the other members of the department, the new lecturers will be responsible for undergraduate and graduate courses for students of mathematics, natural sciences, and engineering. The moderate teaching load leaves ample room for further professional development. Courses at Master level may be taught in English.

Applicants should have proven excellence in research in any area of mathematics and possess potential for further outstanding achievements. Some research and teaching after the Ph. D. is usually expected.

Applications with curriculum vitae and a list of publications should be submitted to the chairman of the Department of Mathematics, ETH Zentrum, 8092 Zurich, Switzerland, by January 9, 2006. Later applications can be considered for remaining positions. In addition, three letters of recommendation supporting the application should be sent directly to us. ETH Zurich specifically encourages female candidates to apply.

Department Mathematik

ETH

Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

AMERICAN MATHEMATICAL SOCIETY

D. R. Fulkerson Prize

Call for nominations

The Fulkerson Prize Committee invites nominations for the Delbert Ray Fulkerson Prize, sponsored jointly by the Mathematical Programming Society and the American Mathematical Society. Up to three awards of US$1,500 each are presented at each (triennial) International Symposium of the MPS. The Fulkerson Prize is for outstanding papers in the area of discrete mathematics. The prize will be awarded at the 19th International Symposium on Mathematical Programming to be held in Rio de Janeiro, Brazil, July 30–August 4, 2006.

Eligible papers should represent the final publication of the main result(s) and should have been published in a recognized journal or in a comparable, well-refereed volume intended to publish final publications only, during the six calendar years preceding the year of the Symposium (thus, from January 2000 through December 2005). The prizes will be given for single papers, not series of papers or books, and in the event of joint authorship the prize will be divided.

The term "discrete mathematics" is interpreted broadly and is intended to include graph theory, networks, mathematical programming, applied combinatorics, applications of discrete mathematics to computer science, and related subjects. While research work in these areas is usually not far removed from practical applications, the judging of papers will only be based on their mathematical quality and significance.

Previous winners of the Fulkerson Prize are listed below. Further information about the Fulkerson Prize can be found at http://www.mathprog.org/prz/fulkerson.htm and at http://www.ams.org/prizes/fulkerson-prize.html.

The Fulkerson Prize Committee consists of Noga Alon (Tel-Aviv University), Bill Cunningham (University of Waterloo), and Michel Goemans (Massachusetts Institute of Technology), chair.

Please send your nominations (including reference to the nominated article and an evaluation of the work) by January 31, 2006, to the chair of the committee. Electronic submissions to goemans@math.mit.edu are preferred.

Michel Goemans
MIT, Room 2-351
Department of Mathematics
77 Massachusetts Avenue
Cambridge, MA 02139, USA
e-mail: goemans@math.mit.edu

Previous winners of the Fulkerson Prize:

1979: Kenneth Appel and Wolfgang Haken; Richard M. Karp; Paul D. Seymour
1982: L.G. Khachiyan/D.B. Iudin and A.S. Nemirovskii; G.P. Egorychev/D.I. Falikman; Martin Grötschel, László Lovász, and Alexander Schrijver
1985: Jozsef Beck; H.W. Lenstra Jr.; Eugene M. Luks
1988: Éva Tardos; Narendra Karmarkar
1991: Alfred Lehman; Nikolai E. Mnev; Martin Dyer, Alan Frieze, and Ravi Kannan
1994: Lou Billera; Neil Robertson, Paul D. Seymour, and Robin Thomas; Gil Kalai
1997: Jeong Han Kim
2000: Michel X. Goemans and David P. Williamson; Michele Conforti, Gerard Cornuéjols, and M. R. Rao
2003: J.F. Geelen, A.M.H. Gerards, and A. Kapoor; B. Guenin; S. Iwata, L. Fleischer, and S. Fujishige/A. Schrijver

AMS
AMERICAN MATHEMATICAL SOCIETY

Mathematics Calendar

The most comprehensive and up-to-date Mathematics Calendar information is available on e-MATH at `http://www.ams.org/mathcal/`.

December 2005

* 2–4 **International Conference on Harmonic Analysis and Ergodic Theory**, DePaul University, Chicago, Illinois.
Main Feature: Two mini-courses will be offered during the conference, on harmonic analysis and on ergodic theory, talks by C. Kenig and D. Rudolph.
Invited Speakers: John Baxter, University of Minnesota; Vitaly Bergelson, Ohio State University; Charles Fefferman, Princeton University; Richard Gundy, Rutgers University; Carlos Kenig, University of Chicago; Robert Kaufman, University of Illinois at Urbana-Champaign; Michael Lacey, Georgia Institute of Technology; Michael Lin, Ben-Gurion University of the Negev Beer-Sheva, Israel; Fedor Nazarov, Michigan State University; Joseph Rosenblatt, University of Illinois at Urbana-Champaign; Daniel Rudolph, Colorado State University; Arkady Tempelman, Pennsylvania State University; Mate Wierdl, University of Memphis.
Financial Support: Partial financial support is available, contact the organizing committee.
Sponsors: The conference is partially supported by grants from the NSF and DePaul University.
Organizing Committee: Joseph Rosenblatt, University of Illinois at Urbana-Champaign, Ahmed Zayed and Alexander Stokolos, DePaul University.
Information: `http://www.depaul.edu/~haet`.

4–9 **19th Large Installation System Administration Conference (LISA '05)**, San Diego, California. (Oct. 2005, p. 1087)

5–9 **IMA Workshop: Integration of Sensing and Processing**, University of Minnesota, 207 Church St. SE, 400 Lind Hall, Minneapolis, Minnesota. (Jan. 2005, p. 82)

5–9 **30th Australasian Conference in Combinatorial Mathematics and Combinatorial Computing (30ACCMCC)**, The University of Queensland, Brisbane, Australia. (May 2005, p. 570)

12–15 **The Second International Conference on Technology, Knowledge and Society**, Hyderabad, India. (Jun/Jul. 2005, p. 672)

12–16 **Intersection of Arithmetic Cycles and Automorphic Forms**, Centre de recherche mathématiques, Université de Montréal, Montréal, Québec, Canada. (Apr. 2005, p. 477)

12–16 **Recent developments in real and harmonic analysis meeting in honor of Carlos Segovia**, Instituto Argentino de Matemática, Buenos Aires, Argentina. (Nov. 2005, p. 1263)

12–16 **The Modeling of Cancer Progression and Immunotherapy**, AIM Research Conference Center, Palo Alto, California. (Sept. 2005, p. 949)

* 12–17 **International conference on "Infinite Dimensional Lie Algebras and its Applications"**, Harish Chandhra Research Institute, Allahabad, India.
Description: The conference will focus on Extended Affine Lie Algebras which includes Affine Lie Algebras and Toroidal Lie Algebras and Lie Algebras based on Quantum Torus. Further topics are Extended Affine Root Systems (including Elliptic Root Systems) and Extended Affine Weyl Group.
Organizers: S. Eswara Rao (TIFR, Mumbai), Punita Batra (HRI, Allahabad,India) and Kailash C. Misra (NCSU, USA).
Speakers: T. Miwa, Oliver Mathieu, Kyoji Saito, Karl Hermann Neeb, Shrawan Kumar, V. Laksmibai, Yuly Billig, Drazen Adamovic, Saeid Azam, Shaobin Tan, Ben Cox, Slava Futorny, Yoji Yoshii and more expected.
Information: Write to S. Eswara Rao (`senapati@math.tifr.res.in`)

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 held in North America 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. Meetings held outside the North American area may carry more detailed information. In any case, 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/`.

and Punita Batra (batra@mri.ernet.in).

14–16 **CRAMS-05 International Conference on Applied Nonharmonic Fourier Analysis, Business & Computer**, University College (BCU), Beirut, Lebanon. (Apr. 2005, p. 477)

14–18 **First Joint International Meeting with the Taiwanese Mathematial Society**, Taiwan, Taiwan. (Dec. 2004, p. 1379)

15–January 31 **Semidefinite Programming and its Applications**, Institute for Mathematical Sciences, National University of Singapore, Singapore. (Nov. 2005, p. 1263)

17–19 **International Symposium on Recent Advances in Mathematics & its Applications (ISRAMA 2005)**, Calcutta Mathematical Society, AE-374, Sector-1, Salt Lake City, Calcutta, India. (Oct. 2005, p. 1087)

27–30 **ASL Winter Meeting (with APA)**, New York, New York. (Jun/Jul. 2005, p. 673)

15–January 31, 2006 **Semidefinite Programming and its Applications**, Institute for Mathematical Sciences, National University of Singapore, Singapore. (Apr. 2005, p. 477)

January 2006

2–5 **International Conference on Geometric Function Theory, Special Functions and Applications**, Conference Hall, Hotel Surguru, 104, Sardar Vallabai Patel Road, Pondicherry-605 001, India. (Sept. 2005, p. 949)

2–5 **Mathematics in the Twentieth Century: In Commemoration of the Birth Centenary of André Weil**, Delhi, India. (Aug. 2005, p. 786)

3–7 **Moduli spaces of knots**, AIM Research Conference Center, Palo Alto, California. (Jun/Jul. 2005, p. 673)

5–9 **Partially hyperbolic dynamics, laminations, and Teichmuller flow Workshop**, Fields Institute, Toronto, Canada. (Nov. 2005, p. 1263)

6–11 **Enumerative invariants in algebraic geometry and string theory**, Cetraro, Italy. (Jun/Jul. 2005, p. 673)

9–12 **IMA Workshop: New Mathematics and Algorithms for 3-D Image Analysis**, University of Minnesota, 207 Church St. SE, 400 Lind Hall, Minneapolis, Minnesota. (Jan. 2005, p. 82)

9–June 30 **Principles of the Dynamics of Non-Equilibrium Systems**, Isaac Newton Institute for Mathematical Sciences, Cambridge, England. (Aug. 2004, p. 835)

12–15 **Joint Mathematics Meetings**, San Antonio, Texas. (May 2005, p. 570)

14–15 **ASL Winter Meeting (with Joint Mathematics Meetings)**, San Antonio, Texas. (Jun/Jul. 2005, p. 673)

16–18 **5th Annual Hawaii International Conference on Statistics, Mathematics, and Related Fields**, Waikiki, Honolulu, Hawaii. (Jun/Jul. 2005, p. 673)

16–20 **Random analytic functions**, AIM Research Conference Center, Palo Alto, California. (Aug. 2005, p. 787)

16–27 **"Propagation of Waves" CIMPA school and workshop**, Instituto de Matemáticas, UNAM, Cuernavaca, Mexico. (Apr. 2005, p. 478)

16–July 7 **Logic and Algorithms**, Isaac Newton Institute for Mathematical Sciences, Cambridge, England. (Aug. 2004, p. 835)

*21–22 **XIIIth Southern California Geometric Analysis Seminar**, University of California at Irvine
Brief Description: We will have six top mathematicians in geometric analysis to give talks and allow enough time for participants to communicate each other in this two-day Seminar.
Deadline: Funds available from NSF, application deadline December 12, 2005.
List of Speakers: Alice Chang (Princeton), Michael Douglas (Rutgers), Richard Hamilton (Columbia), Toshiki Mabuchi (Osaka), Mutao Wang (Columbia).
Information: Details at http://www.math.uci.edu/~scgas.

22–24 **ACM-SIAM Symposium on Discrete Algorithms (SODA)**, Radisson Hotel Miami, Miami, Florida. (Aug. 2005, p. 787)

23–27 **The property of rapid decay**, AIM Research Conference Center, Palo Alto, California. (Jun/Jul. 2005, p. 673)

23–28 **C*-algebras and elliptic theory. II**, Banach Center, Bedlewo, Poland. (Sept. 2005, p. 951)

25–27 **DIMACS Workshop on The Epidemiology and Evolution of Influenza**, DIMACS Center, CoRE Bldg, Rutgers University, Piscataway, New Jersey. (Nov. 2005, p. 1263)

30–February 3 **Mathematics-in-Industry Study Group 2005**, Massey University, Auckland, New Zealand. (Jun/Jul. 2005, p. 673)

30–February 3 **The Caccetta-Haggkvist conjecture**, AIM Research Conference Center, Palo Alto, California. (Jun/Jul. 2005, p. 673)

February 2006

6–9 **DIMACS Workshop on Computers in Scientific Discovery III**, Ghent University, Ghent, Belgium. (Nov. 2005, p. 1263)

6–10 **IMA Workshop: The Mathematics and Art of Film Editing and Restoration**, University of Minnesota, 207 Church St. SE, 400 Lind Hall, Minneapolis, Minnesota. (Jan. 2005, p. 82)

*6–10 **Recent Trends in Nonlinear Science 2006**, Universidad de Oviedo, Gijón, Spain.
Description: This is the Third Winter School in Dynamical Systems of the DANCE (Dinàmica, Atractores y Nolinealidad: Caos y Estabilidad) Spanish network. This series of winter schools aims at training their participants both theoretically and in applications in the field of the nonlinear science; with the aim that theory and applications enforce each other. This will be done in an atmosphere of informal discussion, interchange of ideas and critical discussion of results. Attention will be paid to the numerical and computational issues.
Courses: Shui-Nee Chow (Georgia Tech) & John Mallet-Paret (Brown University), Lattice Dynamical Systems and Applications; Rafael Ortega (Universidad de Granada), Topology of the plane and periodic differential equations; Edriss S. Titi (University of California), Finite dimensional long-term dynamics of infinite dimensional dissipative evolution equations and their numerical reduction methods.
Deadlines: The registration period for RTNS2006 is currently open. It will end in November 5, 2005. The registration price is 300 Euro. It includes attendance, materials and lunch. People registering before October 22, 2005, are entitled to have reduced registration fee which is 250 Euro. There will be a number of registration and partial or full accommodation grants for young participants. Payment of Registration Fee: from November 25 to December 23, 2005. Note: The number of available places in the school is limited. Final admissions will be done by the registration order.
Information: http://www.dance-net.org/.

13–17 **Barcelona Conference in Planar Vector Fields**, Centre de Recerca Matemàtica, Bellaterra, Spain. (Jun/Jul. 2005, p. 673)

13–17 **Mathematical and Geophysical Fluid Dynamics**, AIM Research Conference Center, Palo Alto, California. (Sept. 2005, p. 951)

13–18 **L-functions and Related Themes**, Centre de recherche mathématiques, Univ. de Montréal, Montréal, Québec, Canada. (Apr. 2005, p. 478)

15–17 **DIMACS Workshop on Data Mining, Systems Analysis, and Optimization in Neuroscience**, University of Florida, Gainesville, Florida. (Nov. 2005, p. 1263)

20–24 **p-adic representations, modularity, and beyond**, AIM Research Conference Center, Palo Alto, California. (Jun/Jul. 2005, p. 673)

20–25 **Advanced Course on Arakelov Geometry and Shimura Varieties**, Centre de Recerca Matemàtica, Bellaterra, Spain. (Jun/Jul. 2005, p. 674)

21–24 **XV International Symposium on Mathematical Methods applied to the Sciences**, San José, Costa Rica. (Sept. 2005, p. 951)

*22–24 **SIAM Conference on Parallel Processing for Scientific Computing**, Sir Francis Drake Hotel, San Francisco, California.
Themes: Main Theme: Large-Scale Parallel Computing with emphasis on Algorithms, Tools and Techniques for performing scientific computations on 100 to 100,000 processors.
Subthemes: Scalable algorithms including latency-tolerant schemes, programming models and languages for mathematical applications, data-intensive science and engineering applications, high-compute density systems (e.g., clusters, cell processor,...), performance modeling.
Deadlines: Minisymposium proposals: Friday, September 30, 2005. Contributed abstracts: Friday, September 30, 2005.
Organizing Committee Co-chairs: Charbel Farhat, Stanford University; William Gropp, Argonne National Laboratory.
Information: email: cyoung@siam.org.

24–27 **Lie groups: Dynamics, Rigidity, Arithmetic, in honor of Gregory Margulis' 60th birthday**, Yale University, New Haven, Connecticut. (Sept. 2005, p. 952)

March 2006

6–10 **IMA Workshop: Natural Images**, University of Minnesota, 207 Church St. SE, 400 Lind Hall, Minneapolis, Minnesota. (Jan. 2005, p. 82)

7–11 **Holomorphic Dynamics Workshop**, Fields Institute, Toronto, Canada. (Nov. 2005, p. 1263)

*12–18 **Workshop on "Special Geometries in Mathematical Physics"**, Kühlungsborn, Germany.
Organizers: Ilka Agricola (agricola@mathematik.hu-berlin.de); Richard Cleyton (cleyton@math.ucr.edu); Simon Chiossi (sgc@mathematik.hu-berlin.de); Thomas Friedrich (friedric@mathematik.hu-berlin.de); Paul-Andi Nagy (nagy@mathematik.hu-berlin.de).
Aim: To bring together in a casual and friendly atmosphere, scientists from mathematics and theoretical physics working on special geometric structures on Riemannian manifolds, spinorial field equations and supersymetries, geometric methods of string theory.
Confirmed invited speakers: Vestislav Apostolov (Montreal), Paul Gauduchon (Palaiseau), Jan Louis (Hamburg), George Papadopoulos (King's College London), Simon Salamon (Torino), Andrew Swann (Odense).
Information: http://www-irm.mathematik.hu-berlin.de/~pahlisch/public_html/tagung-klgsborn/kuehlungsborn.html.

13–17 **Anatomy of Integers**, Centre de recherche mathématiques Université de Montréal, Montréal, Québec, Canada. (Apr. 2005, p. 478)

21–24 **Workshop on Valuation Theory and its Applications - In Memoriam Otto Endler**, State University of Campinas (UNICAMP), Campinas, SP/Brazil. (Nov. 2005, p. 1263)

April 2006

1–2 **AMS Southeastern Section Meeting**, Florida International University, Miami, Florida. (May 2005, p. 570)

3–7 **IMA Workshop: Shape Spaces**, University of Minnesota, 207 Church St. SE, 400 Lind Hall, Minneapolis, Minnesota. (Jan. 2005, p. 82)

*3–7 **8th International Conference on Approximation and Optimization in the Caribbean**, Universidad Autonoma de Santo Domingo (UASD), Dominican Republic.
Description: This is the first announcement and call for papers. The deadline for submitting papers is January the 30th. We are inviting lectures, tutorials, mini-symposia, and contributed talks on the following topics: Approximation: Wavelets, polynomial and rational approximation, splines, orthogonal polynomials, interpolation, asymptotic analysis, radial basis function. Optimization: Continous and discrete optimization, parametric, stochastic and global optimization, nonlinear equations and inequalities, nonsmooth analysis, critical point theory, control theory. Mathematical economics:fixed point theory, equilibria of competitive economics, portfolio problems, cooperative and noncooperative games. Applications: engineering and energy models, robotics, pattern recognition, image restoration, applications in biology, economy and sciences.
Organizers: Jüergen Guddat, Humboldt-University, Berlin Institute of Mathematics Unter den Linden 6 D-10099 Berlin, Germany; email: guddat@mathematik.hu-berlin.de; Amado Reyes Universidad Autonoma de Santo Domingo, Ciudad Universitaria, Departamento de matematica, Facultad de Ciencias, Santo Domingo, Dominican Republic. Phone: (809)732-2575, Fax (809)732-2556; email: sunlandamado@verizon.net.do.

*3–7 **Workshop on Jordan Structures in Analysis and Geometry**, National Sun Yat-sen University, Kaohsiung, Taiwan.
Objectives: Recent years have seen many important developments and applications of Jordan structures in geometry, analysis and operator algebras. The aim of the workshop is to bring together experts in relevant areas to exchange ideas and inform recent progress, with a view to stimulate new research as well as generating new directions and opportunities for young researchers including research students.
Call for papers: To give a contributed talk, please contact the organizers before February 28, 2006.
Organizers: Cho-Ho Chu (c.chu@qmul.ac.uk); Ngai-Ching Wong (wong@math.nsysu.edu.tw).
Speakers include: L. G. Brown (Purdue), L. J. Bunce (Reading), C-H. Chu (London), Hong-ke Du (China), C. M. Edwards (Oxford), Y. Friedman (Jerusalem), Hwa-Long Gau (Taiwan), Mark C. Ho (Taiwan), R. Iordanescu (Bucharest), J. M. Isidro (Santiago), J-S. Jeang (Taiwan), Guoxing Ji (China), Chunglan Jiang (China), W. Kaup (Tübingen), T. Honda (Hiroshima), C. W. Leung (Hong Kong), Chin-Cheng Lin (Taiwan), Ying-Fen Lin (Taiwan), M. Mackey (Dublin), K. McCrimmon (Virginia), M. Neal (Denison), C. K. Ng (Nankai), T. Nomura (Kyushu), R. Pantilie (Bucharest), A. M. Peralta (Granada), G. Roos (St. Petersburg), B. Russo (Irvine), S-Y. Shaw (Taiwan), M-H. Shih (Taiwan), L. Stacho (Szeged), H. Upmeier (Marburg), M. V. Velasco (Granada) (to be confirmed), W. Werner (Münster), N-C. Wong (Taiwan), P-Y. Wu (Taiwan), J-C. Yao (Taiwan), B. Zalar (Maribor), G. Zhang (Chalmers).
Information: http://www.math.nsysu.edu.tw/~wong/wjs2006.

3–8 **International Workshop on Multi-Rate Processes & Hysteresis**, University College Cork, Cork, Ireland. (Jun/Jul. 2005, p. 674)

6–12 **Additive Combinatorics**, Centre de recherche mathématiques, Université de Montréal, Montréal, Québec. (Apr. 2005, p. 478)

8–9 **AMS Central Section Meeting**, University of Notre Dame, Notre Dame, Indiana. (May 2005, p. 570)

*20–22 **2006 SIAM International Conference on Data Mining**, Hyatt Regency Bethesda, Bethesda, Maryland.
Description: Data mining is becoming an important tool in science, engineering, industrial processes, healthcare, and medicine. The datasets in these fields are large, complex, and often noisy. Extracting knowledge requires the use of sophisticated, high-performance and principled analysis techniques and algorithms,

based on sound statistical foundations. These techniques in turn require powerful visualization technologies; implementations that must be carefully tuned for performance; software systems that are usable by scientists, engineers, and physicians as well as researchers; and infrastructures that support them.
Information: http://www.siam.org/meetings/sdm06/index.htm.

20-22 **Logic, Models and Computer Science: LMCS06**, Dipartimento di Matematica e Informatica, Università di Camerino, Camerino, Italy. (Oct. 2005, p. 1087)

22-23 **AMS Eastern Section Meeting**, University of New Hampshire, Durham, New Hampshire. (May 2005, p. 570)

29-30 **AMS Western Section Meeting**, San Francisco State University, San Francisco, California. (May 2005, p. 570)

20-May 2 **INFORMS Practice Conference: Applying Science to the Art of Business**, Hotel Intercontinental Miami, Florida. (Aug. 2005, p. 787)

29-May 1 **2006 Barrett Lectures in Topology**, University of Tennessee, Knoxville, Tennessee. (Sept. 2005, p. 953)

May 2006

*1-June 30 **Random Graphs and Large-Scale Real-World Networks**, Institute for Mathematical Sciences, National University of Singapore, Singapore.
Program: The aim of the program is to bring together people who have done much work on the rigorous mathematical theory of random graphs and experts (mostly physicists and computer scientists) on measuring real-world graphs, modeling them and studying them experimentally. The problems concerning complex networks vary greatly in importance and difficulty, so the program should not only enable young researchers to gain access to the methods and problems of a large and very active field, but the research community should also benefit from the collective wisdom of the participants as to the direction of future research.
Organizing Committee: Bela Bollobas (University of Memphis and University of Cambridge).
Co-chairs: Khee-Meng Koh (National University of Singapore); Oliver Riordan (University of Cambridge); Chung-Piaw Teo (National University of Singapore); Vikram Srinivasan (National University of Singapore).
Information: For general enquiries, please email ims@nus.edu.sg. For enquiries on scientific aspects of the program, please email Bela Bollobas at bollobas@msci.memphis.edu. Completed forms should be received by the Institute at least one month before commencement of each activity. Registration is free of charge. Institute membership is not required for participation. Information about the program and registration forms are available at the website http://www.ims.nus.edu.sg/Programs/randomgraphs/index.htm.

5-10 **Combinatorial and Geometric Group Theory**, Vanderbilt University, Nashville, Tennessee. (Jun/Jul. 2005, p. 674)

6-11 **International Conference on Fourier and Complex Analysis: Classical problems current view**, Protaras, Cyprus. (Oct. 2005, p. 1087)

8-19 **CANT 2006: Combinatorics, Automata and Number Theory**, University of Liege, Belgium. (Jun/Jul. 2005, p. 674)

*9-11 **DIMACS Workshop on Clustering Problems in Biological Networks**, DIMACS Center, CoRE Bldg, Rutgers University, Piscataway, New Jersey.
Short Description: DIMACS and CSNA (Classification Society of North America) cordially invite you to participate in the "DIMACS Workshop on Clustering Problems in Biological Networks" in conjunction with "Classification Society of North America 2006 Meeting on Network Data Analysis and Data Mining: Applications in Biology, Computer Science, Intrusion Detection, and Other areas".
Scope: The purpose of this conference is to explore a wide range of advances in network clustering techniques in the study of biological networks. This workshop will provide a forum for leading as well as beginning researchers to discuss recent advances and identify current and future challenges/trends arising in the research concerning clustering problems in computational biology.
Organizers: Sergiy Butenko, Texas A&M, butenko@tamu.edu; W. Art Chaovalitwongse, Rutgers University, wchaoval@rci.rutgers.edu; Panos Pardalos, University of Florida, pardalos@ufl.edu.
Deadlines: To submit an abstract, please email the title and abstract to W. Art Chaovalitwongse, email: wchaoval@rci.rutgers.edu by April 1, 2006. Full papers presented at the conference will be considered for publication in special issues of international journals.
Information: http://dimacs.rutgers.edu/Workshops/Clustering. Further information including instructions for registration may be obtained from the conference web site or by email from wchaoval@rci.rutgers.edu. Proposals for special sessions, contributed papers and invited speakers are welcome and may be submitted via this email address.

*10-13 **CSNA06. Annual meeting of the Classification Society of North America**, DIMACS Center, Rutgers University, Piscataway, New Jersey.
Theme: Network data analysis and data mining: Applications in biology, sociology, computer science, intrusion detection and related areas. The general theme involves data analysis of various types of networks, and as is typical in DIMACS sponsored events, the meeting will involve interdisciplinary approaches that will include ideas from discrete mathematics, statistics, and computer science. Background material will be provided by means of tutorials and expository talks, and there will be a strong emphasis on the solution of real world problems. The formation of research alliances for future work will be encouraged. CSNA meetings are traditionally informal and interdisciplinary. The annual meeting of CSNA will be held as part of this meeting, as will the meeting of its Board of Directors. Further information about the meeting may be obtained by email from csna06@dimacs.rutgers.edu. Proposals for special sessions, contributed papers and invited speakers are welcome and may be submitted via this email address. This meeting will be held partly as a joint meeting with the DIMACS workshop "Clustering Problems in Biological Networks" that is being held May 9-11, 2006 at DIMACS. See: http://dimacs.rutgers.edu/Workshops/Clustering/. Both DIMACS and the CSNA cordially invite you to participate in these meetings.
Information: Detailed inforation is available at http://dimacs.rutgers.edu/Workshops/CSNA.

13-18 **Analytic methods for Diophantine equations**, Banff International Research Station, Banff, Alberta, Canada. (Apr. 2005, p. 478)

15-17 **SIAM Conference on Imaging Science**, Radisson Hotel Metrodome, Minneapolis, Minnesota. (Oct. 2005, p. 1087)

16-20 **5th Conference on Function Spaces at SIUE**, Southern Illinois University, Edwardsville, Illinois. (Oct. 2005, p. 1087)

17-19 **Conference of Applied Statistics in Ireland**, University College Cork, Cork, Ireland. (Sept. 2005, p. 953)

17-21 **ASL Annual Meeting**, Montreal, Canada. (Jun/Jul. 2005, p. 674)

22-26 **IMA Workshop: Visual Learning and Recognition**, University of Minnesota, Minneapolis, Minnesota. (Jan. 2005, p. 82)

22-26 **Low Eigenvalues of Laplace and Schrodinger Operators**, AIM Research Conference Center, Palo Alto, California. (Oct. 2005, p. 1087)

23-27 **Hyperbolic Geometry Workshop**, Fields Institute, Toronto, Canada. (Nov. 2005, p. 1264)

24–26 **International Workshop on Post-Quantum Cryptography**, Katholieke Universiteit Leuven, Belgium. (Sept. 2005, p. 953)

25–27 **Complex and Harmonic Analysis, an international conference**, Thessaloniki, Greece. (Oct. 2005, p. 1088)

*29–June 3 **International Conference on Toric Topology**, Osaka City University, Osaka, Japan.
Description: The conference will provide an opportunity for interaction between people who work on different aspects of torus actions, such as topological, combinatorial, and symplectic- or algebro-geometric. We hope that the conference will provide an opportunity for researchers in a wide range of fields to interact. As such, we hope to arrange for a mix of survey talks and research talks (or talks that are a little of both).
Information: http://www.math.toronto.edu/~megumi/ToricTopology/.
Speakers: The following people agreed to give 1-hour or 45-min talks: Victor Buchstaber (Steklov Mathematical Institute), Akio Hattori (University of Tokyo), Askold Khovanskii (University of Toronto), Dusa McDuff (SUNY-Stonybrook), Robert MacPherson (Institute of Advanced Study), Leonid Polterovich (Tel Aviv University), Nigel Ray (University of Manchester), Chris Allday (University of Hawaii), Paul Biran [to be confirmed] (Tel Aviv University), Ana Cannas da Silva (IST - Lisbon), Eugene Lerman (University of Illinois), Dietrich Notbohm (University of Leicester), Hiroshi Konno (University of Tokyo), Susan Tolman (University of Illinois), Alexander Veselov [to be confirmed] (Loughborough University).
Organizers: Megumi Harada (Univ. of Toronto), megumi@math.toronto.edu; Yael Karshon (Univ. of Toronto), karshon@math.toronto.edu; Mikiya Masuda (Osaka City Univ.), masuda@sci.osaka-cu.ac.jp; Taras Panov (Moscow State Univ. & Osaka City Univ.), tpanov@mech.math.msu.su.

*30–June 3 **2006 USENIX Annual Technical Conference**, Boston, Massachusetts.
Description: The USENIX Annual Technical Conference has always been the place to present groundbreaking research and cutting-edge practices in a wide variety of technologies and environments and 2006 is no exception. There will be an extensive Training Program and Technical Sessions, featuring refereed papers in the new Systems Practice & Experience Track, Invited Talks, Guru Is In Sessions, and a Poster Session. Join the community of programmers, developers, and systems professionals in sharing solutions and fresh ideas.
Information: http://www.usenix.org/usenix06/.

30–June 6 **NAFSA 8–8th International Spring School on Nonlinear ANalysis, Function Spaces and Applications**, Czech University of Agriculture, Prague, Czech Republic. (Oct. 2005, p. 1088)

June 2006

*1–July 31 **Algorithmic Biology: Algorithmic Techniques in Computational Biology**, Institute for Mathematical Sciences, National University of Singapore, Singapore.
Program: The theme of this program is algorithmic biology: algorithmic techniques in computational biology. The program will bring together researchers in algorithmic biology from a wide spectrum of application areas including, but not limited to, sequence comparison and analysis, microarray design and analysis, whole genome alignment, motif finding, recognition of genes and regulatory elements, motif finding, gene network, phylogeny reconstruction, phylogenetic networks, molecular evolution, computational proteomics, and systems biology.
Organizing Committee: Co-chairs: Hon Wai Leong (National University of Singapore); Pavel Pevzner (University of California, San Diego); Franco Preparata (Brown University); Ken W. K. Sung (National University of Singapore); Louxin Zhang (National University of Singapore).
Information: email: ims@nus.edu.sg. For enquiries on scientific aspects of the program, please email Hon-Wai Leong at leonghw@comp.nus.edu.sg.
Deadline: Completed forms should be received by the Institute at least one month before commencement of each activity. Registration is free of charge. Institute membership is not required for participation.
Information: http://www.ims.nus.edu.sg/Programs/algorithmicbiology/index.htm.

*5–9 **Selfsimilar groups and conformal dynamics**, AIM Research Conference Center, Palo Alto, California.
Workshop topics: This workshop, sponsored by AIM and the NSF, will be devoted to developing newly discovered connections between the theory of automaton groups and conformal dynamical systems. Specific goals will focus on explaining and developing relationships between algebraic and geometric properties.
Organizers: Rostislav Grigorchuk and Kevin Pilgrim.
Application deadline: March 5, 2006.
Information:http://aimath.org/ARCC/workshops/selfsimgroups.html.

*5–12 **Motives and Periods**, University of British Columbia, Vancouver, BC, Canada.
Description: The Conference is intended to cover recent developments of motives and periods with an emphasis on connections to physics, arithmetic and algebraic cycles. The conference has an instructional component which consists of a series of survey talks. The conference will provide an opportunity for young speakers to present their results.
Workshop topics: Motives, especially its connections to Periods, Cycles, Arithmetic and Physics.
Organizers: Jim Carrell, James Lewis, Stefan Müeller-Stach, Andreas Rosenchon, Pramath Sastry.
Speakers: S. Bloch, P. Colmez, K. Kato [Tentative], D. Kriemer, M. Levine, M. Nori.
Information: email: pramath@math.toronto.edu.

7–10 **Symposium in Complex Analysis**, Kranjska Gora, Slovenia. (Nov. 2005, p. 1264)

9–14 **Eight International Conference on Geometry, Integrability and Quantization**, Sts. Constantine and Elena resort (near Varna), Bulgaria. (Oct. 2005, p. 1088)

12–15 **2006 International Conference on Applied Mathematics and Interdisciplinary Research-Nankai**, Nankai University, Tianjin, P. R. China. (May 2005, p. 570)

12–16 **Function Theories in Higher Dimensions**, Tampere University of Technology, Tampere, Finland. (Jun/Jul. 2005, p. 674)

*12–16 **The Twenty-Second Annual Mathematical Problems in Industry Workshop**, Needham, Massachusetts.
Description: The challenge facing business and industry is to prosper in an era of rapid technological growth. Meeting the challenge requires continually improving productivity, resource management, and innovation, both to refine existing productions and processes, and to create new ones.
This lively five-day interaction (in cooperation with SIAM) begins with the industry representatives presenting their problems to the group of attendees. For the rest of the week, the workshop participants break into small working groups consisting of senior faculty and attending scientists, students, and the industrial representatives, to discuss and tackle the problems in an informal setting. Examples of problems brought to recent workshops include:
• Stability of the Oil-Air Boundary in Fluid Dynamic Bearings of Hard Disk Drives (Hitachi GST).
• Enhanced Leak Detection (Gilibarco/Veeder-Root).
• Lubricating Layer Perturbations in Chemical-Mechanical Polishing (Araca, Inc.).
• Need a Lift? An Elevator Queuing Problem (United Technologies).
• Multiphase Flow in a Thin Porous Material (W. L. Gore).

On the last day of the workshop, an academic representative from each group presents the results obtained and discusses possible future directions. A written report detailing the progress made during the workshop is prepared subsequently and sent to the industry representatives. The format of the workshop is not strict and some variation is possible.

19–23 **Free Analysis**, AIM Research Conference Center, Palo Alto, California. (Jun/Jul. 2005, p. 674)

19–23 **Modern stochastics: theory and applications**, Kyiv National Taras Shevchenko University, Kyiv, Ukraine. (Sept. 2005, p. 953)

*19–23 **The International Summer School in Several Complex Variables**, Szczyrk, Poland.
Description: We wish to bring together the leading specialists and the young researchers working in pluripotential theory, complex dynamics, complex approximation theory, invariant distances and geometrical aspects of complex analysis. We plan four 4 hours long courses, delivered by leading specialists, introducing to the recent developments in algebraic geometry (given by X.X. Chen (Madison)), multivariable complex dynamics (E. Bedford (Bloomington)), invariant distances (P. Pflug (Oldenburg)) and approximation theory (W. Pleüniak (Kraków)).
Scientific Committee: E. Bedford (Bloomington), U. Cegrell (Umea), E. Chirka (Moscow), F. Forstneric (Ljubljana), P. Guan (Montreal), T. Ohsawa (Nagoya), P. Pflug (Oldenburg)), J. Siciak (Kraków), A. Zeriahi (Toulouse).
Invited Speakers: T. Bloom (Toronto), U. Cegrell (Umea), Bo-Yong Chen (Shanghai), D. Coman (Syracuse), E. Chirka (Moscow), Dinh Tien-Cuong (Paris), F. Forstneric (Ljubljana), V. Guedj (Toulouse), N. Levenberg (Bloomington), E. Ligocka (Warszawa), A. Nicoara (Harvard), Ohsawa (Nagoya), E. Poletsky (Syracuse), G. Tian (Princeton), A. Zeriahi (Toulouse).
Information and Fee: We estimate the conference fee (including hotel and meals) at 300-320 euro. For further information please contact: email: scv2006@im.uj.edu.pl. Also see http://www.im.uj.edu.pl/scv2006/.

21–23 **ICNPAA-2006: Mathematical Problems in Engineering and Aerospace Sciences**, Budapest, Hungary. (May 2005, p. 570)

*22–24 **2nd International Workshop on Graph-Theoretic Concepts in Computer Science**, Bergen, Norway.
Aim: The workshop aims at uniting theory and practice by demonstrating how graph-theoretic concepts can be applied to various areas in Computer Science, or by extracting new problems from applications. The goal is to present recent research results and to identify and explore directions for future research. The workshop is well-balanced with respect to established researchers and young scientists. For many years now, the proceedings have been published in the "Lecture Notes of Computer Science" (LNCS) series of Springer-Verlag.
Important Dates: Paper submission deadline: March 3, 2006. Notification of acceptance: April 29, 2006.
Information: Further information, such as submission guidelines, contacts, and local information, will be available at the conference web site: http://www.ii.uib.no/wg06/.

*25–28 **SIAM Conference on Discrete Mathematics**, University of Victoria, Victoria, British Columbia, Canada.
Conference Themes: Discrete mathematics, Combinatorics, Graph theory and matroids, Combinatorial algorithms, Coding theory and cryptology, Ordered sets: and its connections to other disciplines, including: Computer science, Computational biology, Optimization, Geometry, Probability.
Submission Deadlines: Minisymposium proposals: January 18, 2006. Abstracts for all contributed and minisymposium presentations: February 8, 2006.
Organizing Committee Chair: Douglas B. West, University of Illinois at Urbana-Champaign.
Information: email: ross@siam.org.

25–28 **INFORMS International Hong Kong 2006**, Sheraton Hotel & Towers Hong Kong, Hong Kong, China. (Jun/Jul. 2005, p. 674)

25–28 **The Sixth AIMS Conference on Dynamical Systems, Differential Equations and Applications**, University of Poitiers, Poitiers, France. (Jun/Jul. 2005, p. 674)

*26–30 **Algebraic Combinatorics: An International Conference in honor of Eiichi Bannai's 60th birthday**, Sendai International Center, Sendai, Japan.
Organizers: Akihiro Munemasa (Tohoku, Japan. Local organizer), Mitsugu Hirasaka (Busan, Korea), Tatsuro Ito (Kanazawa, Japan), Izumi Miyamoto (Yamanashi, Japan) and Sung-Yell Song (Ames, Iowa).
Invited Speakers: Christine Bachoc (Bordeaux, France), Andries Brouwer (Eindhoven, Netherlands), Michel Deza (Paris, France), Koichiro Harada (Columbus, Ohio), Alexander Ivanov (London, UK), Mikhail Klin (Beer Sheva, Israel), Jack Koolen (Pohang, Korea), Sergey Shpectorov (Bowling Green, Ohio), Neil J. A. Sloane (AT&T, New Jersy), Patrick Sole (CNRS, France), Paul Terwilliger (Madison, Wisconsin), Boris Venkov (St. Petersburg, Russia), Zhe-Xian Wan (Beijing, China).
Information: Further information and registration forms will be available from the website at http://homepage.mac.com/amunemas/ac2006/index.html.

26–30 **Calibrations**, AIM Research Conference Center, Palo Alto, California. (Sept. 2005, p. 954)

27–July 3 **International Commission on Mathematical Instruction: Challenging Mathematics In and Beyond the Classroom**, Trondheim, Norway. (Apr. 2005, p. 478)

July 2006

2–7 **ICOTS 7, Working Cooperatively in Statistics Education**, Salvador (Bahia), Brazil. (Mar. 2004, p. 361)

3–7 **Inverse Problems in Applied Sciences—toward break through**, University Conference Hall, Hokkaido University, Sapporo, Japan. (Nov. 2005, p. 1264)

7–8 **Second International Conference on Nonsmooth/Nonconvex Mechanics with Applications in Engineering**, Faculty of Engineering, Aristotle University, Thessaloniki, Greece. (Apr. 2005, p. 478)

*10–12 **SIAM Conference on Analysis of Partial Differential Equations**, Boston Park Plaza Hotel and Towers, Boston, Massachusetts.
Description: This second conference organized by the SIAM Activity Group (SIAG) on Analysis of Partial Differential Equations (SIAG/APDE) will have seven 45-minute invited lectures, minisymposia, and contributed talks. The winner of the SIAG on Analysis of Partial Differential Equations Prize will give one of the plenary lectures. This conference targets all researchers in partial differential equations with an interest at the intersection of analysis and applications. Advanced graduate students and young researchers are encouraged to participate. Limited funding is available for graduate students and recent Ph.D.s.
Information: email: wilden@siam.org.

10–14 **International Conference on Analytic Topology**, Lake Plaza Hotel, Rotorua, New Zealand. (Apr. 2005, p. 478)

10–14 **Ninth International Conference on p-adic functional analysis**, University of Concepcion, Concepcion, Chile. (Aug. 2005, p. 787)

*17–August 4 **International Conference and Instructional Workshop on Discrete Groups**, The Morningside Center of Mathematics, Beijing, People's Republic of China.
Description: Locally symmetric spaces and discrete subgroups of Lie groups have played a fundamental role in many branches of modern mathematics.Various aspects of these important objects

are often studied by different groups of people using different methods. It would be beneficial and fruitful to bring together experts in all these areas to exchange their results, techniques,to develop possible collaborations, and to show the power and beauty of locally symmetric spaces and discrete subgroups of Lie groups.
Invited Speakers: Minicourses (4 hours): M. Burger, T. Farrell, T. Kobayashi, A. Koranyi, A. Lubotzky W. Lueck*, N. Mok, W. Mueller, G. Prasad, B. Speh.
Research talks: Herbert Abels, Yves Benoist, Ulrich Bunke, D. Canary Haibao Duan, Jun Hu, Enrico Leuzinger, Fang Li, Ke-Zheng Li Kefeng Liu, R. Miatello, A. Nair, Pierre Pansu, Liangang Peng J. Rohlfs, Hebin Rui, L. Saper, Joachim Schwermer, Jian-yi Shi R. Spatzier, Yucai Su, T. N. Venkataramana, Changchang Xi Nanhua Xi, Jie Xiao, Fei Xu, Xiaoping Xu, Pu Zhang Zhu-Jun Zheng, Xiangyu Zhou, S. Zucker.
Organizing Committee: Shing-Tung Yau (chair), Lizhen Ji, Kefeng Liu, Nanhua Xi Hongwei Xu, Lo Yang, Zhu-Jun Zheng, Xiangyu Zhou.
Contacts: Xiaoning Li (for hotel and arrival information); email: xnli@mail.math.ac.cn, Chen Fang (for titles and abstracts of talks); email: qjpam@henu.edu.cn.
Information: http://qjpam.henu.edu.cn/.

17–August 11 **Spectral Theory and Partial Differential Equations**, Isaac Newton Institute for Mathematical Sciences, Cambridge, England. (Aug. 2004, p. 835)

23–27 **The Ninth International Conference on Integral Methods in Science and Engineering (IMSE-2006)**, Sheraton Fallsview Hotel and Conference Centre, Niagara Falls, Ontario, Canada. (Aug. 2005, p. 787)

24–December 22 **Noncommutative Geometry**, Isaac Newton Institute for Mathematical Sciences, Cambridge, England. (Aug. 2004, p. 835)

27–August 2 **ASL European Summer Meeting (Logic Colloquium '06)**, Nijmegen, Netherlands. (Jun/Jul. 2005, p. 675)

* 30–August 5 **International Conference on Radicals (ICOR-2006)**, Kiev National Taras Shevchenko University, Kiev, Ukraine.
Organizer: Vladimir Kirichenko (Kiev, Ukraine).
Deadline: The registration till April 1, 2006. Abstracts: A one-page abstract till May 15, 2006.
Information: Department of Mechanics and Mathematics (ICOR-2006), Kiev National Taras Shevchenko University, Vladimirskaya Str., 64, 01033 Kiev, Ukraine.

30–August 24 **Bayesian Nonparametric Regression: Theory, Methods and Applications**, Isaac Newton Institute for Mathematical Sciences, Cambridge, United Kingdom. (Oct. 2004, p. 1097)

* 31–August 2 **2006 Symposium on Performance Evaluation of Computer and Telecommunication Systems**, Calgary, Canada.
Information: http://www.scs.org/summersim/spects.

August 2006

14–18 **Seventh International Conference on Monte Carlo and Quasi-Monte Carlo Methods in Scientific Computing (MCQMC 2006)**, Ulm, Germany. (Nov. 2005, p. 1264)

22–30 **International Congress of Mathematicians**, Madrid, Spain. (Nov. 2005, p. 1264)

September 2006

* 1–4 **Topics in Mathematical Analysis and Graph Theory**, University of Belgrade, Faculty of Electrical Engineering, Department of Applied Mathematics, Serbia and Montenegro.
Description: This conference is a satellite to International Congress of Mathematicians, August 22–30, 2006.
Topics: Classical mathematical analysis, including inequalities and convexity, Graph theory and combinatorics, Special functions, Differential equations, Functional analysis, Numerical analysis, Complex analysis, Probability and Statistics, Mathematical aspects of computer science, Differential geometry and related topics, Number theory, Applications of mathematics in Electrical Engineering and Telecommunications.
Invited speakers: R. P. Agarwal (USA), L. M. Berkovich (Russia), Dragos Cvetkovic (Serbia), Curtis Cooper (USA), Soon-Yeong Chung (Korea), Sever Dragomir (Australia), A.M. Fink (USA), Aleksandar Ivic (Serbia), Hira Koul (USA), Gradimir Milovanovic (Serbia), Ingram Olkin (USA), B.G. Pachpatte (India), Themistocles Rassias (Greece), Peter Rowlinson (UK), Hari M. Srivastava (USA), Zsolt Tuza (Hungary).
Scientific Committee: L. M. Berkovich (Russia), Dragos Cvetkovic (Serbia), Sever Dragomir (Australia), A. M. Fink (USA), Aleksandar Ivic (Serbia), Hira Koul (USA), Gradimir Milovanovic (Serbia), Ingram Olkin (USA), Peter Rowlinson (UK), Hari M. Srivastava (USA), Zsolt Tuza (Hungary).
Local organizing committee: Milan Merkle (coordinator), Nenad Cakic, Dragos Cvetkovic, Cemal Dolicanin, Ivan Lackovic, Zoran Radosavljevic, Dejan Tosic, Dobrilo Tosic, Slobodan Simic, Gradimir Milovanovic, Stevan Pilipovic, Milan Taskovic.
Information: http://magt.etf.bg.ac.yu; email: pefmath@etf.bg.ac.yu.

4–8 **Satellite Conference on Differential Equations and Singularities, in honor of J. M. Aroca's 60th birthday**, Tordesillas(Valladolid, Spain). (Jun/Jul. 2005, p. 675)

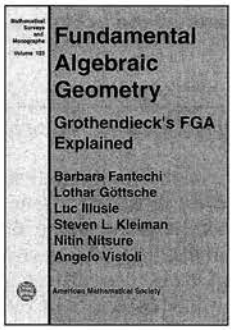
The following new announcements will not be repeated until the criteria in the next to the last paragraph at the bottom of the first page of this section are met.

May 2007

* 14–July 13 **Braids**, Institute for Mathematical Sciences, National University of Singapore, Singapore.
Program: The main theme of the program is the mathematical structure of the braid group, together with applications arising from this structure both within mathematics, and outside of mathematics such as (a) magnetohydrodynamics, (b) robotics and (c) stereochemistry. It is proposed to invite workers in these different areas with the intention of cross-fertilization. The interests of the organizers lie mostly in topology. Therefore it is likely that most long-term visitors will be from that area.
Deadline: Completed forms should be received by the Institute at least one month before commencement of each activity. Registration is free of charge. Institute membership is not required for participation.
Organizing Committee: Co-chairs: Jon Berrick (National University of Singapore); Fred R. Cohen (University of Rochester).
Information: email: ims@nus.edu.sg. For enquiries on scientific aspects of the program, please email A.J. Berrick at berrick@math.nus.edu.sg; http://www.ims.nus.edu.sg/Programs/braids/index.htm.

New Publications Offered by the AMS

Algebra and Algebraic Geometry



Fundamental Algebraic Geometry
Grothendieck's FGA Explained

Barbara Fantechi, *SISSA, Trieste, Italy*, **Lothar Göttsche**, *International Centre for Theoretical Physics, Trieste, Italy*, **Luc Illusie**, *Université Paris-Sud, Orsay, France*, **Steven L. Kleiman**, *MIT, Cambridge, MA*, **Nitin Nitsure**, *Tata Institute of Fundamental Research, Mumbai, India*, and **Angelo Vistoli**, *Università di Bologna, Italy*

Alexander Grothendieck's concepts turned out to be astoundingly powerful and productive, truly revolutionizing algebraic geometry. He sketched his new theories in talks given at the Séminaire Bourbaki between 1957 and 1962. He then collected these lectures in a series of articles in *Fondements de la géométrie algébrique* (commonly known as FGA).

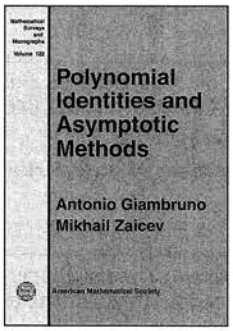
Much of FGA is now common knowledge. However, some of it is less well known, and only a few geometers are familiar with its full scope. The goal of the current book, which resulted from the 2003 Advanced School in Basic Algebraic Geometry (Trieste, Italy), is to fill in the gaps in Grothendieck's very condensed outline of his theories. The four main themes discussed in the book are descent theory, Hilbert and Quot schemes, the formal existence theorem, and the Picard scheme. The authors present complete proofs of the main results, using newer ideas to promote understanding whenever necessary, and drawing connections to later developments.

With the main prerequisite being a thorough acquaintance with basic scheme theory, this book is a valuable resource for anyone working in algebraic geometry.

Contents: *Grothendieck topologies, fibered categories and descent theory:* Introduction; Preliminary notions; Contravariant functors; Fibered categories; Stacks; *Construction of Hilbert and Quot schemes:* Construction of Hilbert and Quot schemes; *Local properties and Hilbert scheme of points:* Introduction; Elementary deformation theory; Hilbert schemes of points; *Grothendieck's existence theorem in formal geometry:* Grothendieck's existence theorem in formal geometry with a letter of Jean-Pierre Serre; *The Picard scheme:* The Picard scheme; Bibliography; Index.

Mathematical Surveys and Monographs, Volume 123

December 2005, approximately 352 pages, Softcover, ISBN 0-8218-3541-6, LC 2005053614, 2000 *Mathematics Subject Classification*: 14-01, 14C20, 13D10, 14D15, 14K30, 18F10, 18D30, **Individual member US$51**, List US$85, Institutional member US$68, Order code SURV/123



Polynomial Identities and Asymptotic Methods

Antonio Giambruno, *Universitá di Palermo, Italy*, and **Mikhail Zaicev**, *Moscow State University, Russia*

This book gives a state of the art approach to the study of polynomial identities satisfied by a given algebra by combining methods of ring theory, combinatorics, and

representation theory of groups with analysis. The idea of applying analytical methods to the theory of polynomial identities appeared in the early 1970s and this approach has become one of the most powerful tools of the theory.

A PI-algebra is any algebra satisfying at least one nontrivial polynomial identity. This includes the polynomial rings in one or several variables, the Grassmann algebra, finite-dimensional algebras, and many other algebras occurring naturally in mathematics. The core of the book is the proof that the sequence of codimensions of any PI-algebra has integral exponential growth – the PI-exponent of the algebra. Later chapters further apply these results to subjects such as a characterization of varieties of algebras having polynomial growth and a classification of varieties that are minimal for a given exponent. Results are extended to graded algebras and algebras with involution.

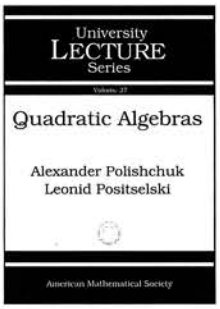
The book concludes with a study of the numerical invariants and their asymptotics in the class of Lie algebras. Even in algebras that are close to being associative, the behavior of the sequences of codimensions can be wild.

The material is suitable for graduate students and research mathematicians interested in polynomial identity algebras.

Contents: Polynomial identities and PI-algebras; S_n-representations; Group gradings and group actions; Codimension and colength growth; Matrix invariants and central polynomials; The PI-exponent of an algebra; Polynomial growth and low PI-exponent; Classifying minimal varieties; Computing the exponent of a polynomial; G-identities and $G \wr S_n$-action; Superalgebras, *-algebras and codimension growth; Lie algebras and non-associative algebras; The generalized-six-square theorem; Bibliography; Index.

Mathematical Surveys and Monographs, Volume 122

December 2005, 352 pages, Hardcover, ISBN 0-8218-3829-6, LC 2005053010, 2000 *Mathematics Subject Classification*: 16R10, 16R20, 16R30, 16R40, 16R50, 16P90, 16W22, 16W55, 17B01, **Individual member US$51**, List US$85, Institutional member US$68, Order code SURV/122



Quadratic Algebras

Alexander Polishchuk, *University of Oregon, Eugene, OR*, and **Leonid Positselski**, *Independent University of Moscow, Russia*

This book introduces recent developments in the study of algebras defined by quadratic relations. One of the main problems in the study of these (and similarly defined) algebras is how to control their size. A central notion in solving this problem is the notion of a Koszul algebra, which was introduced in 1970 by S. Priddy and then appeared in many areas of mathematics, such as algebraic geometry, representation theory, noncommutative geometry, K-theory, number theory, and noncommutative linear algebra.

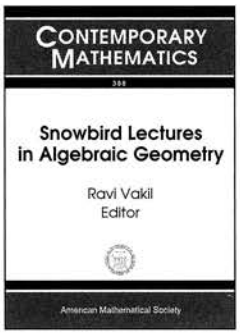
The authors give a coherent exposition of the theory of quadratic and Koszul algebras, including various definitions of Koszulness, duality theory, Poincaré–Birkhoff–Witt-type theorems for Koszul algebras, and the Koszul deformation principle. In the concluding chapter of the book, they explain a surprising connection between Koszul algebras and one-dependent discrete-time stochastic processes.

The book can be used by graduate students and researchers working in algebra and any of the above-mentioned areas of mathematics.

Contents: Preliminaries; Koszul algebras and modules; Operations on graded algebras and modules; Poincaré-Birkhoff-Witt bases; Nonhomogeneous quadratic algebras; Families of quadratic algebras and Hilbert series; Hilbert series of Koszul algebras and one-dependent processes; DG-algebras and Massey products; Bibliography.

University Lecture Series, Volume 37

December 2005, approximately 176 pages, Softcover, ISBN 0-8218-3834-2, LC 2005048198, 2000 *Mathematics Subject Classification*: 16S37, 16S15, 16E05, 16E30, 16E45, 16W50, 13P10, 60G10, **Individual member US$21**, List US$35, Institutional member US$28, Order code ULECT/37



Snowbird Lectures in Algebraic Geometry

Ravi Vakil, *Stanford University, CA*, Editor

A significant part of the 2004 Summer Research Conference on Algebraic Geometry (Snowbird, UT) was devoted to lectures introducing the participants, in particular, graduate students and recent Ph.D.'s, to a wide swathe of algebraic geometry and giving them a working familiarity with exciting, rapidly developing parts of the field. One of the main goals of the organizers was to allow the participants to broaden their horizons beyond the narrow area in which they are working. A fine selection of topics and a noteworthy list of contributors made the resulting collection of articles a useful resource for everyone interested in getting acquainted with the modern topic of algebraic geometry.

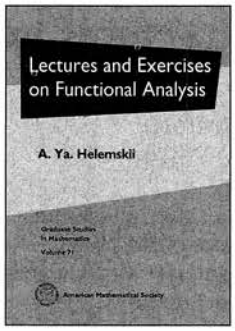
The book consists of ten articles covering, among others, the following topics: the minimal model program, derived categories of sheaves on algebraic varieties, Kobayashi hyperbolicity, groupoids and quotients in algebraic geometry, rigid analytic varieties, and equivariant cohomology. Suitable for independent study, this unique volume is intended for graduate students and researchers interested in algebraic geometry.

Contents: **C. Araujo**, Rationally connected varieties; **C. Cadman, I. Coskun, K. Jabbusch, M. Joyce, S. J. Kovács, M. Lieblich, F. Sato, M. Szczesny**, and **J. Zhang**, A first glimpse at the minimal model program; **A. Căldăraru**, Derived categories of sheaves: A skimming; **I. Coskun**, The arithmetic and the geometry of Kobayashi hyperbolicity; **S. Grushevsky**, Multiplier ideals in algebraic geometry; **D. Lehavi**, Mikhalkin's classification of M-curves in maximal position with respect to three lines; **M. Lieblich**, Groupoids and quotients in algebraic geometry; **B. Osserman**, Two degeneration techniques for maps of curves; **M. Papikian**, Rigid-analytic geometry and the uniformization of abelian varieties; **N. Proudfoot**, Geometric invariant theory and projective toric varieties; **J. S. Tymoczko**, An introduction to equivariant cohomology and homology, following Goresky, Kottwitz, and MacPherson.

Contemporary Mathematics, Volume 388

November 2005, 188 pages, Softcover, ISBN 0-8218-3719-2, LC 2005053606, 2000 *Mathematics Subject Classification*: 14-02, 14-06, **All AMS members US$47**, List US$59, Order code CONM/388

Analysis



Lectures and Exercises on Functional Analysis

For Classroom Use

A. Ya. Helemskii, *Moscow State University, Russia*

This book contains a unique exposition intended to serve as an introduction to functional analysis. Topics covered include normed spaces and bounded operators, Banach spaces, polynormed spaces and distributions, compact operators, C^*-algebras, spectral theorems, Fourier transform, and more.

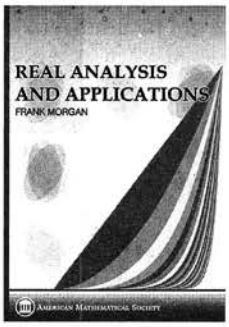
A distinguishing feature of the book is the wide use of the language and elementary constructions of category theory, which are explained in the opening chapter of the book. Among nonstandard topics discussed in the book are the theory of Banach tensor products, basics of quantum functional analysis, and Borel operator calculus. General definitions and main results are supplemented with many examples and exercises.

Prerequisites for the main part of the book include standard undergraduate courses in algebra and analysis. It is suitable for graduate students and researchers interested in functional analysis.

Contents: Foundations: Categories and the like; Normed spaces and bounded operators ("Waiting for completeness"); Banach spaces and their advantages; From compact spaces to Fredholm operators; Polynormed spaces, weak topologies, and generalized functions; At the gates of spectral theory; Hilbert adjoint operators and the spectral theorem; Fourier transform; Bibliography; Index.

Graduate Studies in Mathematics, Volume 71

December 2005, approximately 496 pages, Hardcover, ISBN 0-8218-3552-1, LC 2005053605, 2000 *Mathematics Subject Classification*: 46-01, 47-01, **All AMS members US$63**, List US$79, Order code GSM/71



Real Analysis and Applications

For Classroom Use

Including Fourier Series and the Calculus of Variations

Frank Morgan, *Williams College, Williamstown, MA*

Real Analysis and Applications starts with a streamlined, but complete, approach to real analysis. It finishes with a wide variety of applications in Fourier series and the calculus of variations, including minimal surfaces, physics, economics, Riemannian geometry, and general relativity. The basic theory includes all the standard topics: limits of sequences, topology, compactness, the Cantor set and fractals, calculus with the Riemann integral, a chapter on the Lebesgue theory, sequences of functions, infinite series, and the exponential and Gamma functions. The applications conclude with a computation of the relativistic precession of Mercury's orbit, which Einstein called "convincing proof of the correctness of the theory [of General Relativity]."

The text not only provides clear, logical proofs, but also shows the student how to derive them. The excellent exercises come with select solutions in the back. This is a text that makes it possible to do the full theory and significant applications in one semester.

Frank Morgan is the author of six books and over one hundred articles on mathematics. He is an inaugural recipient of the Mathematical Association of America's national Haimo award for excellence in teaching. With this applied version of his *Real Analysis* text, Morgan brings his famous direct style to the growing numbers of potential mathematics majors who want to see applications along with the theory.

The book is suitable for undergraduates interested in real analysis.

Contents: *Part I: Real numbers and limits:* Numbers and logic; Infinity; Sequences; Subsequences; Functions and limits; Composition of functions; *Part II: Topology:* Open and closed sets; Compactness; Existence of maximum; Uniform continuity; Connected sets and the intermediate value theorem; The Cantor set and fractals; *Part III: Calculus:* The derivative and the mean value theorem; The Riemann integral;

The fundamental theorem of calculus; Sequences of functions; The Lebesgue theory; Infinite series $\sum_{n=1}^{\infty} a_n$; Absolute convergence; Power series; The exponential function; Volumes of n-balls and the gamma function; *Part IV: Fourier series:* Fourier series; Strings and springs; Convergence of Fourier series; *Part V: The calculus of variations:* Euler's equation; First integrals and the Brachistochrone problem; Geodesics and great circles; Variational notation, higher order equations; Harmonic functions; Minimal surfaces; Hamilton's action and Lagrange's equations; Optimal economic strategies; Utility of consumption; Riemannian geometry; Noneuclidean geometry; General relativity; Partial solutions to exercises; Greek letters; Index.

January 2006, approximately 208 pages, Hardcover, ISBN 0-8218-3841-5, LC 2005041221, 2000 *Mathematics Subject Classification*: 26-01, 49-01, 42-01, 83Cxx, **All AMS members US$31**, List US$39, Order code REALAPP

This volume is recommended for independent study and is suitable for graduate students and researchers interested in symplectic geometry, algebraic geometry, and geometric combinatorics.

This item will also be of interest to those working in algebra and algebraic geometry.

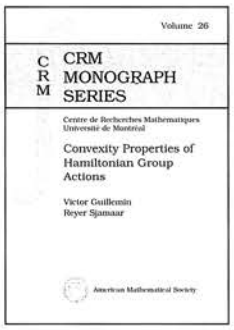
Contents: Introduction; The convexity theorem for Hamiltonian G-spaces; A constructive proof of the non-abelian convexity theorem; Some elementary examples of the convexity theorem; Kähler potentials and convexity; Applications of the convexity theorem; Bibliography.

CRM Monograph Series, Volume 26

November 2005, 88 pages, Hardcover, ISBN 0-8218-3918-7, LC 2005044490, 2000 *Mathematics Subject Classification*: 53D20; 14L24, 53-02, 53C55, **All AMS members US$28**, List US$35, Order code CRMM/26

New AMS-Distributed Publications

Geometry and Topology

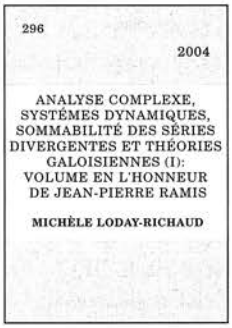


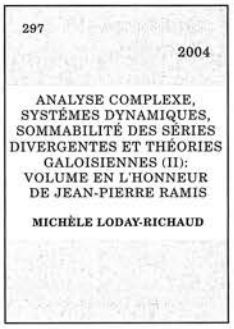
Convexity Properties of Hamiltonian Group Actions

Victor Guillemin and **Reyer Sjamaar**

This is a monograph on convexity properties of moment mappings in symplectic geometry. The fundamental result in this subject is the Kirwan convexity theorem, which describes the image of a moment map in terms of linear inequalities. This theorem bears a close relationship to perplexing old puzzles from linear algebra, such as the Horn problem on sums of Hermitian matrices, on which considerable progress has been made in recent years following a breakthrough by Klyachko. The book presents a simple local model for the moment polytope, valid in the "generic" case, and an elementary Morse-theoretic argument deriving the Klyachko inequalities and some of their generalizations. It reviews various infinite-dimensional manifestations of moment convexity, such as the Kostant type theorems for orbits of a loop group (due to Atiyah and Pressley) or a symplectomorphism group (due to Bloch, Flaschka and Ratiu). Finally, it gives an account of a new convexity theorem for moment map images of orbits of a Borel subgroup of a complex reductive group acting on a Kähler manifold, based on potential-theoretic methods in several complex variables.

Differential Equations





Analyse Complexe, Systémes Dynamiques, Sommabilité des Séries Divergentes et Théories Galoisiennes (I) (II)

Michèle Loday-Richaud, *Université d'Angers, France*, Editor

These two bound volumes present the proceedings of the conference, Complex Analysis, Dynamical Systems, Summability of Divergent Series and Galois Theories, held in Toulouse on the occasion of J.-P. Ramis' sixtieth birthday.

The first volume opens with two articles composed of recollections and three articles on J.-P. Ramis' works on complex analysis and ODE theory, both linear and non-linear. This introduction is followed by papers concerned with Galois theories, arithmetic

or integrability: analogies between differential and arithmetical theories, q-difference equations, classical or p-adic, the Riemann–Hilbert problem and renormalization, b-functions, descent problems, Krichever modules, the set of integrability, Drach theory, and the VI^{th} Painlevé equation.

The second volume contains papers dealing with analytical or geometrical aspects: Lyapunov stability, asymptotic and dynamical analysis for pencils of trajectories, monodromy in moduli spaces, WKB analysis and Stokes geometry, first and second Painlevé equations, normal forms for saddle-node type singularities, and invariant tori for PDEs.

The volumes are suitable for graduate students and researchers interested in differential equations, number theory, geometry, and topology.

This item will also be of interest to those working in geometry and topology and number theory.

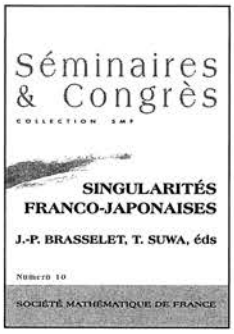
A publication of the Société Mathématique de France, Marseilles (SMF), distributed by the AMS in the U.S., Canada, and Mexico. Orders from other countries should be sent to the SMF. Members of the SMF receive a 30% discount from list.

Contents: Volume I: B. Malgrange, Les premiers travaux de Jean-Pierre Ramis; **G. Ruget**, Témoignage; **D. Bertrand**, Travaux de J.-P. Ramis sur les équations différentielles linéaires; **D. Cerveau**, Travaux de J.-P. Ramis sur les équations différentielles non linéaires; **M. Loday-Richaud**, Souvenirs strasbourgeois; **Y. André**, Galois representations, differential equations, and q-difference equations: sketch of a p-adic unification; **Y. André** and **L. Di Vizio**, q-difference equations and p-adic local monodromy; **A. Connes**, Renormalisation et ambiguité galoisienne; **Y. Laurent**, b-functions and integrable solutions of holonomic $\mathcal{D}$-module; **A. L. Neto**, Curvature of pencils of foliations; **M. van der Put**, Skew differential fields, differential and difference equations; **M. van der Put** and **M. Reversat**, Krichever modules for difference and differential equations; **J. Sauloy**, Algebraic construction of the Stokes sheaf for irregular linear q-difference equations; **H. Umemura**, Monodromy preserving deformation and differential Galois group I; **Volume II: F. Cano, R. Moussu**, and **F. Sanz**, Pinceaux de courbes intégrales d'un champ de vecteurs analytique; **B. Dubrovin**, On analytic families of invariant tori for PDEs; **N. Joshi, K. Kahwara**, and **M. Mazzocco**, Generating function associated with the determinant formula for the solutions of the Painlevé II equation; **V. Kaloshin, J. N. Mather**, and **E. Valdinoci**, Instability of resonant totally elliptic points of symplectic maps in dimension 4; **T. Kawai, T. Koike, Y. Nishikawa**, and **Y. Takei**, On the Stokes geometry of higher order Painlevé equations; **F. Loray**, Versal deformation of the analytic saddle-node; **C. Simpson**, Asymptotics for general connections at infinity.

Astérisque, Number 296–297

Volume I: April 2005, 270 pages, Softcover, ISBN 2-85629-167-8, 2000 *Mathematics Subject Classification*: 01A70, 11R32, 11R39, 11S80, 12Hxx, 13Nxx, 17B15, 32G34, 32S65, 33E17, 34A30, 34A34, 34Mxx, 35A27, 35D10, 37F75, 39A13, 58B34, 81T15, 14F10, 14H70, 32D20, 32Gxx, 34C08, 34C10, 34D20, 34D23, 34Exx, 35Q53, 37Jxx, 37K10, 37K20, **Individual member US$74,** List US$82, Order code AST/296
Volume II: April 2005, 232 pages, Softcover, ISBN 2-85629-168-6, 2000 *Mathematics Subject Classification*: 01A70, 11R32, 11R39, 11S80, 12Hxx, 13Nxx, 17B15, 32G34, 32S65, 33E17, 34A30, 34A34, 34Mxx, 35A27, 35D10, 37F75, 39A13, 58B34, 81T15, 14F10, 14H70, 32D20, 32Gxx, 34C08, 34C10, 34D20, 34D23, 34Exx, 35Q53, 37Jxx, 37K10, 37K20, **Individual member US$53,** List US$59, Order code AST/297
Set: April 2005, 502 pages, Softcover, 2000 *Mathematics Subject Classification*: 01A70, 11R32, 11R39, 11S80, 12Hxx, 13Nxx, 17B15, 32G34, 32S65, 33E17, 34A30, 34A34, 34Mxx, 35A27, 35D10, 37F75, 39A13, 58B34, 81T15, 14F10, 14H70, 32D20, 32Gxx, 34C08, 34C10, 34D20, 34D23, 34Exx, 35Q53, 37Jxx, 37K10, 37K20, **Individual member US$110**, List US$122, Order code AST/296/97

Geometry and Topology



Singularités Franco-Japonaises

Jean-Paul Brasselet, *CNRS, Marseille, France*, and **Tatsuo Suwa**, *Hokkaido University, Sapporo, Japan*, Editors

The second Franco-Japanese Singularity Conference was held in the CIRM (Marseille-Luminy) in September 2002. The proceedings of the meeting published in this volume show not only the diversity, but also the consistency of the fields discussed. The main topics covered by the lectures were characteristic classes, residues, stratifications, singularities of curves and surfaces, valuations, resolution of singularities, and toric varieties. Several papers present the results recently obtained in the field so as to be accessible to non-specialists and to users of singularity theory.

The volume is suitable for graduate students and research mathematicians interested in geometry and topology.

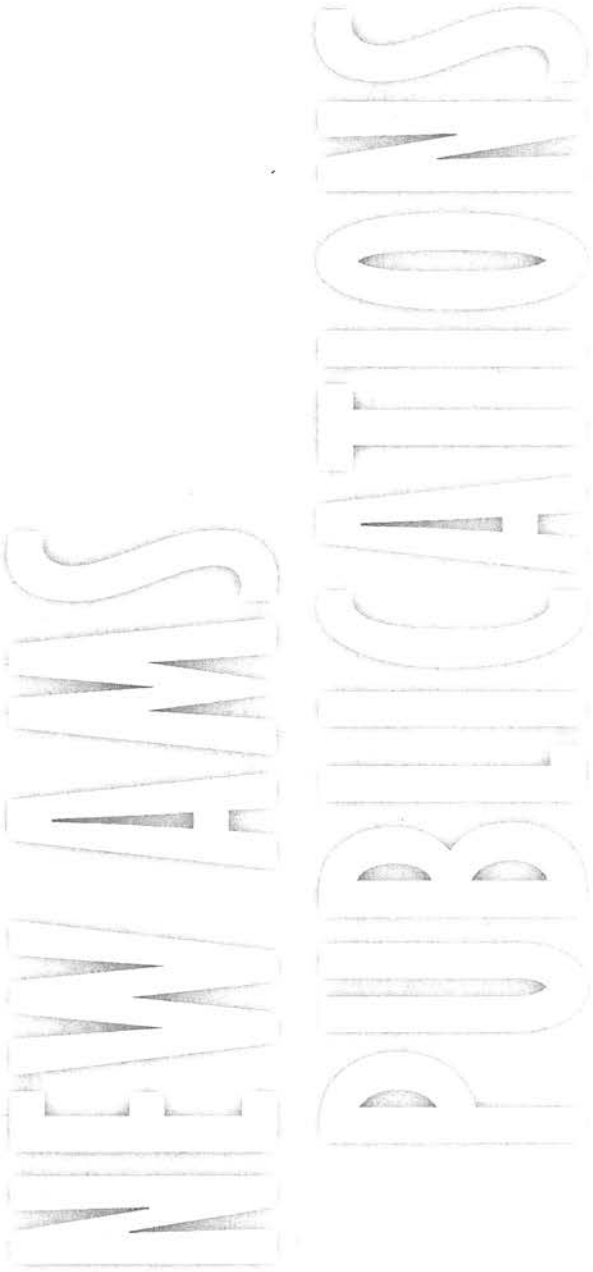
A publication of the Société Mathématique de France, Marseilles (SMF), distributed by the AMS in the U.S., Canada, and Mexico. Orders from other countries should be sent to the SMF. Members of the SMF receive a 30% discount from list.

Contents: F. Aroca and **J. Snoussi**, Normal quasi-ordinary singularities; **R. Bondil**, General elements of an m-primary ideal on a normal surface singularity; **J.-P. Brasselet, J. Seade**, and **T. Suwa**, An explicit cycle representing the Fulton-Johnson class, I; **T. Brélivet**, Sur les paires spectrales de

polynômes à deux variables; **D. Garber**, On the connection between affine and projective fundamental groups of line arrangements and curves; **H. A. Hamm** and **D. T. Lê**, On the Picard group for non-complete algebraic varieties; **H. Hironaka**, Three key theorems on infinitely near singularities; **D. Juniati** and **D. Trotman**, Determination of Lipschitz stratifications for the surfaces $y^a = z^b x^c + x^d$; **V. P. Kostov**, On arrangements of the roots of a hyperbolic polynomial and of one of its derivatives; **K. Kurdyka** and **L. Paunescu**, Arc-analyticity is an open property; **I. Luengo** and **A. Pichon**, Lê's conjecture for cyclic covers; **Y. Nakamura** and **S. Tajima**, Unimodal singularities and differential operators; **M. Oka**, A survey on Alexander polynomials of plane curves; **H. Ohta** and **K. Ono**, Symplectic 1-manifolds containing singular rational curves with $(2,3)$-cusp; **A. Parusiński**, Integrability of some functions on semi-analytic sets; **P. Polo**, Construction d'hypersurfaces affines à cohomologie d'intersection prescrite; **T. Suwa**, Residues of Chern classes on singular varieties; **S. Tajima** and **Y. Nakamura**, Computational aspects of Grothendieck local residues; **H. Tokunaga**, 2-dimensional versal S_4-covers and rational elliptic surfaces; **T. Tomaru**, On some classes of weakly Kodaira singularities; **M. Tosun**, ADE surface singularities, chambers and toric varieties; **S. Tsuboi**, The Chern numbers of the normalization of an algebraic threefold with ordinary singularities; **N. C. Tu**, On semi-stable, singular cubic surfaces; **M. Vaquié**, Famille admise associée à une valuation de $K[x]$; **S. Yokura**, Generalized Ginzburg-Chern classes; **A. Y. Yoshikawa** and **K. Yoshikawa**, Isolated critical points and adiabatic limits of Chern forms.

Séminaires et Congrès, Number 10

March 2005, 460 pages, Softcover, ISBN 2-85629-166-X, 2000 *Mathematics Subject Classification*: 12D10, 13A18, 14B05, 14C05, 14C17, 14C22, 14D05, 14E15, 14E20, 32A27, 14H30, 14J17, 32B20, 32S05, 32S10, 32S15, 32S25, 32S45, 32S60, 53D35, 58K05, **Individual member US$74**, List US$82, Order code SECO/10



Classified Advertisements

Positions available, items for sale, services available, and more

ALABAMA

UNIVERSITY OF ALABAMA IN HUNTSVILLE
Mathematical Sciences Department

The Mathematical Sciences Department at the University of Alabama in Huntsville invites applications for two tenure-track faculty positions with the rank of assistant/associate professor, beginning August, 2006. A Ph.D. degree in mathematics or applied mathematics is required. Applicants must also have a strong commitment to teaching both non-majors and majors and show evidence of excellent teaching ability. Applicants should show evidence of outstanding research potential in an area that matches the interests of the department. Preference will be given to applicants whose research areas are probability/stochastic processes and numerical analysis.

Applicants should send a curriculum vita with the AMS standard cover sheet, and three letters of recommendation (with at least one letter addressing teaching) to:

Chairman
Department of Mathematical Sciences
University of Alabama in Huntsville
Huntsville, AL 35899
email: math-chr@math.uah.edu

For more information about the department, visit our website at http://www.math.uah.edu.

To ensure full consideration, all materials should be received by January 10, 2006. Late applications will be reviewed until the position is closed. Women and minorities are encouraged to apply. The University of Alabama in Huntsville is an Affirmative Action, Equal Opportunity Institution.

000176

ARIZONA

ARIZONA STATE UNIVERSITY
Department of Mathematics and Statistics
Assistant Professor

The Department of Mathematics and Statistics at Arizona State University invites applications for a tenure-track position at the Assistant Professor level, beginning in the fall semester of 2006. Applicants are required to have a doctorate in mathematics by August 16, 2006, with a research emphasis in algebra. Preference will be given to those whose specialty supports the department's existing strengths in number theory (including arithmetic algebraic geometry and cryptography) or algebraic combinatorics. Candidates must also have demonstrated potential for excellence in mathematical research and teaching at all levels.

The successful candidate will be expected to secure external funding for research, to publish in the area of algebra or closely related fields, to provide quality teaching of undergraduate and graduate students, and to perform appropriate professional service.

The Tempe campus of Arizona State University has approximately 50,000 students and is located in the rapidly growing metropolitan Phoenix area, which provides a wide variety of recreational and cultural opportunities. The Department of Mathematics and Statistics currently has 50 full time faculty members and 140 graduate students. The department has excellent computing resources, including individual faculty workstations and access to the university's central computing facilities.

Applicants must send: (1) a curriculum vita, (2) an AMS Cover Sheet available at http://www.ams.org/coversheet/, (3) a personal statement addressing their research agenda, and (4) a statement of teaching philosophy, and must also arrange for three letters of recommendation to be sent to:

Algebra Search Committee
Department of Mathematics and Statistics
Arizona State University
PO Box 871804
Tempe, AZ 85287-1804

A background check is required for employment.

Review of the applications will begin on December 15, 2005; if not filled, weekly thereafter or until the search is closed. AA/EOE

000182

ARIZONA STATE UNIVERSITY
Mathematical Sciences and Applied Computing Department

The Mathematical Sciences and Applied Computing Department at Arizona State University's West campus invites applications for a full-time tenured/tenure-track position at either Assistant or Associate Professor rank beginning August 16, 2006. We are seeking applicants to conduct research in applied mathematics, to develop and teach new undergraduate courses, and to forge interdisciplinary collaborations

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 2005 rate is $100 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: January 2006 issue–October 28, 2005; February 2006 issue–November 29, 2005; March 2006 issue–December 30, 2005; April 2006 issue–January 31, 2006; May 2006 issue–February 28, 2006; June/July 2006 issue–April 28, 2006.

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.

in research and/or teaching. Faculty are expected to provide service to the department, campus, and community.

Candidates must have a Ph.D. in mathematics or related field; an ongoing research program; and a record of extramural funding appropriate to rank. Candidates must demonstrate evidence of excellence in undergraduate teaching and potential for interdisciplinary collaborative research and/or teaching appropriate to rank. Evidence of experience with undergraduate student involvement in research and/or internships is desired. Evidence of interest or expertise in applied mathematics, statistics, and applied computing, and interest in collaborations spanning these fields is desired also.

Deadline: December 15, 2005; if not filled, the 10th of every month thereafter until the search is closed. Send a letter of application, CV, unofficial graduate transcripts, and statements about teaching and research interests and arrange to have three letters of recommendation sent to Mathematics Search, Mathematical Sciences and Applied Computing Department, ASU at the West campus, PO Box 37100, Phoenix, AZ 85069-7100 or electronically to http://www.west.asu.edu/newcollege/8401.

As a new American university, Arizona State University is a force for discovery, turning students into leaders who shape the future. The West campus of ASU, located in Phoenix, fulfills this mission through interdisciplinary teaching, research and community engagement. The campus serves more than 7,500 students and offers 31 bachelor's degree programs, nine master's degrees, eight professional certificates, and is currently developing its first doctoral degree program. Please visit our website at http://www.west.asu.edu/. ASU is an Equal Opportunity/Affirmative Action employer in policy and practice. A background check is required for employment.

000172

CALIFORNIA

CALIFORNIA INSTITUTE OF TECHNOLOGY
Harry Bateman Research Instructorships in Mathematics

Description: Appointments are for two years. The academic year runs from approximately October 1 to June 1. Instructors are expected to teach one course per quarter for the full academic year and to devote the rest of their time to research. During the summer months there are no duties except research.

Eligibility: Open to persons who have recently received their doctorates in mathematics.

Grant amount: The annual salary for academic year 2006–2007 is $51,000. Deadline: January 1, 2006.

Application information: Please send applications to Search Committee, 253-37 Sloan Laboratory, California Institute of Technology, Pasadena, CA 91125. Include a CV and a statement of anticipated research. Please ensure that at least three letters of recommendation are sent to Caltech. To avoid duplication of paperwork, your application may also be considered for an Olga Taussky and John Todd Instructorship. Caltech is an Affirmative Action/Equal Opportunity Employer. Women, minorities, veterans, and disabled persons are encouraged to apply.

000113

CALIFORNIA INSTITUTE OF TECHNOLOGY
Scott Russell Johnson Senior Postdoctoral Scholar in Mathematics

Description: There are three terms in the Caltech academic year. The fellow is expected to teach one course in two terms each year, and is expected to be in residence even during terms when not teaching. The initial appointment is for three years with an additional three-year terminal extension expected.

Eligibility: Offered to a candidate within six years of having received the Ph.D. who shows strong research promise in one of the areas in which Caltech's mathematics faculty is currently active.

Grant amount: The annual salary for 2006–2007 is $60,500 plus a $3,000 per year research fund. Deadline: January 1, 2006.

Application information: Please send applications to Search Committee, 253-37 Sloan Laboratory, California Institute of Technology, Pasadena, CA 91125. Include a CV and a statement of anticipated research. Please ensure that at least three letters of recommendation are sent to Caltech. To avoid duplication of paperwork, your application may also be considered for an Olga Taussky and John Todd Instructorship. Caltech is an Affirmative Action/Equal Opportunity Employer. Women, minorities, veterans, and disabled persons are encouraged to apply.

000114

CALIFORNIA INSTITUTE OF TECHNOLOGY
Olga Taussky and John Todd Instructorships in Mathematics

Description: Appointments are for three years. There are three terms in the Caltech academic year, and instructors are expected to teach one course in all but two terms of the total appointment. These two terms will be devoted to research. During the summer months there are no duties except research.

Eligibility: Offered to persons within three years of having received the Ph.D. who show strong research promise in one of the areas in which Caltech's mathematics faculty is currently active.

Grant amount: The annual salary for 2006–2007 is $53,600 plus a $3,000 per year research fund.

Deadline: January 1, 2006.

Application information: Please send applications to Search Committee, 253-37 Sloan Laboratory, California Institute of Technology, Pasadena, CA 91125. Include a CV and a statement of anticipated research. Please ensure that at least three letters of recommendation are sent to Caltech. To avoid duplication of paperwork, your application may also be considered for an Olga Taussky and John Todd Instructorship. Caltech is an Affirmative Action/Equal Opportunity Employer. Women, minorities, veterans, and disabled persons are encouraged to apply.

000115

CALIFORNIA STATE UNIVERSITY CHANNEL ISLANDS
Department of Mathematics

CSUCI, the newest campus of the CSU System, located in Camarillo, invites applications for tenure/tenure-track faculty positions within the discipline of Mathematics beginning fall 2006. Excellence in both teaching and research is essential, and a Ph.D. is required. Preference will be given to broadly trained individuals who have postdoctoral experience and ability and interest in teaching a wide range of courses within and across disciplines. To submit an application please visit our website at: http://csucifacultyjobs.com.

000193

CALIFORNIA STATE POLY. UNIV., POMONA
Math. & Stat. Dept.

4 tenure-track positions: 2 in Math. Ed., 1 in Stat. & 1 in Math., beginning 9/2006. Rank/salary dep. on quals. Good benefits. Start-up funds, reduced teaching first year. Potential for excellent teaching, scholarship & directing Master's theses. We have a student body with diverse socio-economic, cultural backgrounds & learning styles. We are looking for faculty who can work successfully in this environment. Math. Ed. (Asst./Assoc. Prof. Level) Ph.D in Math. Ed. (or rel. field) w/MA in Math. (or equiv). Teach undergrad/grad Math. Ed. Supervise sec. math. student teachers, work w/teachers in local schools, grant work related to K-16 teaching and learning, dev. curriculum in new Masters' emphasis in Math Ed. Statistics (Asst./Assoc. Prof. Level): Ph.D. in Stats (or rel. area). Teach undergrad/grad statistics. Stats. consulting expected. Preferred areas: stats. consulting, design of experiments, multivariate analysis, time series analysis, & biostatistics. Mathematics (Asst. Prof.

Level): Ph.D. in Math (or rel. area). Teach broad range of undergrad/grad. mathematics. Interested in those who can teach some of following: combinatorics, geometry, graph theory & op. research. Application deadlines: Math Ed., 12/7/05; Stat., 1/19/06; & Math. 1/26/06. Late appls. may be reviewed until position filled/closed. Submit appl. form, curr. vitae, teaching philosophy, research statement, undergrad and grad transcripts, min, 3 recent ref letters. Indicate position. Address potential to meet position description listed above. Send to: Faculty Search Committee, Math. & Stat Dept, Cal. Poly Pomona, 3801 W. Temple Ave., Pomona, CA 91768-4007; 909-869-4008; Fax: 909-869-4904; See http://www.csupomona.edu/~math/position. AA/EEO.

000194

UNIVERSITY OF CALIFORNIA, BERKELEY
Department of Mathematics
Berkeley, CA 94720
Charles B. Morrey Jr. Assistant Professorships

We invite applications for these special (nontenure-track) positions effective July 1, 2006. The terms of these appointments may range from two to three years. Applicants should have a recent Ph.D., or the equivalent, in an area of pure or applied mathematics. Applicants should send a resume, reprints, preprints and/or dissertation abstract, and ask three people to send letters of evaluation to The Vice Chair for Faculty Affairs at the above address. All letters of evaluation are subject to Berkeley campus policies on confidentiality of letters of evaluation, a summary of which can be found on our home page http://math.berkeley.edu by clicking on People, then Employment, and then Academic Openings. We request that applicants use the AMS standardized application form and indicate their subject area using the AMS subject classification numbers. The form is the Academic Employment in Mathematics, Application Cover Sheet. It is available courtesy of the American Mathematical Society.

Applications must be postmarked by December 15, 2005. Applications postmarked after the deadline will not be considered. The University of California is an Equal Opportunity, Affirmative Action Employer.

000121

UNIVERSITY OF CALIFORNIA AT BERKELEY
Department of Mathematics
Berkeley, CA 94720
Temporary Postdoctoral Positions

Several temporary positions beginning in Fall 2006 are anticipated for new and recent Ph.D.'s of any age, in any area of pure or applied mathematics. The terms of these appointments may range from one to three years. Applicants for NSF or other postdoctoral fellowships are encouraged to apply for these positions. Mathematicians whose research interests are close to those of regular department members will be given some preference. Applicants should send a resume and reprints, preprints, and/or dissertation abstract, and ask three people to send letters of evaluation to The Vice Chair for Faculty Affairs at the above address. All letters of evaluation are subject to Berkeley campus policies on confidentiality of letters of evaluation, a summary of which can be found on our home page http://math.berkeley.edu by clicking on People, then Employment, and then Academic Openings. We request that applicants use the AMS standardized application form and indicate their subject area using the AMS subject classification numbers. The form is the Academic Employment in Mathematics, Application Cover Sheet. It is available courtesy of the American Mathematical Society.

Applications must be postmarked by December 15, 2005. Applications postmarked after the deadline will not be considered. The University of California is an Equal Opportunity, Affirmative Action Employer.

000122

UNIVERSITY OF CALIFORNIA AT BERKELEY
Department of Mathematics
Berkeley, CA 94720
Tenured or Tenure-Track Position

Pending budget approval, we invite applications for three positions effective July 1, 2006, at either the tenure-track (Assistant Professor) or tenured (Associate or Full Professor) level, in pure or applied mathematics. We are seeking candidates with no more than 10 years experience after their Ph.D.

Tenure-track applicants are expected to have demonstrated outstanding research potential, normally including major contributions beyond the doctoral dissertation. Such applicants should send a resume, and reprint or preprints, and/or dissertation abstract, and ask three people to send letters of evaluation to The Vice Chair for Faculty Affairs at the above address. It is the responsibility of the tenure-track applicants to make sure that letters of evaluation are sent. All letters of evaluation are subject to Berkeley campus policies on confidentiality of letters of evaluation, a summary of which can be found on our home page http://math.berkeley.edu by clicking on People, then Employment, and then Academic Openings.

Tenure applicants are expected to demonstrate leadership in research and should send a curriculum vitae, list of publications, a few selected reprints or preprints, and the names and addresses of three references to The Vice Chair for Faculty Affairs at the above address. Applicants should indicate whether they are applying for an Associate Professor or a Full Professor position. The department will assume responsibility to solicit letters of evaluation and will provide evaluators with a copy of the summary of policies on confidentiality of letters of evaluation.

All applicants are requested to use the AMS standardized application form and to indicate their subject area using the AMS subject classification numbers. The form is the Academic Employment in Mathematics, Application Cover Sheet. It is available courtesy of the American Mathematical Society.

Applications for both tenure-track and tenure applications must be postmarked by December 15, 2005. Applications postmarked after the deadline will not be considered. The University of California is an Equal Opportunity, Affirmative Action Employer.

000135

UNIVERSITY OF CALIFORNIA, IRVINE
Department of Mathematics
Irvine, CA 92697-3875

Applications are invited for tenure-track Assistant Professor level positions in all areas of pure and applied mathematics. Appointments will be effective July 1, 2006, or later. Applicants must demonstrate excellence and potential in research and teaching. The Ph.D. degree is required.

Completed applications must be submitted electronically and must contain (1) a curriculum vitae (with email address), (2) selected reprints and/or preprints, (3) four reference letters sent electronically, as directed online, and (4) a research plan.

Instructions for the electronic application process can be found at: http://ps.uci.edu/employment/apply.html.

Applications are welcome at any time. The review process starts November 15, 2005, and will continue until positions are filled. The University of California, Irvine, is an Equal Opportunity Employer committed to excellence through diversity. UC Irvine has an active Career Partners Program and has a National Science Foundation ADVANCE Gender Equity Program.

000128

UNIVERSITY OF CALIFORNIA, IRVINE
Department of Mathematics
Irvine, CA 92697-3875

Applications are invited for lecturer with potential security of employment positions (Lecturer PSOE positions) in all areas of pure and applied mathematics. Appointments will be effective July 1, 2006, or later. An excellent record of teaching and the Ph.D. degree are required.

Completed application must be submitted electronically and must contain (1) a curriculum vitae (with email address), (2) selected reprints and/or preprints, (3) three reference letters sent electronically,

as directed online, and (4) teaching evaluations.

Instructions for the electronic application process can be found at: http://ps.uci.edu/employment/apply.html.

Applications are welcome at any time. The review process starts November 15, 2005, and will continue until positions are filled. The University of California, Irvine, is an Equal Opportunity Employer committed to excellence through diversity. UC Irvine has an active Career Partners Program and has a National Science Foundation ADVANCE Gender Equity Program.

000129

UNIVERSITY OF CALIFORNIA, IRVINE
Department of Mathematics
Irvine, CA 92697-3875

The Department of Mathematics at the University of California, Irvine, invites applications from Full Professors to fill a newly endowed $2.5M chair—the UCI Excellence in Teaching Endowed Chair in Mathematics. This chair is made possible through a gift from the California Community Foundation. It is the largest endowed chair ever received by UC Irvine.

The successful candidate will be an exceptionally talented research mathematician, with national and international recognition for scholarship, demonstrated excellence in teaching, and strong commitment to service. Additionally, the candidate should be interested in assuming a leadership role to enhance the supply and preparation of science and mathematics teachers for California's public schools.

Completed applications should be sent to the Recruiting Committee at the address shown above, and should contain (1) a curriculum vitae (with email address), (2) selected reprints and/or preprints, and (3) contact information for three references.

Applications are welcome at any time. The review process starts November 15, 2005, and will continue until position is filled. The University of California, Irvine, is an Equal Opportunity Employer committed to excellence through diversity. UC Irvine has an active Career Partners Program and has a National Science Foundation ADVANCE Gender Equity Program.

000142

UNIVERSITY OF CALIFORNIA, IRVINE
Department of Mathematics
Irvine, CA 92697-3875

Applications are invited for several Visiting Assistant Professor positions, renewable up to three years, in the following areas of research: A) applied and computational mathematics; B) analysis and PDE (includes mathematical physics); C) geometry and topology (includes geometric analysis); D) logic and set theory; E) probability; and F) algebra and number theory (includes algebraic and arithmetic geometry). VAPs teach no more than five quarter classes per year, at a current annual salary of $46,300. Applicants must possess a Ph.D., and strong promise in research and teaching is required. Appointments will be effective July 1, 2006, or later.

Completed applications must be submitted electronically and must contain (1) a curriculum vitae (noting email address and research area A-F), (2) selected reprints and/or preprints, and (3) three reference letters sent electronically, as directed online.

Instructions for the electronic application process can be found at: http://ps.uci.edu/employment/apply.html.

Applications are welcome at any time. The review process starts December 15, 2005, and will continue until positions are filled. The University of California, Irvine is an Equal Opportunity Employer committed to excellence through diversity. UC Irvine has an active Career Partners Program and has a National Science Foundation ADVANCE Gender Equity Program.

000158

UNIVERSITY OF CALIFORNIA,
LOS ANGELES
Department of Mathematics

The following positions are available for the 2006-07 academic year, subject to availability of resources and administrative approval.

(1) Tenure-track/Tenured Faculty positions.

(2) E.R. Hedrick Assistant Professorships. Salary is $53,200. And appointments are for three years. The teaching load is four quarter courses per year.

(3) Research Assistant Professorships in Computational and Applied Mathematics (CAM). The salary is $53,200, and appointments are for three years. The teaching load is normally reduced to two or three quarter courses per year by research funding as available.

(4) Hedrick or CAM applicants who are U.S. citizens or permanent residents may also apply for a VIGRE Assistant Professor position. These are also three-year appointments with a salary of $53,200. The teaching load is 3 quarter courses per year.

(5) Assistant Adjunct Professorships in the Program in Computing (PIC). Applicants for these positions must show very strong promise in teaching and research in an area related to computing. The teaching load is four one-quarter programming courses each year and one seminar every two years. Initial appointments are for one year and possibly longer, up to a maximum service of four years. The salary is $56,800.

(6) Assistant Adjunct Professorships and Research Postdocs. Normally appointments are for one year, with the possibility of renewal. Strong research and teaching background required. The salary range is $48,900–$53,200. Teaching load for Adjuncts is five quarter courses per year.

Applicants should complete the application located on the website at http://www.math.ucla.edu/~search.

Preference will be given to applicants whose applications are completed by January 9, 2006.

UCLA is an Equal Opportunity/Affirmative Action Employer. Under Federal law, the University of California may employ only individuals who are legally authorized to work in the United States as established by providing documents specified in the Immigration Reform and Control Act of 1986.

000110

UNIVERSITY OF CALIFORNIA,
SAN DIEGO
Department of Mathematics
Tenure-Track/Tenured Positions

The Department of Mathematics at the University of California, San Diego, is seeking outstanding candidates to fill tenure - track/tenured positions to start July, 2006. The preferred level for these positions is at the Assistant Professor level, but applicants with all levels of experience from Assistant Professor to Full Professor will be considered. One position is available for an extremely distinguished mathematician with an exceptional research record of the highest caliber.

Applicants for all positions must possess a Ph.D. and should have outstanding accomplishments in both research and teaching. We encourage applications from any area of pure or applied mathematics. Level of appointment will be based on qualifications with appropriate salary per UC pay scales. Applications should be submitted online through http://www.mathjobs.org by December 1, 2005. For further instructions and information, see http://math.ucsd.edu/about/employment/faculty.

In compliance with the Immigration Reform and Control Act of 1986, individuals offered employment by the University of California will be required to show documentation to prove identity and authorization to work in the United States before hiring can occur. UCSD is an Equal Opportunity/Affirmative Action Employer with a strong institutional commitment to the achievement of diversity among its faculty and staff.

All applications should include the following items: Reference Letters (sent under separate cover, at least one should address teaching experience in some depth), Cover Letter, Curriculum Vitae, Publications List, Research Statement, Teaching Statement.

000168

UNIVERSITY OF CALIFORNIA, SAN DIEGO
Department of Mathematics
Stefan E. Warschawski
Assistant Professorship Recruitment

The Department at Mathematics of the University of California, San Diego, is seeking outstanding candidates for a special two-year assistant professorship, the S. E. Warschawski Assistant Professorship. The nine-month salary is $48,000. This is a two-year nonrenewable appointment.

Applicants should possess a recent Ph.D. degree (received no earlier than 2003) in mathematics or expect to receive one prior to July 2006. We expect these candidates to have excellent teaching skills and excellent research potential. Candidates with teaching and research interests compatible with current faculty are sought. Applications should be submitted online through http://www.mathjobs.org by December 1, 2005. For further instructions and information, see http://math.ucsd.edu/about/employment/faculty.

In compliance with the Immigration Reform and Control Act of 1986, individuals offered employment by the University of California will be required to show documentation to prove identity and authorization to work in the United States before hiring can occur. UCSD is an Equal Opportunity/Affirmative Action Employer with a strong institutional commitment to the achievement of diversity among its faculty and staff.

All applications should include the following items: Reference Letters (at least one of which should address teaching experience in some depth) Cover Letter, Curriculum Vitae, Publications List, Research Statement Teaching Statement.

000169

UNIVERSITY OF SAN FRANCISCO
Department of Mathematics

The Department of Mathematics at the University of San Francisco invites applications for a tenure-track position at the assistant professor level, to begin in fall 2006. Candidates from all fields of mathematics are encouraged to apply. The successful candidate should have university teaching experience and an earned doctorate in mathematics by fall 2006. She/he will teach throughout the undergraduate mathematics curriculum, from courses for majors to service courses for non-science majors. The position requires a passionate commitment to excellence in teaching within a culturally diverse environment, as well as a strong potential for research and scholarship.

Candidates should submit a letter of application, curriculum vitae, statement of teaching philosophy and research plans, copies/scans of complete teaching evaluations and recent syllabi, graduate transcripts, and three letters of recommendation. All of the above elements are required to complete your application.

As many as possible of these elements should be submitted electronically to: email: mathjob@math.usfca.edu.

The Subject Line of your e-mail(s) should begin with your full name: e.g.

Subject: Mary L. McEnroe—Teaching Evaluations

Any remaining elements that cannot be submitted electronically should be mailed to:

Mathematics Search Committee
c/o Tristan Needham, Chair
Department of Mathematics
University of San Francisco
2130 Fulton St.
San Francisco, CA 94117-1080

In order to insure full consideration, completed applications must be received (not postmarked) by December 16, 2005. We invite candidates to find out about our department at http://artsci.usfca.edu/math.

The University of San Francisco is a Jesuit Catholic university founded in 1855 to educate leaders who will fashion a more humane and just world. Candidates should demonstrate a commitment to work in a culturally diverse environment and to contribute to the mission of the University.

USF is an Equal Opportunity Employer dedicated to affirmative action and to excellence through diversity. The University provides reasonable accommodations to qualified applicants with disabilities upon request.

000076

COLORADO

UNIVERSITY OF DENVER
Department of Mathematics

We invite applications for a tenure-track faculty position in mathematics at the Assistant Professor level to begin in the fall of 2006. Candidates must have a Ph.D. in mathematics by September 2007 and show a commitment to excellence in both teaching and research. All research areas will be considered but we are especially interested in a person who can interact with current faculty. Active areas of research include ordered algebra, functional analysis, mathematical physics, quantum computation, C*-algebras, non-associative algebra, combinatorics, and topological dynamics.

The University of Denver is a medium-size (10,000 students) private university located in a thriving metropolis at the base of the Rocky Mountains. Class sizes are small, the teaching load is moderate and the salary is competitive. The department offers bachelor's, master's and Ph.D. degrees in mathematics. The University of Denver is committed to enhancing the diversity of its faculty and staff and encourages applications from women, persons of color, persons with disabilities and veterans.

Applications received by January 6, 2006, will be given full consideration. The position will remain open until filled. Qualified applicants should submit a curriculum vitae, a statement of teaching and statement of research interests. In addition, three letters of recommendation should be sent on behalf of the applicant. All materials should be mailed to:

Mathematics Search Committee
Mathematics Department
University of Denver
Denver, CO 80208

000187

CONNECTICUT

FAIRFIELD UNIVERSITY
Department of Mathematics

The Department of Mathematics and Computer Science at Fairfield University invites applications for a tenure-track assistant professorship, to begin in September 2006. A doctorate in mathematics is required. Strong evidence of research potential, demonstrated success in classroom instruction and a solid commitment to teaching are essential. Preference will be given to those candidates with the ability and willingness to conduct or lead undergraduate student research.

Fairfield University, the Jesuit Catholic university of Southern New England, is a comprehensive university with about 3,000 undergraduates and a strong emphasis on liberal arts education. The Department of Mathematics and Computer Science consists of 15 full-time faculty members. The department offers a BS and an MS in mathematics. The teaching load is 3 courses/9 credit hours per semester. Fairfield offers competitive salaries and compensation benefits. The picturesque campus is located on Long Island Sound in southwestern Connecticut, about 50 miles from New York City. For further details see http://cs.fairfield.edu/mathhire. Applicants should send a letter of application, a curriculum vitae, and three letters of recommendation commenting on the applicants' experience and promise as a teacher and scholar, to Matt Coleman, Chair of the Department of Mathematics and Computer Science, Fairfield University, Fairfield CT 06824-5195. Full consideration will be given to complete applications received by January 20, 2006.

Fairfield is an Affirmative Action/Equal Opportunity Employer. Women, minorities, and persons with disabilities are strongly encouraged to apply.

DISTRICT OF COLUMBIA

MATHEMATICAL ASSOCIATION OF AMERICA
Director of Publications

The Mathematical Association of America (MAA) seeks a Director of Publications to begin by July 2006. The Association, with nearly 30,000 members, is dedicated to the advancement of mathematics, particularly at the collegiate level. The Director will oversee the publications program which includes three journals, three magazines, nine book series, a variety of columns and articles, and the MAA Digital Library (MathDL). Appointments are for two or three years and may be renewed for multiple years.

Candidates should have a significant record of work in publications in the mathematical sciences; a Ph.D. degree in a mathematical science or mathematics education is preferred. A candidate should have successful experiences in all or most of the following areas: book publishing; journal production; administration including financial management; editorial/reviewing experience; mathematical writing not limited to research publications; and, electronic publications.

More information about this position and about the MAA may be found at `http://www.maa.org` and in the November issue of FOCUS. The deadline for submission of applications is January 21, 2006. Candidates should send a resume and letter of interest to:

Ms. Julie Kraman
Mathematical Association of America
1529 18th Street, NW
Washington, DC 20036.

Applications may be submitted electronically to `jkraman@maa.org`. References will be requested after review of applications. Applications from individuals from underrepresented groups are encouraged. AA/EOE.

000185

FLORIDA

UNIVERSITY OF WEST FLORIDA
Department of Mathematics

The University of West Florida, Department of Mathematics and Statistics, invites applications for two anticipated tenure-track positions at the assistant professor level, beginning August 2006. Ph.D. in mathematics required with preference given to candidates in applied mathematics. Salary competitive. Candidates should have strong commitment to teaching at the undergraduate and master's levels, scholarly activity and service. A police background screening is required.

To apply, please go to `http://jobs.uwf.edu` to create your application. Please be prepared to attach the following documents in digital format: letter of interest and vita. Interested persons should also send transcripts and at least three sealed letters of reference to Dr. Kuiyuan Li, Chairperson, Department of Mathematics and Statistics, University of West Florida, 11000 University Parkway, Pensacola, FL 32514. Active review of candidates' materials will begin January 16, 2006, and will continue until the position is filled. UWF is an Equal Opportunity, Access, Affirmative Action Employer.

000167

UNIVERSITY OF CENTRAL FLORIDA
Department of Mathematics

The University of Central Florida (UCF) has recently celebrated its 40th anniversary. UCF has a total enrollment of over 45,000 students, which is double the enrollment of 12 years ago. To support the transformation (From Promise to Prominence), the Department of Mathematics at UCF will continue in the next few years an aggressive hiring plan to increase the size of its faculty and hire outstanding candidates at all ranks. For Fall 2006, the Department of Mathematics seeks to fill 4 tenure-track or visiting positions at the Assistant Professor level in Applied Mathematics and Analysis. The visiting positions are renewable up to 4 years. All applicants must possess (or expect to possess by June 30, 2006) a Ph.D. in Mathematics or Applied Mathematics. Other requirements include: strong research potential, evidence of excellence in teaching, and effective communication skills in English. Expectations of developing externally funded research grants and interest in interdisciplinary research are desirable. Preference will be given to applicants whose mathematical interests augment and support existing strength both within the Department as well as other departments and centers at the University (see `www.math.ucf.edu`). Informal inquiries for future senior positions are welcome. All applications should be sent to: Faculty Search Committee, Mathematics Department, University of Central Florida, P.O. Box 161364, Orlando, FL 32816-1364. Applicants should send curriculum vitae, letter of application, completed AMS Application Cover Sheet, and arrange for four recent recommendation letters (including one letter that addresses teaching) to be sent to the Search Committee. Consideration of applications will begin December 5, 2005, and will continue until the positions are filled or the department closes the search.The candidates selected for these positions must meet eligibility requirements to work in the United States and must prove eligibility within three days after hire. The University of Central Florida is an Affirmative Action Employer dedicated to excellence through diversity. All qualified individuals are invited to apply. Search documents may be viewed by the public upon request in accordance with the Florida statute.

000198

GEORGIA

GEORGIA INSTITUTE OF TECHNOLOGY
School of Mathematics

The School of Mathematics at Georgia Tech is now in the second year of an ambitious faculty recruitment program—one which will be sustained over a five year period. During the first year, four appointments were made, including one at the full professor level and two at the associate professor level. Building on past successes, this recruiting effort is intended to make rapid advances in the scope and quality of our research and graduate education programs. Candidates will be considered at all ranks, with priority given to those candidates who (1) bring exceptional quality research credentials to Georgia Tech; (2) complement existing strengths in the School of Mathematics; (3) reinforce bridges to programs in engineering and the physical, computing and life sciences; (4) have strong potential for external funding; and (5) have a demonstrated commitment to high quality teaching at both the undergraduate and graduate levels. Consistent with these priorities, candidates will be considered in all areas of Pure and Applied Mathematics and Statistics. Candidates should arrange for a resume, at least three letters of reference, and a summary of future research plans to be sent to the Hiring Committee, School of Mathematics, Georgia Institute of Technology, Atlanta, GA, 30332-0160, USA. Candidates for Associate and Full Professor positions should also submit a statement outlining their vision for service as a senior faculty member at Georgia Tech. Review of applications will begin in September 2005, and the roster of candidates being considered will be updated on a monthly basis. Georgia Tech, an institution of the University System of Georgia, is an Equal Opportunity/Affirmative Action Employer.

000108

IDAHO

BOISE STATE UNIVERSITY
Department of Mathematics
Assistant Professor

The Department of Mathematics at Boise State University invites applications for an Assistant Professor position beginning the Fall of 2006. A Ph.D. in mathematics or statistics is required and preference will be given to applicants who can assume a leadership role in the development of research programs which interact with

Biology, Electrical Engineering, or Geophysics.

Review of applications will begin on January 9, 2006, and continue until finalists have been identified. For more information consult http://math.boisestate.edu, or contact us at facultysearch@math.boisestate.edu. Boise State University is an EEO/AA Institution. Vet Preferences may be applicable.

000159

ILLINOIS

UNIVERSITY OF ILLINOIS AT CHICAGO
Department of Mathematics, Statistics, and Computer Science

The Department has active research programs in centrally important areas of pure mathematics, computational and applied mathematics, combinatorics and computer science, statistics, and mathematics education. See http://www.math.uic.edu for more information.

Applications are invited for the following positions, effective August 16, 2006, subject to budgetary approval.

Tenure-track positions. Candidates in all areas of interest to the Department will be considered. The position is at the Assistant Professor level. Applicants must have a Ph.D. or equivalent degree in mathematics, computer science, statistics, mathematics education or related field; an outstanding research record; and evidence of strong teaching ability. The salary is negotiable.

Send vita and at least three (3) letters of recommendation, clearly indicating the position being applied for, to: Appointments Committee; Dept. of Mathematics, Statistics, and Computer Science; University of Illinois at Chicago; 851 S. Morgan (m/c 249); Box T; Chicago, IL 60607. No email applications will be accepted. To ensure full consideration, materials must be received by November 30, 2005. However, we will continue considering candidates until all positions have been filled. Minorities, persons with disabilities, and women are particularly encouraged to apply. UIC is an AA/EOE.

000164

UNIVERSITY OF ILLINOIS AT CHICAGO
Department of Mathematics, Statistics, and Computer Science

The Department has active research programs in centrally important areas of pure mathematics, computational and applied mathematics, combinatorics and computer science, statistics, and mathematics education. See http://www.math.uic.edu for more information.

Applications are invited for the following positions, effective August 16, 2006, subject to budgetary approval.

Research Assistant Professorships. These are non-tenure-track positions, normally renewable annually to a maximum of three years. These positions carry a teaching responsibility of one course per semester, and the expectation that the incumbent play a significant role in the research life of the Department. The salary for AY 2005-2006 for these positions is $49,000, the salary for AY 2006-2007 may be higher. Applicants must have a Ph.D. or equivalent degree in mathematics, computer science, statistics, mathematics education or related field, and evidence of outstanding research potential.

Send vita and at least three (3) letters of recommendation, clearly indicating the position being applied for, to: Appointments Committee; Dept. of Mathematics, Statistics, and Computer Science; University of Illinois at Chicago; 851 S. Morgan (m/c 249); Box R; Chicago, IL 60607. No email applications will be accepted. To ensure full consideration, materials must be received by November 30, 2005. However, we will continue considering candidates until all positions have been filled. Minorities, persons with disabilities, and women are particularly encouraged to apply. UIC is an AA/EOE.

000165

UNIVERSITY OF ILLINOIS AT CHICAGO
Tenure-Track Assistant Professor in Statistics

The Department of Mathematics, Statistics, and Computer Science seeks to recruit an outstanding statistician with strong academic background and a demonstrated interest in research and teaching. Applicants must have a Ph.D. or equivalent degree in statistics. The salary is negotiable. The position is effective August 16, 2006, subject to budgetary approval.

The Department has active research programs in centrally important areas of pure mathematics, computational and applied mathematics, combinatorics and computer science, statistics, and mathematics education. See http://www.math.uic.edu for more information.

Send vita and at least three (3) letters of recommendation, clearly indicating Statistics as the position being applied for, to: Statistics Search Committee; Dept. of Mathematics, Statistics, and Computer Science; University of Illinois at Chicago; 851 S. Morgan (m/c 249); Box S; Chicago, IL 60607. No email applications will be accepted. To ensure full consideration, application materials must be received by November 30, 2005. However, we will continue considering candidates until the position is filled. Minorities, persons with disabilities, and women are particularly encouraged to apply. UIC is an AA/EOE.

000166

SOUTHERN ILLINOIS UNIVERSITY CARBONDALE
Department of Mathematics
Mathematical Biology Position

Applications are invited for a tenure-track position in mathematical biology at the rank of assistant professor to begin on August 16, 2006. The department seeks applicants whose mathematical research interests and expertise involve the mathematical modeling and/or analysis of biological phenomena and data. The successful candidate for this position will be expected to contribute to a newly formed cluster in Mathematical Biology at SIUC linking the Departments of Mathematics and Plant Biology and the Center for Ecology. Applicants must demonstrate evidence of, or potential for, excellence in research and in teaching at both undergraduate and graduate levels. Ph.D. in a field of pure or applied mathematics required by August 15, 2006. Postdoctoral experience preferred. The applicant hired into this position will be expected to teach effectively, to maintain a vigorous research program, to seek external research funding, and to develop a satisfactory record of service. To apply, please send letter of application, curriculum vitae and statements of research and teaching interests, and have three letters of recommendation sent, to: Mathematical Biology Position, Department of Mathematics, Mailcode 4408, Southern Illinois University Carbondale, 1245 Lincoln Drive, Carbondale, Illinois 62901. Review of applications will begin December 5, 2005, and continue until position is filled. SIUC is an Affirmative Action/Equal Opportunity Employer that strives to enhance its ability to develop a diverse faculty and staff and to increase its potential to serve a diverse student population. All applications are welcomed and encouraged and will receive consideration.

000171

INDIANA

INDIANA UNIVERSITY-PURDUE UNIVERSITY INDIANAPOLIS
Tenure-Track Positions in Mathematics, Mathematics Education, and Statistics/Biostatistics

The IUPUI Department of Mathematical Sciences announces one or more tenure-track positions, pending final budgetary approval, in mathematics (pure or applied), mathematics education, and in statistics/biostatistics, beginning 8/2006. A Ph.D. and a demonstrated potential for excellence in research and in teaching are required. Rank and salary will be commensurate with qualifications. For more detailed information about each position, as well as minimum qualifications, see http://www.math.iupui.edu/news/employment/, or send letter of interest,

AMS form, CV, statements on research and on teaching, and four letters of recommendation (including one on teaching) to the Search & Screen Committee, Department of Mathematical Sciences, IUPUI, 402 N. Blackford Street, LD270, Indianapolis, IN 46202-3216. Screening will begin on December 15, 2005, and will continue until the positions are filled. IUPUI is an EEO/AA Employer, M/F/D.

000183

INDIANA UNIVERSITY SOUTH BEND
Department of Mathematical Sciences

Indiana University South Bend, Department of Mathematical Sciences, invites applications for a tenure-track, assistant professor position in actuarial science starting August 2006. The successful applicant will have completed all of the requirements for a Ph.D. in actuarial science or a related field by the time of appointment. Applicants with a Ph.D. in a related field must have work experience in the actuarial field, experience in teaching actuarial courses, or have shown significant progress toward a Fellowship or Associateship status in a professional actuarial society. For detail of the job description, visit the website http://www.iusb.edu/~math/.

To apply, send a letter of application, curriculum vitae, copies of graduate school transcripts, a statement of research interests, a statement of teaching philosophy, and arrange for at least three letters of recommendation to be sent to:

Actuarial Search Committee
Department of Mathematical Sciences
Indiana University South Bend
South Bend, IN, 46634

IUSB is an Affirmative Action/Equal Opportunity Employer, and encourages applications from underrepresented groups. Applications will be reviewed as they are received, but full consideration will be given to any application completed by January 16, 2006.

000197

UNIVERSITY OF NOTRE DAME
Department of Mathematics
Notre Dame, IN 46556
Howard J. Kenna Chair in Mathematics

The successful candidate for this senior chair will be an internationally recognized mathematician in a central discipline of pure or applied mathematics. The department is particularly interested in candidates whose research activities are related to those of current faculty, but all applications are welcome. For an overview of the department, see http://www.math.nd.edu/.

Applications should include a letter of interest, curriculum vitae, and the names, addresses, and telephone numbers of three references. Applications and nominations should be sent to: Professor William Dwyer, Department of Mathematics, University of Notre Dame, Notre Dame, IN 46556. Notre Dame is an Equal Opportunity Employer. Women and minorities are urged to apply.

The review of candidates will begin immediately and continue until the position is filled. The desired starting date for the position is August 22, 2006.

000068

UNIVERSITY OF NOTRE DAME
Department of Mathematics
Notre Dame, IN 46556
Regular Position in Algebra

The Department of Mathematics of the University of Notre Dame invites applications for a position in the area of algebra, including algebraic geometry and number theory. The starting date for the position is August 22, 2006. Candidates at any rank will be considered. The teaching load is one course one semester and two courses the other semester. The salary is competitive. Applications, including a curriculum vitae, a letter of application, and a completed AMS standard cover sheet, should be sent to: William G. Dwyer, Chair, at the above address. Applicants should also arrange for at least three letters of recommendation to be sent to the chair. These letters should address the applicant's research accomplishments and supply evidence that the applicant has the ability to communicate articulately and teach effectively. Notre Dame is an Equal Opportunity Employer. Women and minorities are urged to apply. The evaluation of candidates will begin December 1, 2005. Information about the department is available at http://www.math.nd.edu/.

000066

UNIVERSITY OF NOTRE DAME
Department of Mathematics
Notre Dame, IN 46556
Regular Position in Numerical Analysis

The Department of Mathematics of the University of Notre Dame invites applications from an applied mathematician with a special interest in numerical analysis. The starting date for the position is August 22, 2006. Candidates at any rank will be considered. The teaching load is one course one semester and two courses the other semester. The salary is competitive. Applications, including a curriculum vitae, a letter of application, and a completed AMS standard cover sheet, should be sent to: William G. Dwyer, Chair, at the above address. Applicants should also arrange for at least three letters of recommendation to be sent to the chair. These letters should address the applicant's research accomplishments and supply evidence that the applicant has the ability to communicate articulately and teach effectively. Notre Dame is an Equal Opportunity Employer. Women and minorities are urged to apply. The evaluation of candidates will begin December 1, 2005. Information about the department is available at http://www.math.nd.edu/.

000067

UNIVERSITY OF NOTRE DAME
Department of Mathematics
Notre Dame, IN 46556
Special Professional Faculty Position

The Department of Mathematics of the University of Notre Dame invites applications for a Special Professional Faculty position. Candidates should have a doctorate in Mathematics or Mathematics Education, a passion for undergraduate teaching, and a record of excellence in the classroom. The starting date for these positions is August 22, 2006. Candidates at any rank will be considered. The teaching load can vary between two and three courses a semester, depending on class size and other duties. These are not tenure-track positions, but they provide all usual faculty benefits, and have the possibility of being renewed indefinitely. The salary is competitive. Applications, including a curriculum vitae, a letter of application, and a completed AMS standard cover sheet, should be sent to: William G. Dwyer, Chair, at the above address. Applicants should arrange for at least three letters of recommendation to be sent to the chair. These letters should document the applicant's ability as a creative and effective teacher of undergraduate mathematics. Notre Dame is an Equal Opportunity Employer. Women and minorities are urged to apply. The evaluation of candidates will begin December 1, 2005. Information about the department is available at http://www.math.nd.edu/.

000069

UNIVERSITY OF NOTRE DAME
Department of Mathematics
Notre Dame, IN 46556
Regular Position in Interdisciplinary Applied Mathematics

The Department of Mathematics of the University of Notre Dame invites applicaitons from an interdisciplinary applied mathematician with a special interest in multiscale methods, discrete mathematics, stochastic dynamical systems, reaction-diffusion systems, stochastic optimization and other fields. Applicants at all levels are welcome. The starting date for the position is August 22, 2006. Teaching load is one course one semester and two courses the other semester. The salary is competitive. Applications, including a curriculum vitae, a letter of application, and a completed AMS standard cover sheet, should be sent to William G. Dwyer, Chair, at the above address. Applicants should also arrange for at least three letters of recommendation to be sent to the chair. These letters should address the applicant's research accomplishments and supply evidence that the applicant has the ability to

communicate articulately and teach effectively. Notre Dame is an Equal Opportunity Employer. Women and minorities are urged to apply. The evaluation of candidates will begin December 1, 2005. Information about the department is available at http://www.math.nd.edu.

000099

IOWA

IOWA STATE UNIVERSITY
Department of Mathematics

Iowa State University Department of Mathematics is seeking a computational applied mathematician. Candidates with experience in such areas as numerical PDEs and multi-scale computation, and with a strong interest in applications, are particularly encouraged to apply. The position could be filled at either the Assistant or Associate Professor level.

We are interested in hiring mathematicians whose research programs are complementary to the existing strengths in the department and who can interact with current faculty in the department as well as faculty in other units of the university. For further information about the department, visit the department's website at http://www.math.iastate.edu.

The teaching load for untenured faculty is three courses per year.

For Assistant Professor, a Ph.D. in mathematics or related discipline by the start date of the position, and a demonstrated excellent record in research and teaching are required. We prefer applicants with two to four years of experience beyond the Ph.D., normally achieved through a postdoctoral position. For Associate Professor, in addition to the above, a demonstrated superior record in research and teaching is expected.

Applicants must submit a vita and a brief statement describing their research accomplishments and plans. They must also arrange for four (4) letters of recommendation, one (1) of which must address the applicant's teaching ability and experience. Mail to: Computational Applied Math Search, Department of Mathematics, 396 Carver, Iowa State University, Ames, IA 50011-2064.

Iowa State University is an Affirmative Action/Equal Opportunity Employer and strongly encourages women and members of underrepresented groups to apply.

000170

THE UNIVERSITY OF IOWA
Department of Mathematics

The Department of Mathematics at the University of Iowa invites applications for the following positions:

(i) A tenure-track assistant professorship, starting in August 2006, in the area, broadly defined, of computational and mathematical biology. Selection will be based on evidence of outstanding research accomplishments or potential and excellent teaching. (ii) A tenure-track assistant professorship, starting in August 2006, in the areas, broadly defined, of algebraic geometry and geometric analysis. Selection will be based on evidence of outstanding research accomplishments or potential and excellent teaching. (iii) One or more three-year visiting assistant professorships starting in August 2006. These positions are open as to research area but preference will be given to applicants whose scholarly activity is of particular interest to current faculty members. Selection will be based on excellent research accomplishments or potential, and excellent teaching. These positions carry a reduced teaching load. (iv) One or more visiting positions for all or part of the 2006-2007 academic year. Preference will be given to applicants whose scholarly activity is of particular interest to current faculty members. Selection will be based on research expertise and teaching ability. Assignment to rank will be commensurate with qualifications.

A Ph.D. or equivalent is required for these positions. Screening of applications will begin December 1, 2005. Applications will be accepted until the position is filled. To apply, send a letter of application, a completed AMS cover sheet, a complete vita, a research statement, and a statement of teaching philosophy. Also have three letters of recommendation sent. Please indicate in your application the position or positions for which you are applying. Materials should be sent to:

Professor David Manderscheid, Chair
Department of Mathematics
The University of Iowa
Iowa City, Iowa 52242-1419

The University of Iowa is an Equal Opportunity/Affirmative Action Employer. Applications from women and minorities are strongly encouraged. For further information about the Department see http://www.math.uiowa.edu.

000174

UNIVERSITY OF NORTHERN IOWA
Department of Mathematics
Assistant Professor

Applications are invited for two and possibly three tenure-track positions at the assistant professor level effective August 2006. Candidates must possess a Ph.D. in mathematics by the date of appointment. The Department seeks candidates in the research areas of algebra, analysis, applied mathematics, differential geometry or topology. Excellent teaching and communication skills are required.

Candidates will be expected to teach courses at all levels. The standard teaching load averages 9 credit hours per semester. Further information is available at http://www.math.uni.edu/Jobs/math.html.

A complete application contains a letter of application with a current vita, a copy of graduate transcripts, a statement of teaching philosophy, a summary of research goals, and three letters of reference sent directly to the department. At least one of the reference letters should address the applicant's teaching ability and communication skills. Applications received by January 3, 2006, will receive full consideration.

The Department encourages applications from minority persons, women, persons with disabilities, and Vietnam era veterans. Address inquiries and applications to: Adrienne Stanley, Search Committee Chair, Department of Mathematics, University of Northern Iowa, Cedar Falls, IA 50614-0506. Inquiries may be sent to stanley@math.uni.edu or call (319) 273-2631.

The University is an Equal Opportunity Employer with a comprehensive plan for affirmative action.

000186

KANSAS

KANSAS STATE UNIVERSITY
Department of Mathematics

Subject to budgetary approval, applications are invited for a tenure-track position commencing August 13, 2006; rank and salary commensurate with qualifications. The Department seeks candidates whose research interests mesh well with current faculty. The Department has research groups in the areas of analysis, algebra, geometry/topology, and differential equations. Applicants must have strong research credentials as well as strong accomplishment or promise in teaching. Letter of application, current vita, description of research, and at least three letters of reference evaluating research should be sent to:

Louis Pigno
Department of Mathematics
Cardwell Hall 138
Kansas State University
Manhattan, KS 66506

The Department also requires that the candidate arrange for letters to be submitted evaluating teaching accomplishments and potential. Offers may begin by December 1, 2005, but applications for positions will be reviewed until February 1, 2006, or until positions are closed. Kansas State University is an equal opportunity employer. Paid for by Kansas State University.

000161

MAINE

COLBY COLLEGE
Department of Mathematics

The Department of Mathematics at Colby College invites applications for a tenure-track position in mathematics at the as-

sistant professor level. Preference will be given to candidates with active research programs in subfields of combinatorics, algebra, or number theory. Exceptional candidates in other fields will also be considered. Candidates should have a Ph.D. in mathematics and should show promise in both teaching and research. The appointee will be expected to maintain a vigorous research program while also being an exceptional teacher and advisor at the undergraduate level. Teaching load is five courses a year. Salary is competitive.

Send curriculum vitae, statements on teaching and research, and three letters of recommendation to:

Tenure Track Search Chair
Department of Mathematics
Colby College
5830 Mayflower Hill
Waterville, ME 04901

We cannot accept applications in electronic form. Review of applications will begin on November 15, 2005, and will continue until the position is filled.

Colby is a highly selective liberal arts college located in central Maine. The college is a three-hour drive north of Boston and has easy access to lakes, skiing, the ocean, and other recreational and cultural activities. For more information about the position and the department, visit our website at http://www.colby.edu/math.

Colby is an Equal Opportunity/Affirmative Action Employer, committed to excellence through diversity, and strongly encourages applications and nominations of persons of color, women, and members of other under-represented groups. For more information about the College, please visit the Colby Website at http://www.colby.edu.

000181

MARYLAND

JOHNS HOPKINS UNIVERSITY
Department of Mathematics, Director of Undergraduate Studies

Subject to availability of resources and administrative approval, the Department of Mathematics solicits applications for a Director of Undergraduate Studies for the 2006-2007 academic year.

Candidates for the position of Director of Undergraduate Studies should demonstrate excellence in teaching and organizational abilities. Responsibilities include the training and supervision of teaching assistants, maintenance and development of the undergraduate curriculum, and coordination of registration issues. The teaching load is three courses per academic year.

To submit your applications go to http://www.mathjobs.org/jobs/jhu. Applicants are strongly advised to submit their other materials electronically at this site.

If you do not have computer access, you may mail your application to: Appointments Committee, Department of Mathematics, Johns Hopkins University, 404 Krieger Hall, Baltimore, MD 21218, and should include a vita, at least four letters of recommendation of which one concerns teaching, and a teaching statement. Write to email: math@math.jhu.edu for questions concerning these positions. Applications received by January 15, 2006, will be given priority. The Johns Hopkins University is an Affirmative Action/Equal Opportunity Employer. Minorities and women candidates are encouraged to apply.

For more information about the position or institution/company: http://www.mathematics.jhu.edu/mathnew/jobs.html.

000070

JOHNS HOPKINS UNIVERSITY
Department of Mathematics
J.J. Sylvester Assistant Professor

Subject to availability of resources and administrative approval, the Department of Mathematics solicits applications for one non-tenure-track J.J. Sylvester Assistant Professor for the 2006-2007 academic year.

The J.J. Sylvester Assistant Professorship is a three-year position offered to recent Ph.D.'s with outstanding research potential. Candidates in all areas of pure mathematics, including analysis, mathematical physics, geometric analysis, complex and algebraic geometry, number theory, and topology are encouraged to apply. The teaching load is three courses per academic year.

To submit your applications go to http://www.mathjobs.org/jobs/jhu. Applicants are strongly advised to submit their other materials electronically at this site.

If you do not have computer access, you may mail your application to: Appointments Committee, Department of Mathematics, Johns Hopkins University, 404 Krieger Hall, Baltimore, MD 21218, and should include a vita, at least four letters of recommendation of which one concerns teaching, and a description of current and planned research. Write to email: math@math.jhu.edu for questions concerning these positions. Applications received by November 1, 2005, will be given priority. The Johns Hopkins University is an Affirmative Action/Equal Opportunity Employer. Minorities and women candidates are encouraged to apply.

For more information about the position or institution/company: http://www.mathematics.jhu.edu/mathnew/jobs.html.

000071

UNITED STATES NAVAL ACADEMY
Mathematics Department

The USNA Mathematics Department anticipates at least one tenure-track position (subject to approval and funding) at the Assistant Professor level to start in August 2006. See website http://www.usna.edu/MathDept/website/Hire.htm for full information. Tel: 410-293-6701; Fax: 410-293-4883; email: amg@usna.edu. The United States Naval Academy is an Affirmative Action/Equal Employment Opportunity Employer and provides reasonable accommodations to applicants with disabilities.

000163

UNIVERSITY OF MARYLAND, COLLEGE PARK
Department of Mathematics

Applications are invited for tenured and tenure-track positions in the Department of Mathematics. There is a particular interest in candidates specializing in (1) Applied Harmonic Analysis, (2) Applied Partial Differential Equations and (3) Statistics. Applications are also invited for a three-year VIGRE Postdoctoral Fellowship.

Priority will be given to applications received by December 15, 2005. Appointments will commence in Fall 2006.

The University of Maryland is an Equal Opportunity and Affirmative Action employer that strongly encourages applications from female and minority candidates.

Applicants must provide a curriculum vitae, an AMS Standard Cover Sheet, and four letters of recommendation, three regarding research and one regarding teaching. Application material should be sent directly to:

The Hiring Committee
Department of Mathematics
University of Maryland
College Park, Maryland 20742

We recommend that Postdoctoral and Assistant Professor Candidates also register with the AMS application service mathjobs.org.

000154

MASSACHUSETTS

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Department of Mathematics

The Department of Mathematics may make appointments at the level of lecturer and assistant professor or higher, in pure mathematics for the year 2006-2007. These positions are open to mathematicians with doctorates who have demonstrated outstanding qualifications. Applications and other materials, including (a) curriculum vitae, (b) three letters of reference, (c) a de-

scription of your most recent research, and (d) a research plan for the immediate future, must be submitted online at www.mathjobs.org by January 1, 2006 (please do not mail duplicates). We request that your letters of reference be submitted online. Alternatively, they may be sent to: Pure Mathematics Committee, Massachusetts Institute of Technology, Room 2-263, 77 Massachusetts Ave., Cambridge, MA 02139-4307. To ensure full consideration of your application, all references must arrive by January 16. MIT is an Equal Opportunity, Affirmative Action Employer. (For more information about the MIT Mathematics Department: www-math.mit.edu.)

000149

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
DEPARTMENT OF MATHEMATICS
C.L.E. Moore Instructorships In Mathematics

These positions are open to mathematicians with doctorates who show definite promise in research. Applications and other materials, including (a) curriculum vitae, (b) three letters of reference, (c) a description of the research in your thesis, and (d) a research plan for the next year, must be submitted online at www.mathjobs.org by January 1, 2006 (please do not mail duplicates). We request that your letters of reference be submitted online. Alternatively, they may be sent to: Pure Mathematics Committee, Massachusetts Institute of Technology, Room 2-263, Cambridge, MA 02139-4307. To ensure full consideration of your application, all references must arrive by January 16. MIT is an Equal Opportunity, Affirmative Action Employer. (For more information about the MIT Mathematics Department: www-math.mit.edu.)

000150

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Department of Mathematics
Applied Mathematics

The applied mathematics group at MIT is seeking to fill possible positions at the level of Instructor, Assistant Professor or higher, beginning September 2006. Appointments will be made based on demonstrated outstanding research qualifications. Candidates in all areas of applied mathematics, including physical applied mathematics, computational molecular biology, numerical analysis, scientific computation, and theoretical computer science will be considered. Current activities of the group include: combinatorics, operations research, theory of algorithms, numerical analysis, astrophysics, condensed matter physics, computational physics, fluid dynamics, geophysics, nonlinear waves, theoretical and computational molecular biology, material sciences, quantum computing and quantum field theory, but new hiring may involve other areas.

Applications and other materials, including (a) curriculum vitae, (b) research description, and (c) three letters of recommendation, must be submitted online at www.mathjobs.org by January 1, 2006 (please do not mail duplicates). We request that your letters of reference be submitted online. Alternatively, they may be sent to: Committee on Applied Mathematics, Room 2-345, Department of Mathematics, MIT, 77 Massachusetts Ave., Cambridge, MA 02139-4307. To ensure full consideration of your application, all references must arrive by January 16. MIT is an Equal Opportunity, Affirmative Action Employer. (For more information about the MIT Mathematics Department: www-math.mit.edu.)

000151

WILLIAMS COLLEGE
Department of Mathematics and Statistics

Williams College Department of Mathematics and Statistics invites applications for a newly authorized visiting position in mathematics for the 2006-2007 year, probably at the rank of assistant professor, however, in exceptional cases, a more advanced appointment might be considered. A Ph.D. is required. Send a vita and three letters of recommendation on teaching and research to: Visitor Hiring Committee, Department of Mathematics and Statistics, Williams College, Williamstown, MA 01267. Consideration of applications will begin on November 15th and continue until the position is filled. Williams College is dedicated to providing a welcoming intellectual environment for all of its faculty, staff and students; as an AA/EOE employer, Williams especially welcomes applications from women and minority candidates.

000102

MICHIGAN

MICHIGAN STATE UNIVERSITY
East Lansing, MI 48824
proMSc Program in Industrial Mathematics

Direct your students toward one of the professional M.Sc. programs. Industry needs business-savvy mathematicians. See http://www.sciencemasters.com/.

000019

MICHIGAN STATE UNIVERSITY
Department of Mathematics
RTG Postdoctoral Instructorship in Geometry

Description: One two-year position will be available beginning Fall 2006 for a new or recent Ph.D. who specializes in geometry or geometric analysis and who shows strong promise in research and teaching. This position is supported by a Research Training Group (RTG) grant from the National Science Foundation. The teaching load is 1-1. This position also includes support for two summers plus funds for travel and supplies. There is a strong possibility of renewal for a third year. Eligibility: Applicants must be U.S. citizens or permanent residents. Salary: $45,000 per year plus $10,000 summer support. Application information: Applicants should send a vita and statement of research interests, and should arrange for at least four letters of recommendation to be sent, one of which must specifically address the applicant's ability to teach. Please apply by visiting http://www.mth.msu.edu/Hiring. Further information about Geometry/Topology at Michigan State and about the RTG Program can be found at http://www.math.msu.edu/gt. Completed applications (including letters of recommendation) received by December 30, 2005, are assured of consideration. Women and minorities are strongly encouraged to apply. MSU is an Affirmative Action/Equal Opportunity Institution. Persons with handicaps have the right to request and receive reasonable accommodation.

000180

MINNESOTA

UNIVERSITY OF MINNESOTA
School of Mathematics

The School of Mathematics of the University of Minnesota in conjunction with the Institute for Mathematics and its Applications (IMA) seeks an outstanding mathematical scientist with a record of interdisciplinary research for a faculty position, anticipated to be at the tenure or tenure-track level depending on qualifications. The IMA is a partnership of the National Science Foundation, which recently awarded funding through 2010, the University of Minnesota, and a consortium of affiliated institutions. Since its founding in 1982 the IMA has established itself as a leading research institute for mathematics and its applications, and the successful candidate will enjoy the benefits of its extraordinary scientific environment. In addition to faculty duties in the School of Mathematics the successful candidate will support the activities of the IMA through mentorship, program participation and planning, and interaction with visitors, and have teaching load set accordingly.

Candidates should have a Ph.D. or equivalent terminal degree in mathematics or a closely related field and excellent records in both research and teaching. Women and under-represented minorities are encouraged to apply.

For full consideration, applications and all supporting materials should be submitted electronically through the AMS mathjobs website at http://www.mathjobs.org by December 15, 2005. No paper

submission is needed unless the candidate is unable to submit electronically. Reference letter writers should be asked to submit their letters online through http://www.mathjobs.org. If they are unable to do so, they may send their letters to the following address:

Lawrence F. Gray
Professor and Head
School of Mathematics
127 Vincent Hall
206 Church Street S.E.
Minneapolis, MN 55455
mathsrch@tc.umn.edu

Applicants must include the following: curriculum vitae; at least 3 letters of recommendation, one of which should address teaching ability; and description of research. In addition please complete the Equal Opportunity Employment form at http://www.math.umn.edu/jobs/eo/.

The University of Minnesota is an Equal Opportunity Employer and Educator.

000188

UNIVERSITY OF MINNESOTA
School of Mathematics
Research Assistant Professor

This is a special two- or three-year research-oriented postdoctoral position in the areas of algebra, combinatorics, or geometry, to begin in the fall semester of 2006. The position comes with reduced teaching responsibility of at most two courses per year. Outstanding research and teaching abilities are required. Candidates at all postdoctoral levels, with a Ph.D. or equivalent in mathematics received or expected by the summer of 2006, are encouraged to apply. Salary is competitive. It is possible to combine this position with other postdoctoral fellowships (such as NSF) to lengthen the duration and further reduce teaching. Applicants may be interested in the 2006-2007 Algebraic Geometry year at the Institute for Mathematics and its Applications (IMA) http://www.ima.umn.edu/2006-2007.

For full consideration, applications and all supporting materials must be submitted electronically through the AMS mathjobs site at http://www.mathjobs.org by December 15, 2005. Applications received after the deadline will be considered as positions remain. No paper submission is needed unless the candidate is unable to submit electronically. Reference letter writers should be asked to submit their letters online through http://www.mathjobs.org. If they are unable to do so, they may send their letters to the following address:

Lawrence F. Gray
Professor and Head
School of Mathematics
127 Vincent Hall
206 Church Street S.E.
Minneapolis, MN 55455
mathsrch@tc.umn.edu

Applicants must include the following: curriculum vitae; at least 4 letters of recommendation, one of which should address teaching ability; and description of research. In addition please complete the Equal Opportunity Employment form at http://www.math.umn.edu/jobs.

The University of Minnesota is an Equal Opportunity Employer and Educator.

000189

UNIVERSITY OF MINNESOTA
School of Mathematics

The School of Mathematics of the University of Minnesota is seeking outstanding candidates for 2-3 tenure-track or tenured faculty positions starting fall semester 2006. Particular attention will be paid to applicants at the assistant or associate professor level with strong interests in Geometry or Scientific Computation. Candidates should have a Ph.D. or equivalent terminal degree in mathematics or a closely related field and excellent records in both research and teaching. Women and people of color from all mathematical areas are encouraged to apply.

For full consideration, applications and all supporting materials must be submitted electronically through http://www.mathjobs.org by December 15, 2005. Applications received after the deadline will be considered as positions remain. No paper submission is needed unless the candidate is unable to submit electronically. Reference letter writers should be asked to submit their letters online through http://www.mathjobs.org. If they are unable to do so, they may send their letters to the following address: Lawrence F. Gray, Professor and Head, School of Mathematics, 127 Vincent Hall, 206 Church Street S.E. Mpls. MN 55455; mathsrch@tc.umn.

Applicants must include the following: curriculum vitae; at least 4 letters of recommendation, one of which should address teaching ability; and description of research. See also http://www.math.umn.edu. In addition please complete the Equal Opportunity Employment form at http://www.math.umn.edu/jobs/.

The University of Minnesota is an Equal Opportunity Employer and Educator.

000190

NEW HAMPSHIRE

DARTMOUTH COLLEGE
John Wesley Young Research Instructorship

The John Wesley Young Instructorship is a postdoctoral, two-year appointment intended for promising Ph.D. graduates with strong interests in both research and teaching and whose research interests overlap a department member's. Current research areas include applied mathematics, combinatorics, geometry, logic, non-commutative geometry, number theory, operator algebras, probability, set theory, and topology. Instructors teach four ten-week courses distributed over three terms, though one of these terms in residence may be free of teaching. The assignments normally include introductory, advanced undergraduate, and graduate courses. Instructors usually teach at least one course in their own specialty. This appointment is for 26 months with a monthly salary of $4,500.00 and is not renewable. Salary includes two-month research stipend for Instructors in residence during two of the three summer months in 2007 and 2008. To be eligible for a 2006-2008 Instructorship, candidate must be able to complete all requirements for the Ph.D. degree before September 2006. Applications may be obtained at http://www.math.dartmouth.edu/recruiting/. Or, submit a letter of application, curriculum vitae, graduate school transcript, thesis abstract, statement of research plans and interests, and at least three, preferably four, letters of recommendation to Donna Black, Department of Mathematics, Dartmouth College, 6188 Bradley Hall, Hanover, New Hampshire 03755-3551. At least one referee should comment on applicant's teaching ability; at least two referees should write about applicant's research ability. Applications received by January 3, 2006, receive first consideration; applications will be accepted until position is filled. Dartmouth College is committed to diversity and strongly encourages applications from women and minorities.

000094

DARTMOUTH COLLEGE
Department of Mathematics

The Department of Mathematics anticipates a tenure-track opening with initial appointment in the 2006-2007 academic year. In extraordinary cases, appointment at a higher rank is possible. Preference is given to candidates working in discrete or combinatorial mathematics with connections to existing research interests in the department, including discrete probability, graph theory, algebraic combinatorics, combinatorial number theory, and discrete geometry. Candidates for the position must be committed to outstanding teaching and interaction with students at all levels of undergraduate and graduate study. To create an atmosphere supportive of research, Dartmouth offers new faculty members grants for research-related expenses, a quarter of sabbatical leave for each three academic years in residence, and flexible scheduling of teaching responsibilities. The teaching responsibility in mathematics is three courses spread over three of four ten-week terms. Applications may be obtained at http://www.math.dartmouth.edu/recruiting/. Or, send a letter of application, curriculum vitae, and a brief statement of research results and interests, and arrange for four letters of reference, at least one of which specifically addresses teaching, to be sent to Donna Black, Recruiting Secretary, Department of Mathematics, Dartmouth Col-

lege, 6188 Bradley Hall, Hanover, New Hampshire 03755-3551. Applications received by December 15, 2005, will receive first consideration. Dartmouth College is committed to diversity and strongly encourages applications from women and minorities. Inquiries about the progress of the selection process may be directed to David Webb, Recruiting Chair.

000095

NEW MEXICO

UNIVERSITY OF NEW MEXICO
Tenure-Track Assistant Professor in Statistics

University of New Mexico seeks tenure-track Asst. Professor in Statistics. Senior candidates may be considered. See www.stat.unm.edu for job description. Selection begins Dec. 1, 2005, and continues until the position is filled. Send CV, statement of interests, 3 letters of recommendation to: Statistics Search Committee, Department of Math and Statistics, University of New Mexico, Albuquerque, NM 87131. EEO/AA.

000145

NORTH CAROLINA

WAKE FOREST UNIVERSITY
Department of Mathematics

Applications are invited for a tenure-track position in mathematics at the assistant professor level beginning August 2006. We seek one person whose research is in Topology or Geometry. Duties include teaching at the undergraduate and graduate levels and continuing research. A Ph.D. in mathematics or equivalent is required. The department has 18 members and offers a B.A., B.S., and M.A. in mathematics and a B.S. in each of mathematical business and mathematical economics. Send letter of application and resume to Stephen Robinson, Department of Mathematics, Wake Forest University, P.O. Box 7388, Winston-Salem, NC 27109-7388. AA/EO employer.

000103

OHIO

CASE WESTERN RESERVE UNIVERSITY
CLEVELAND, OHIO
Department of Mathematics

One or more tenure-track appointments. Open rank, however appointment at the rank of assistant professor is strongly preferred. We especially emphasize coordination with Department, College, and University goals, including undergraduate teaching in the University's SAGES Program. Areas of preference have been identified to meet Department priorities. For more information and instructions, see http://www.case.edu/artsci/dean/searches/math06.html. Indicate in which area you wish to be considered. The successful candidate will hold the Ph.D. or equivalent and have, relative to career stage, a distinguished record of publication, research, service, and teaching. Compensation commensurate with qualifications. Electronic applications only, to: James Alexander, math-faculty-position@cwru.edu, consisting of a letter of application, which indicates in which area of preference you wish to be considered, AMS cover sheet, a c.v., and the names and contact information for four referees to whom we may write. Visiting positions/instructorships/lectureships may also be open. Evaluation of applications will begin December 15, 2005. Case is a recipient of an NSF ADVANCE institutional transformation grant to increase the participation of women in science and engineering. Case Western Reserve University is committed to diversity and is an Affirmative Action, Equal Opportunity Employer. Applications from women or minorities are especially encouraged.

000173

THE OHIO STATE UNIVERSITY
College of Mathematical and Physical Sciences
Department of Mathematics

The Department of Mathematics in the College of Mathematical and Physical Sciences at The Ohio State University expects to have tenure-track/tenured positions and several visiting positions available, effective Autumn Quarter 2006. Candidates in all areas of pure and applied mathematics are invited to apply. A Ph.D. in mathematics, significant mathematical research accomplishment, and evidence of excellent teaching ability are required.

Candidates should apply online at http://www.math.ohio-state.edu/applications/. Senior candidates should arrange for at least five letters of recommendation and junior candidates should arrange for at least three letters of recommendation to be sent to:

Advisory Committee
Department of Mathematics
The Ohio State University
231 W. 18th Avenue
Columbus, OH 43210

If you cannot apply online, please send vitae, research statement, and teaching statement to the above address.

Applications are considered on a continuing basis but the review process begins November 15, 2005. Please direct inquiries to email: facultysearch@math.ohio-state.edu.

To build a diverse workforce, Ohio State encourages applications from minorities, veterans, women, and individuals with disabilities. Flexible work options available. EEO/AA employer.

000104

THE OHIO STATE UNIVERSITY
College of Mathematical and Physical Sciences
Department of Mathematics

The Department of Mathematics in the College of Mathematical and Physical Sciences at The Ohio State University expects to have several Hans J. Zassenhaus Assistant Professorships and VIGRE Arnold Ross Assistant Professorships available effective Autumn Quarter 2006. These term positions are renewable annually for up to a total of three years. Candidates are expected to have a Ph.D. in mathematics and to present evidence of excellence in research and teaching. Further information on the department can be found at http://www.math.ohio-state.edu and http://mbi.osu.edu.

All candidates should apply online at http://www.math.ohio-state.edu/applications/ and have at least three letters of recommendation sent to:

Advisory Committee
Department of Mathematics
The Ohio State University
231 W. 18th Avenue
Columbus, OH 43210

If you cannot apply online, please send vitae, research statement, and teaching statement to the above address.

Applications are considered on a continuing basis but the annual review process begins November 15, 2005. Please direct inquiries to email: facultysearch@math.ohio-state.edu.

To build a diverse workforce, Ohio State encourages applications from minorities, veterans, women, and individuals with disabilities. Flexible work options available. EEO/AA Employer.

000105

THE OHIO STATE UNIVERSITY
College of Mathematical and Physical Sciences
Department of Mathematics

The Department of Mathematics in the College of Mathematical and Physical Sciences at The Ohio State University expects to have openings at both the junior and senior level in the area of mathematical and computational biology.

Applicants should have a Ph.D. in mathematics or a related area, such as mathematical sciences, biomathematics, biology, chemistry, computer science, physics, and engineering and should show outstanding promise and/or accomplishments in both research and teaching. The successful candidate will be expected to teach courses in the Mathematics Department and actively participate in the Mathematical Biosciences Institute.

All candidates should apply online at http://www.math.ohio-state.edu/

applications/. Further information on the Department and the MBI can be found at http://www.math.ohio-state.edu and http://mbi.osu.edu.

Senior candidates should arrange for at least five letters of recommendation and junior candidates should arrange for at least three letters of recommendation to be sent to:

Mathematical Biosciences Search
Department of Mathematics
The Ohio State University
231 W. 18th Avenue
Columbus, OH 43210

If you cannot apply online, please send vitae, research statement, and teaching statement to the above address.

Applications are considered on a continuing basis but the review process begins November 15, 2005. Please direct inquiries to email: facultysearch@math.ohio-state.edu.

To build a diverse workforce, Ohio State encourages applications from minorities, veterans, women, and individuals with disabilities. Flexible work options available. EEO/AA Employer.

000106

THE OHIO STATE UNIVERSITY AT LIMA
Mathematical Biosciences Institute

The Mathematical Biosciences Institute (MBI) at The Ohio State University is accepting applications for postdoctoral positions to start September, 2006, which are renewable for up to 3 years. Some positions are co-sponsored by industry or academic bioscience labs. The deadline for applications is January 18, 2006. Short- and long-term visitors may apply at any time. To access the application form or for more information, visit the MBI website at http://mbi.osu.edu or call (614) 292-3648. The Mathematical Biosciences Institute adheres to the AA/EOE hiring guidelines.

000152

UNIVERSITY OF DAYTON
Department of Mathematics

Applications are invited for an anticipated tenure-track position in the Department of Mathematics at the assistant professor level starting in August 2006. The position focuses on applied discrete mathematics.

Candidates must have a Ph.D. in mathematics. The candidate must have a commitment to teaching, advisement, curriculum development, and research supervision at both the undergraduate and graduate levels. The person filling this position will be expected to develop an ongoing research agenda, and complement the core group of discrete mathematicians in the department. Preference will be given to candidates who intend to develop research and curricular collaborations with faculty members from other disciplines.

The selection process begins December 12, 2005. To receive full consideration, all materials must be received by January 19, 2006. A complete application consists of a resume, three letters of recommendation, a statement of research and professional plans, a statement of teaching philosophy, and a graduate transcript. Both teaching abilities and research abilities should be addressed in the letters of recommendation. Please include an e-mail address in your correspondence.

Send applications to: Dr. Robert Gorton, Chair of the Mathematics Search Committee, Department of Mathematics, University of Dayton, Dayton, OH 45469-2316. Contact the search committee at Robert.Gorton@notes.udayton.edu. To obtain further information, see http://www.udayton.edu/~mathdept.

The University of Dayton is a private comprehensive Catholic university founded by the Society of Mary in 1850. It has more than 6,000 undergraduate and 3,000 graduate students. The Department of Mathematics offers the B.A. and B.S. degrees in mathematics, the B.S degree in applied mathematical economics, and the M.S. degree in applied mathematics and professional master's degrees in both financial mathematics and in mathematics education. The University of Dayton is an Equal Opportunity/Affirmative Action employer. Women, minorities, individuals with disabilities, and veterans are encouraged to apply. The University of Dayton is firmly committed to the principle of diversity.

000140

OKLAHOMA

OKLAHOMA STATE UNIVERSITY
Department of Mathematics

The Department anticipates filling four tenure-track positions beginning Fall 2006. Exceptionally qualified individuals may be considered for appointment at a rank higher than Assistant Professor. Applicants should have outstanding research potential and have made major contributions beyond their doctoral research. Candidates should also be committed to excellence in undergraduate and graduate education; the usual teaching load is 6 hours per semester. The Department seeks accomplished individuals in any field of mathematics, but preference may be given to enhancing one of our existing research groups, particularly, applied math/PDE, algebraic geometry, Lie groups, number theory, or analysis.

The Department also invites applications from recent recipients of the Ph.D. for several temporary postdoctoral positions beginning Fall 2006. These are one-year appointments which are typically renewed for a second year. Appointment to these positions does not preclude future consideration for a tenure-track position. The duties include research and teaching, with a teaching load of usually 6 hours each semester. Mathematicians with research interests close to those of the permanent faculty may receive preference.

All applicants should submit a curriculum vita, abstracts of completed research, and a statement regarding teaching experience, and have 4 letters of recommendation sent to the address below. One letter of recommendation should appraise the applicant's teaching abilities. Applicants should use the AMS standardized form: Academic Employment in Mathematics, Application Cover Sheet, and indicate their subject area using the AMS subject classification numbers. Full consideration will be given to applications received by December 2, 2005. Paper versions of all the application documents must be submitted to the address given below.

Oklahoma State University is located in Stillwater in north central Oklahoma, about an hour by car from both Tulsa and Oklahoma City. The Department boasts a dynamic faculty with 32 tenured or tenure-track members engaged in mathematics research and education. An active Ph.D. program, support for colloquium and other visitors, approximately 3-6 postdoctoral fellows, as well as involvement of undergraduates in research experiences, create a lively atmosphere in the Department. The Department has received national recognition for the faculty's contributions to mathematical research and education. More information on the Department is available at http://www.math.okstate.edu/.

Oklahoma State University is an Equal Opportunity/Affirmative Action Employer. Women and minorities are encouraged to apply.

000155

OREGON

OREGON STATE UNIVERSITY
Department of Mathematics

The Department of Mathematics invites applications for a tenure-track Assistant Professor position specializing in numerical analysis and/or scientific computing. Applicants should have a Ph.D. in mathematics or a closely related field, significant active research engagement in numerical analysis and/or scientific computing, and excellence in teaching. The appointee will be expected to maintain a vigorous research program while participating in teaching, advising and mentoring at the graduate and undergraduate levels. The duties associated with this position include some teaching and advising in mathematics in connection with an interdisciplinary graduate program in Ecosystem Informatics. For this effort, we seek can-

didates whose numerical and/or computing background is complemented by a broad interest in mathematical modeling, especially as applied to problems involving multiple space and time scales and/or stochastic behavior. Further information about this position is available at http://www.math.oregonstate.edu/hiring.

Applicants should send a letter of interest and a detailed curriculum vitae including a description of current and future research interests and a list of publications to:

Search Committee: Numerical Analysis
Department of Mathematics
Oregon State University
Corvallis, OR 97331

Additionally, three letters of recommendation are required. One letter should address teaching. These should be sent to the above address. For full consideration, complete application materials must arrive by December 15, 2005. OSU is an Affirmative Action/Equal Opportunity Employer.

000092

OREGON STATE UNIVERSITY
Department of Mathematics

The Department of Mathematics invites applications for a full-time, 9-month, fixed-term Postdoctoral/Research Associate position in Applied Mathematics beginning in Winter 2006 or later depending on arrangements. This position will involve some teaching responsibilities and mainly research activities in the direction of the project "Multiscale modeling, analysis, and simulation of preferential flow in porous media". For more information on the project see http://www.math.oregonstate.edu/~multiscale or write to multiscale@math.oregonstate.edu. The successful applicant will have a Ph.D. in Mathematics or closely related field, significant active research engagement in modeling and/or analytical, and/or computational aspects of multiscale phenomena and teaching experience. Strong background and/or experience in at least two of the three areas: i) modeling and analysis of flow and transport phenomena, ii) computational methods appropriate for such models, and iii) experience with multiscale methods is required. Reappointment is at the discretion of the department Chair. Salary will depend on qualifications and on the extent of duties. For application instruction see full position announcement at oregonstate.edu/jobs. For full consideration, apply by 11/30/05. OSU is an AA/EOE.

000192

PENNSYLVANIA

MILLERSVILLE UNIVERSITY
Department of Mathematics

MATHEMATICS: Full-time, tenure-track assistant professorship to begin August 2006. Area of expertise in MATHEMATICS EDUCATION. The Department includes 20 full-time and several part-time faculty with a broad spectrum of mathematical specialties, and approximately 200 mathematics majors (of whom approximately 2/3 are secondary mathematics education majors). B.A. and B.S. degrees are offered in mathematics, as well as B.S.Ed. and M.Ed. degrees in mathematics education. Duties include an annual 24-hour teaching load, including mathematics courses for preservice elementary and secondary teachers and a variety of undergraduate mathematics service courses, scholarly activity, student advisement, curriculum development in mathematics education at both undergraduate and graduate levels, and committee work. Research support is available through release-time grants, on a competitive basis. Faculty may be required to teach evenings, weekends, or online. Summer teaching opportunities are usually available. Salary and benefits are competitive. Required: Doctorate (or completion by second year of reappointment) in mathematics education or in mathematics with a specialization in mathematics education. Must be broadly trained in mathematics with at least 24 semester hours of graduate level courses in pure or applied mathematics. Must be familiar with current directions in mathematics education, including the use of technology. Must exhibit evidence of strong commitment to excellence in teaching and continued scholarly activity. Must complete a successful interview and teaching demonstration. Evidence of teaching effectiveness is a primary consideration. Candidates must be able to work effectively with professional groups and community groups. Preferred: Experience teaching both K–12 and college-level mathematics. Full consideration will be given to applications received by January 20, 2006. Email applications will not be accepted. Send letter of application that addresses the position requirements, curriculum vita, copies of all undergraduate and graduate transcripts, and three letters of reference addressing position requirements (at least two of which attest to recent teaching effectiveness) to: Dr. Dorothee J. Blum, Search Committee Chair, Department of Mathematics/AMS1205, Millersville University, P.O. Box 1002, Millersville, PA 17551-0302. An EO/AA Institution.

000157

RHODE ISLAND

BROWN UNIVERSITY
Mathematics Department

The Mathematics Department invites applications for an opening at the level of Associate Professor with tenure to begin July 1, 2006. [Exceptionally qualified senior candidates may be considered for appointment as Full Professor.] Candidates should have a distinguished research record and a strong commitment to excellence in undergraduate and graduate teaching. Preference will be given to applicants with research interests consonant with those of the present members of the Department (for more information see http://www.math.brown.edu/faculty/faculty.html). Qualified individuals are invited to send a letter of application, a curriculum vitae, and three letters of recommendation, one of which should address teaching, to be forwarded to: Senior Search Committee, Department of Mathematics, Box 1917, Brown University, Providence, Rhode Island 02912. Applications received by **October 15, 2005**, will receive full consideration, but the search will remain open until the position is closed or filled. For further information or inquiries, write to srsearch@math.brown.edu. Brown University is an Equal Opportunity/Affirmative Action employer and encourages applications from women and minorities.

000132

TENNESSEE

VANDERBILT UNIVERSITY
Department of Mathematics
Non-Tenure-Track Assistant Professor Positions

We invite applications for several visiting and non-tenure-track assistant professor positions in the research areas of the mathematics department beginning Fall 2006. These positions will have variable terms, but most will be two- to three-year appointments with a 2-2 teaching load. We expect that one of the three-year appointments will be a special non-tenure-track assistant professorship with a 1-1 teaching load and a stipend to support research.

In addition, we anticipate a two-year appointment at the non-tenure-track assistant professor level in the area of noncommutative geometry with a 1-1 teaching load, a summer stipend and an award for research related travel. This position is supported by a Research Training Group (RTG) grant from the National Science Foundation. It is intended for recent Ph.D.'s who are U.S. citizens or residents.

We are looking for individuals with demonstrated research potential and a strong commitment to excellence in teaching. Submit your application and sup-

porting materials to the attention of the "NTT Assistant Professor Hiring Committee". These materials should include a vita, a publication list, a research summary and the American Mathematical Society Cover Sheet. Please include an email address and fax number if available. Applicants should also arrange to have four letters of recommendation sent to the hiring committee, including one that discusses the candidate's teaching qualifications. Evaluation of the applications will commence on December 1, 2005, and continue until the positions are filled. For information about the Department of Mathematics at Vanderbilt University please consult the Web at http://www.math.vanderbilt.edu/.

Vanderbilt is an Equal Employment Opportunity/Affirmative Action Employer. Women and minorities are especially invited to apply.

000162

TEXAS

THE UNIVERSITY OF TEXAS AT ARLINGTON
Department of Mathematics

The Department of Mathematics at The University of Texas at Arlington invites applications for two tenure-track assistant professor positions beginning September 1, 2006, subject to available funding. Tenured appointments at the rank of Associate or Full Professor may be considered for exceptional candidates. The salary will be competitive and commensurate with qualifications and experience. The minimum qualifications are an earned Ph.D. in mathematics, mathematics education, or a related field. At least two years of experience beyond the Ph.D. is preferable.

Demonstrated excellence in research, external funding, and teaching is essential. While outstanding applicants from all mathematical research areas will be considered, preference will be given to those with significant research and scholarly accomplishments in mathematics education, operations research, numerical/computational methods, bio-mathematics, statistics/bio-statistics and other areas of applied mathematics. There is particular interest for candidates in mathematics education who will teach courses, supervise theses, and conduct research in the department's fast-growing Master of Arts in Mathematics program for secondary teachers.

For more information about the department, visit our web site at http://www.uta.edu/math.

Applicants should send a letter of application plus a complete curriculum vitae, statement on research interests, statement of teaching philosophy, one or two representative publications, and an AMS cover sheet to:

Dr. James A. M. Epperson
Chair, Faculty Recruiting Committee
Department of Mathematics
The University of Texas at Arlington
Box 19408
Arlington, TX 76019-0408

Applicants should arrange to have at least three letters of recommendation sent to the above address. Inquiries about the position may be directed to Dr. Epperson, Faculty Recruiting Committee Chair, at mathsearch@uta.edu. Review of applications will begin on December 5, 2005, and will continue until the positions are filled.

UTA is an Equal Opportunity and Affirmative Action employer.

000126

TEXAS LUTHERAN UNIVERSITY
Department of Mathematics

Texas Lutheran University, Department of Mathematics invites applications for a tenure-track assistant professorship beginning August 2006. Requirements include Ph.D. in mathematics by appointment date, ability to teach a wide range of introductory and advanced undergraduate courses, and a commitment to mentor students in an undergraduate research program. Submit letter of application, cv, statement of teaching philosophy, and five references (names, addresses including email, telephone) to: Dean John T. Sieben, College of Natural Science and Mathematics, Texas Lutheran University, 1000 W. Court St., Seguin, TX 78155; fax (830) 372-6095, phone (830) 372-6007; email: jsieben@tlu.edu. Review of applications begin November 1 and continue until the position is filled. Full position description is available at http://www.tlu.edu. Texas Lutheran University is an Equal Opportunity Employer.

000153

WISCONSIN

UNIVERSITY OF WISCONSIN-MILWAUKEE
Department of Mathematical Sciences
Milwaukee, WI 53201-0413

The Department invites applications for a tenure-track faculty position in geometry, broadly interpreted to include algebraic geometry, geometric group theory and the geometry of topological and differential structures, starting in August 2006. Candidates must have a strong research record, evidence of or strong potential for extramural funding, and a demonstrated commitment to teaching excellence. Responsibilities include teaching two courses per semester and taking active roles in the undergraduate, Master's, and Ph.D. programs. Additional information is available at http://www.math.uwm.edu/.

Applicants should send the AMS Standard Cover Sheet, a vita, a description of their research, and a teaching statement to the Hiring Committee at the above address. Review of applications will begin December 13, 2005, and will continue until the position is filled. At least three letters of recommendation should be sent to the Hiring Committee; at least one letter should address the applicant's teaching experience and capabilities. UW-Milwaukee is an AA/EEO Employer.

000160

CANADA

UNIVERSITY OF TORONTO
Department of Mathematics
Ted Mossman Chair in Mathematics

Thanks to a generous gift from James Mossman, the Department of Mathematics, University of Toronto, is proud to announce a search for the Ted Mossman Chair in Mathematics. The appointment is at the level of Professor with tenure, and the Chair holder is expected to be an outstanding mathematician, whose research and teaching will make a major contribution to the quality and stature of the department. The appointment is effective July 1, 2006.

Applicants should send a complete Curriculum Vitae and a short statement about their research program and arrange to have four letters of reference sent to the Ted Mossman Search Committee, Department of Mathematics, University of Toronto, 40 St. George Street, Room 6290, Toronto, Ontario M5S 2E4, Canada. Preference will be given to applications received by January 1, 2006.

The University of Toronto offers the opportunity to teach, conduct research, and live in one of the most diverse cities in the world, and is strongly committed to diversity within its community. The University especially welcomes applications from minority candidates and others who may add to the further diversification of ideas.

All qualified candidates are encouraged to apply; however, Canadians and permanent residents will be given priority.

000195

UNIVERSITY OF TORONTO
Department of Mathematics
Limited Term Assistant Professorships

The department invites applications for Limited Term Assistant Professorships (non tenure stream) at the St. George and Mississauga campuses. Applicants must demonstrate strength in teaching and significant research promise. Application material must include the candidate's Curriculum Vitae and list of publications. Applicants must arrange to have four letters of reference, of which at least one letter primarily addresses the candidate's teaching, sent directly to the appointments committee. Candidates are encouraged to send a cover letter specifying that they

are applying for a CLTA position and specifying whether the candidate is a Canadian citizen/permanent resident. Candidates are also encouraged to send a research statement, a teaching statement, and the AMS cover sheet. Application material should be sent to the Appointments Committee, Department of Mathematics, University of Toronto, 40 St. George Street, Room 6290, Toronto Ontario M5S 2E4, Canada. Preference will be given to applications received by December 15, 2005.

The University of Toronto offers the opportunity to teach, conduct research, and live in one of the most diverse cities in the world. The University of Toronto is strongly committed to diversity within its community and especially welcomes applicants from visible minority group members, women, Aboriginal persons, persons with disabilities, members of sexual minority groups, and others who may contribute to the further diversification of ideas.

The appointments are effective July 1, 2006, and are contractually-limited term appointments for a term of three years. All qualified candidates are encouraged to apply; however, Canadians and permanent residents will be given priority.

000196

ENGLAND

IMPERIAL COLLEGE, LONDON
Department of Mathematics
Research Associate in Pure Mathematics

To work on a two-year EPSRC-funded project in differential geometry, working with Professor Simon Donaldson FRS, Dr. Richard Thomas and Dr. Mark Haskins. The specifics of the project are flexible, depending on your tastes and expertise, but the main theme will be based around either higher dimensional gauge theory or calibrated geometry. You will be expected to have a Ph.D. in geometry and knowledge of either gauge theory, calibrated geometry, geometric analysis and gluing theorems, or Picard-Lefschetz theory and algebraic topology. Salary will be in the range, £22,870–£33,330 per annum, depending on qualifications and experience. Informal enquiries may be made to Richard Thomas, richard.thomas@imperial.ac.uk. A job description and an application form can be obtained from: http://www.imperial.ac.uk/employment/research/ index.htm. Alternatively, please contact Rusudan Svanidze, Tel: +44 (0)20 7594 8555, email: r.svanidze@imperial.ac.uk. Completed application forms should be sent with a full curriculum vitae and list of publications to Ms. Rusudan Svanidze, Department of Mathematics, 651 Huxley Building, Imperial College London, SW7 2AZ.

Closing date: 31 December 2005.

Valuing diversity and committed to equality of opportunity.

000175

PORTUGAL

INSTITUTO SUPERIOR TÉCNICO
Departamento de Matemática
Center for Mathematical Analysis Geometry, and Dynamical Systems
Postdoctoral Positions

The Center for Mathematical Analysis, Geometry, and Dynamical Systems of the Department of Mathematics of Instituto Superior Técnico, Lisbon, Portugal, invites applications for postdoctoral positions for research in mathematics, subject to budgetary approval. Positions are for one year, with the possibility of extension for a second year upon mutual agreement. Selected candidates will be able to take up their position between September 1, 2006, and January 1, 2007.

Applicants should have a Ph.D. in mathematics preferably obtained after December 31, 2003. They must show very strong research promise in one of the areas in which the mathematics faculty of the Center is currently active. There are no teaching duties associated with these positions.

Applicants should send a curriculum vitae; reprints, preprints and/or dissertation abstract; description of research project (of no more than 1,000 words); and ask that three letters of reference are sent directly to the director at the above address.

To insure full consideration, complete application packages should be received by January 15, 2006. Additional information about the Center and the positions is available at http://www.math.ist.utl.pt/cam/.

000179

TAIWAN

ACADEMIA SINICA
Institute of Mathematics
Taiwan, R.O.C.

The Institute of Mathematics, Academia Sinica, invites applications for the following positions: (i) Tenure-track faculty positions in all ranks (assistant, associate, and full Research Fellows) for the academic year 2006–2007. The applicants should have a Ph.D. in Mathematics by the end of August 2006. For assistant research fellow, we welcome candidates who show strong promise in research. New or recent Ph.D.'s are encouraged to apply. For associate and full research fellows, candidates should show excellent records in research. Deadline for the application is January 15, 2006. All applications completed before the deadline (including letters of reference) will be given full consideration. (ii) Postdoctoral positions for the academic year 2006–2007. The applicants should have a Ph.D. in Mathematics by the end of August 2006. Promising applicants who received the Ph. D. within five years in all areas of mathematics are welcome to apply. This is a one-year position, renewable according to funding availability. Deadline for the application is May 31, 2006. All applications completed before the deadline (including letters of reference) will be given full consideration. Interested applicants should arrange to have sent a curriculum vitae, a doctoral degree certificate, a description of research work and research plan, copies of representative publications, three letters of reference to:

The Hiring Committee
Institute of Mathematics
Academia Sinica
Nankang 11529, Taipei
Taiwan, R.O.C.

All questions about the job positions should be sent to email: personnel@math.sinica.edu.tw. or faxed to (886-)2-2782-7432. Informal inquiries are also welcome. The Institute Academia Sinica is one of the prominent institutions in Taiwan http://www.sinica.edu.tw. The main buildings of its 24 institutes, including the Institute of Mathematics, are on one campus located in Taipei, Taiwan. The institutes are funded by grants from the government. Our institute has additional funding to establish an excellent library with a complete collection of mathematics journals. The members have strong commitment to the excellence of research. The Institute has several well-established research groups in the areas of algebra and number theory, analysis, combinatorics, geometry, and probability. There are visitor programs, including postdoctoral fellowship, short term visitor program for both local and international visitors. The need to enlarge the scope of the visitor programs is currently under discussion. For more information about the Institute please visit: http://www.math.sinica.edu.tw.

000184

MISCELLANEOUS

VIEW PAPERS ONLINE

The Riemann Hypothesis; The Continuum Hypothesis; Non-Cantorial Cardinal Numbers; posted to http://www.gauge-institute.org.

000177

SITUATIONS WANTED

Ph.D. Cambridge (1979), extensive teaching experience. Available for positions immediately. Please contact: Dr.Mehran Basti: Basti05b@aol.com or call 435-867-4849.

000191

International Congress of Mathematicians
Madrid, Spain
August 22-30, 2006

www.icm2006.org

Second Announcement

The Organizing Committee of the next International Congress of Mathematicians is pleased to send, also on behalf of the International Mathematical Union, an open invitation to attend the Congress in Madrid, Spain, from August 22 to 30, 2006.

The International Congress of Mathematicians (ICM) is the most important mathematical meeting in the world. It takes place every four years since 1897. The Spanish mathematical community is proud to host the Congress for the first time in its history. As in previous occasions, the ICM 2006 will be a major scientific event, bringing together mathematicians from all over the globe and demonstrating the vital role that Mathematics plays in science and society.

This announcement contains useful information about the Congress, including the list of plenary speakers, instructions for registration and submission of abstracts, information about accommodation possibilities, many aspects of the social program, and a list of satellite events.

Contents

A. Location of the Congress

A.1 Venue

PALACIO MUNICIPAL DE CONGRESOS
Campo de las Naciones
Avda. Capital de España Madrid, s/n
28042 Madrid, Spain
Phone: +34 917 220 400; Fax: +34 917 210 607; Website: www.camponaciones.com

This convention center is located in the Northeast area of Madrid, well communicated with the public transportation system, at fifteen minutes from Paseo de la Castellana, five minutes from Barajas International Airport, and ten minutes from the Chamartín railway station. It hosts large exhibition areas, two auditoriums, and thirty auxiliary halls with a variety of capacity and size.

A.2 Access

- By car: Exit 7 from M40 (ring road); N-II road until Gran Vía de Hortaleza; A10 highway.
- By underground: Line 8 (Campo de las Naciones station), which is a direct line from Barajas International Airport to the city centre (Nuevos Ministerios station).
- By bus: No. 122 of EMT (Madrid Transit Company), from the Avenida de América interchange.

A.3 Secretariat

ICM 2006 Secretary General
Facultad de Matemáticas, despacho 524
Universidad Complutense de Madrid
Plaza de las Ciencias, 3
Ciudad Universitaria
28040 Madrid, Spain
Phone: +34 913 944 381; Fax: +34 913 944 383; E-mail: secretariaicm2006@mat.ucm.es

ICM 2006 Technical Secretariat
c/o UNICONGRESS
Bárbara de Braganza, 12 - 3º D
28004 Madrid, Spain
Phone: +34 913 104 376; Fax: +34 913 195 746; E-mail: icm2006@unicongress.com

B. Important Dates

2006	
January 1	Deadline for grant applications
January 1	Opening of registration
January 1	Call for submission of abstracts of short communications, posters, and mathematical software contributions
March 30	Deadline for submission of abstracts of short communications, posters, and mathematical software contributions
May 15	Deadline for registration at a reduced rate
May 30	Deadline for notification to authors of acceptance or rejection of contributions
August 19–20	General IMU Assembly in Santiago de Compostela
August 21	Registration from 9 am to 8 pm
August 22–30	ICM 2006 in Madrid

C. Scientific Program

C.1 Plenary Lectures

After the recommendation of the Program Committee appointed by the International Mathematical Union, the Organizing Committee of the ICM 2006 has invited 20 outstanding mathematicians to give one-hour plenary lectures. All of them have accepted. Their names and affiliations follow.

Percy Deift, Courant Institute of Mathematical Sciences, New York University, New York, USA

Jean-Pierre Demailly, Université Joseph Fourier, Grenoble, France

Ronald DeVore, University of South Carolina, Columbia, USA

Yakov Eliashberg, Stanford University, Stanford, USA

Étienne Ghys, École Normale Supérieure de Lyon, Lyon, France

Richard Hamilton, Columbia University, New York, USA

Henryk Iwaniec, Rutgers University, Piscataway, USA

Iain Johnstone, Stanford University, Stanford, USA

Kazuya Kato, Kyoto University, Kyoto, Japan

Robert V. Kohn, Courant Institute of Mathematical Sciences, New York University, New York, USA

Ib Madsen, Aarhus University, Aarhus, Denmark

Arkadi Nemirovski, Technion—Israel Institute of Technology, Haifa, Israel

Sorin Popa, University of California, Los Angeles, USA

Alfio Quarteroni, École Polytechnique Fédérale de Lausanne, Lausanne, Switzerland

Oded Schramm, Microsoft Corporation, Redmond, USA

Richard P. Stanley, Massachusetts Institute of Technology, Cambridge, USA

Terence Tao, University of California, Los Angeles, USA

Juan Luis Vázquez, Universidad Autónoma de Madrid, Madrid, Spain

Michèle Vergne, École Polytechnique, Palaiseau, France

Avi Wigderson, Institute for Advanced Study, Princeton, USA

Plenary lectures will be delivered in Auditorium A (the main lecture hall of the Palacio Municipal de Congresos), which has a capacity of 2,200 seats. If necessary, talks will also be displayed in Auditorium B via closed-circuit television, so that an additional audience of 900 people can be reached.

C.2 Invited Section Lectures

Also at the recommendation of the Program Committee, 169 lectures of 45 minutes have been scheduled in specific scientific sections. These lectures are intended to be surveys of significant topics in their area of research. The list of sections is the following. Numbers in parentheses indicate the number of lectures scheduled in the corresponding section. Names of speakers are at `www.icm2006.org/scientificprogram/sectionlectures`.

1. Logic and Foundations (5)
2. Algebra (7)
3. Number Theory (10)
4. Algebraic and Complex Geometry (9)
5. Geometry (13)
6. Topology (8)
7. Lie Groups and Lie Algebras (12)
8. Analysis (8)
9. Operator Algebras and Functional Analysis (6)
10. Ordinary Differential Equations and Dynamical Systems (11)
11. Partial Differential Equations (11)
12. Mathematical Physics (11)
13. Probability and Statistics (13)
14. Combinatorics (9)
15. Mathematical Aspects of Computer Science (7)
16. Numerical Analysis and Scientific Computing (7)
17. Control Theory and Optimization (7)
18. Applications of Mathematics in the Sciences (9)
19. Mathematics Education and Popularization of Mathematics (3)
20. History of Mathematics (3)

The above figures include three joint lectures in Sections 2, 3 and 6. In addition, there will be three panel discussions on hot educational issues in Section 19.

C.3 Short Communications, Posters and Mathematical Software

Registered participants will have the opportunity to present their mathematical work in the form of short communications, posters, or contributions on mathematical software. Only one of these three possibilities will be allowed for each participant.

Proposals for presentations in one of the scientific sections of the Congress will be considered by the Local Program Committee, provided that the proposers have registered by March 30, 2006, and indicated on the registration form that they wish to present their work.

Besides this formal framework, it will also be possible to organize ad hoc sessions during the Congress.

Short Communications

Short communications are oral presentations of mathematical work. Sessions will be organized according to the scientific sections of the ICM 2006. Each communication should last up to 20 minutes, including discussion. Rooms for short communications will be equipped with an overhead projector.

Posters

A poster is a display on some flat material, usually stiff paper or cardboard, synthesizing the main points of a mathematical work in a visually attractive layout that can be quickly grasped by other mathematicians.

The Local Program Committee strongly recommends scientific contributions in the form of posters, and encourages participation in the poster competition (see details below). Poster sessions provide a pleasant interaction between colleagues, offering the possibility of discussion in an informal and relaxed atmosphere.

Poster sessions will take place in an exhibit area. They will also be organized according to the scientific sections of the ICM 2006. The precise panel location and timetable for authors to be present and available for questions and discussions will be communicated in due course. Posters will be affixed to ad-hoc vertical panels with two-side adhesive tape provided by the organization. A panel of 2.20 m (height) x 1 m (width) will be allowed for each poster.

Authors should prepare their posters thoroughly in advance. Their contribution to the success of the Congress will be greatly appreciated.

Mathematical Software

The main purpose of the sessions on mathematical software is to give an overview of the state of the art, highlighting the current research and its main developments. They are aimed at attracting a broad audience, including researchers, students, teachers, etc., with a particular focus on software topics.

Sessions will be devoted to presenting mathematical software systems or mathematical applications, either of general scope or focused on particular areas. Implementations of especially designed algorithms solving particular mathematical problems of research interest are also welcome. Contributions should meet the highest standards. Mathematical originality, new solutions to relevant problems, or unusual fields of application will be appreciated. Within this framework, submissions from any mathematical field using software systems will be considered; for instance, numerical analysis, computer algebra, optimization, mathematical visualization, mathematical education software, etc.

Systems that are available free of charge (e.g., public domain) are particularly welcome and clearly preferred. It should be emphasized that this is a scientific section of the Congress with no commercial aim. Established companies in software systems can offer their products in booths especially designed for commercial exhibitors.

Each contribution should last up to 25 minutes, including discussion. The room for contributions on mathematical software will be equipped with video projector and computer. It is the responsibility of contributors to obtain any required permission and license for material contained in their presentations.

C.4 Instructions for Submission of Abstracts

Submission of abstracts for short communications, posters and mathematical software will start on January 1, 2006. Abstracts submitted after March 30 will not be considered. The Local Program Committee will notify authors of the acceptance or rejection of their contribution before May 30.

Abstracts of short communications should be written in English using the LaTeX template available on the Congress website at `www.icm2006.org/scientificprogram/shortcommunications`. Authors should submit both a LaTeX file and a PDF file. The text of the abstract should contain a clear statement of the results and their context (between 150 and 250 words), and optionally references (no more than five).

Abstracts of accepted communications will be published in the abstract booklet of the ICM 2006.

C.5 Poster Competition

The ICM 2006 Local Program Committee is keen to encourage the presentation of posters during the congress with the purpose of attracting a numerous and wide-ranging participation.

The use of posters as a means of scientific communication is on the increase in mathematical congresses as well as in other scientific disciplines. The advantage of presenting posters instead of short oral communications is that, unlike the spoken word, the poster remains on display for several hours, furthering discussion in a relaxed and informal atmosphere between the authors and small groups of researchers interested in the subject, often leading to multiple à la carte presentations.

In order to stimulate the presentation of posters, competitions in each of the 20 scientific sections of the ICM 2006 will be organized. First and second prizes of 200 and 100 Euros, respectively, will be awarded in each section. A diploma will be awarded with each prize.

Rules and Procedure

1. Author(s) of posters must state whether they intend to take part in the competition on submitting their abstracts for inclusion in the Congress website. This statement of intention must be followed up by sending the electronic version of the poster in question before June 30, 2006.

2. The Local Program Committee will be the jury presiding over the competition.

3. Only those posters accepted for presentation, and whose authors have stated their intention to participate in the competition, will be considered eligible by the jury.

4. The jury will base its decisions on the following criteria:
   a) Visual attractiveness and originality of the presentation.
   b) Clarity of exposition of scientific data.
   c) Quality of mathematical content and suitability of presentation in this form.

5. A list of the prize winners in each section will be made public during the Congress. Diplomas will be awarded in a ceremony. Further details will be announced in due time.

6. The jury reserves the right to declare prizes vacant.

C.6 Special Activities

This section gathers other scientific activities mostly promoted or organized by the Local Program Committee. By October 2005, the following are already scheduled:

- A lecture on the Poincaré Conjecture for a general audience, by John Morgan, Columbia University, New York, USA.
- The ICM 2006 Emmy Noether Lecture.
- A panel on e-Learning Mathematics, organized by the Spanish Conference of Deans of Mathematics.

D. Publications

D.1 Proceedings

Proceedings of the ICM 2006 will be published by the European Mathematical Society Publishing House (`www.ems-ph.org`). The Proceedings will consist of three volumes containing articles based on the plenary lectures and invited section lectures, as well as articles based on the lectures delivered by the recipients of the Fields Medal and the Nevanlinna and Gauss Prizes. The first volume will also contain the speeches of the opening and closing ceremonies, and a set of pictures of speakers and participants capturing highlights of the Congress.

Two volumes of the Proceedings will be handed to the participants upon registration at the Congress venue. The third volume will be sent by post mail to the participants within three months. It is the purpose of ICM 2006 to make the scientific content of the Congress as widely available as possible, by using all modern communication resources together with the Proceedings books.

Editors of the ICM 2006 Proceedings: **Marta Sanz-Solé** (Universitat de Barcelona); **Javier Soria** (Universitat de Barcelona); **Juan Luis Varona** (Universidad de La Rioja, Logroño); **Joan Verdera** (Universitat Autònoma de Barcelona).

D.2 Abstracts

Abstracts of plenary lectures and invited section lectures at ICM 2006 will be collected in a booklet published by the European Mathematical Society Publishing House, which will also be included in the package given to participants upon their registration at the Congress venue.

Abstracts of accepted contributions to be presented at short communications, poster sessions or mathematical software sessions of ICM 2006 will be collected in a book issued by the same publisher and will also be included in the Congress registration package.

Electronic versions of abstracts will be available on the Congress website in advance.

D.3 Program

A printed copy of the Congress program, containing the daily schedule of activities and other useful information will be handed out to participants at the registration desk. An electronic version of the program will be available shortly before the Congress.

D.4 The *Madrid Intelligencer*

As in previous occasions, the *Mathematical Intelligencer* from Springer-Verlag will devote a special issue of the journal to the ICM 2006. A local editorial committee is in charge of gathering articles on the following general topics:

- History of Mathematics
- Mathematics, Science, and Society
- Mathematical Research

The *Madrid Intelligencer* will also contain a tourist guide, which will be helpful for Congress participants.

Editorial Committee of the *Madrid Intelligencer*: **Adolfo Quirós** (Universidad Autónoma de Madrid) and **Fernando Chamizo** (Universidad Autónoma de Madrid).

E. Social Program

E.1 Opening Reception

On August 22, an opening reception will be offered to participants in the Palacio Municipal de Congresos immediately after the opening ceremony of the Congress. It will be sponsored by the Madrid City Hall and hence free for Congress participants and registered accompanying persons. *Prior registration for the opening ceremony is compulsory.* Instructions are given in section I.4 below.

E.2 Dinner Party

In the evening of August 28, a dinner party will be organized for Congress participants and registered accompanying persons in the Botanical Garden of the Universidad Complutense de Madrid. The cost will be advised in due course.

E.3 Tourist Program

Pre-Conference Tours

Departure	Tour	Duration
August 18	Madrid - Córdoba - Sevilla - Granada - Madrid	4 days
August 19	Madrid - Ávila - Salamanca - Cáceres - Madrid	3 days

Post-Conference Tours

Departure	Tour	Duration
August 31	Madrid - Córdoba - Sevilla - Granada - Madrid	4 days
August 31	Madrid - Ávila - Salamanca - Cáceres - Madrid	3 days

Conference Excursions

Date / Excursions
Tuesday, August 22
Madrid sightseeing tour
Segovia + Ávila *
Wednesday, August 23
Reina Sofía + Thyssen + Atocha
Alcalá de Henares
Thursday, August 24
Madrid de los Austrias
El Escorial
Friday, August 25
Prado Museum + Botanical Garden
Toledo *
Saturday, August 26
Madrid sightseeing tour
El Escorial
Sunday, August 27
Toledo *
Segovia + La Granja *
Chinchón + Aranjuez *
Monday, August 28
Royal Palace + Pardo Palace
Sepúlveda + Hoces del Río Duratón *
Tuesday, August 29
Madrid de los Austrias
Segovia + Ávila *
Wednesday, August 30
Reina Sofía + Thyssen + Atocha
Chinchón + Aranjuez *

** Full day tours (lunch included)*

Madrid Sightseeing Tour
A panoramic visit of main Madrid sights: Paseo de la Castellana, Cibeles, Neptuno & Carlos V Squares, Flea Market area, Oriente Square, Plaza de España, Gran Vía, Puerta del Sol. King Felipe II made Madrid the capital of his Empire when he chose it as the location for his court in 1561. The small town then underwent considerable urban changes in line with its status of capital city. Thus the Madrid de los Austrias was born, a compact group of streets, squares, monasteries and palaces in the true historic city centre, Plaza Mayor. The most emblematic place in the Madrid de los Austrias is this square, inaugurated by Felipe III in 1620. It was the heart of the city; the market, religious processions, festivities and also bullfights were all held there. Today it is one of Madrid's biggest tourist attractions. The reign of the Bourbons, which began in the 18th century with Felipe V, has also left a legacy of splendid art and monumental treasures in Madrid, the Madrid de los Borbones. The Royal Palace, San Fernando Royal Academy of Fine Arts or the Prado Museum, are just a few examples of places which, apart from their architectural interest, offer to visitors the chance to admire matchless collections of tapestries, furniture, sculptures and world famous art masterpieces.

Reina Sofía Museum
The Reina Sofía museum is Madrid's national museum of modern art. The collection is housed in the former premises of Madrid's General Hospital, which were built in the late 18th century. Although the interior is now a computer-controlled environment, it retains much of the atmosphere of the original building. The highlight of this museum of 20th century art is without doubt Picasso's *Guernica*. It also contains other major works by influential artists including Miró and Picasso, which should not be missed.

Thyssen Museum
The Thyssen Museum is located in the Castellana Street, close to the Gran Vía in the 19th century Palace of Villahermosa. The Museum houses nearly 800 paintings. The collection was begun in 1920 by the Baron von Thyssen-Bornemisza's father, who upon his death distributed the work among his various heirs. Keen to bring his father's collection together, the Baron bought back most of the work from his relatives and subsequently acquired large numbers of new works to assemble one of the world's finest private art collections. The museum was opened in 1992 after an agreement between the Baron and the Spanish government, with the works originally on loan, but a year later the collection was bought outright. The museum contains fine examples of Italian primitives and works from the English, Dutch and German schools. The modern collection includes Impressionist, Expressionist, as well as European and American paintings from the latter half of the 20th century.

Atocha Railway Station
Inside the old building, there is a tropical garden with a special microclimate.

Madrid de los Austrias
The emperor Carlos V ordered the reconstruction of the old Arab fortress, as well as public works around the area where the Royal Palace stands today. Like any other prosperous town, Madrid grew steadily. However, the situation changed abruptly in May 1561, when King Felipe II installed his court in Madrid. Picturesque Renaissance and Baroque buildings mark this period. This tour takes in some of the most representative buildings of the period: Puerta del Sol, Descalzas Reales, Monastery of Encarnación, Capitanía General, Plaza de la Villa (Town Hall Square), Plaza Mayor, Cathedral of San Isidro, the former Court Prison, house of Lope de Vega.

Royal Palace
The Royal Palace of Madrid is the official residence of His Majesty The King of Spain, who makes use of it for official ceremonies, though not residing there. The origins of the Palace go back to the 9th century, during which the Islamic Kingdom of Toledo built a defensive fort on the site, later used by the Kings of Castile. It was on this ancient fortress that the Old Alcázar was constructed in the 16th century. The Alcázar was destroyed by fire on Christmas Eve, 1734, and King Felipe V wished for a New Palace occupying the same site. The entire complex was built with stone and brick vaulting, without any wood, so that no future fire could destroy it. Building work took from 1738 to 1755, and King Carlos III took up residence in the Palace in 1764. The decoration of the Royal Palace of Madrid has evolved over time in accordance with the styles prevailing at different moments. From the reign of King Carlos III are the Throne Room, the King's Chamber (or Gasparini Room), and the Porcelain Room, a masterpiece produced by the Royal Factory of El Buen Retiro. Rich materials were used for the construction and decoration: Spanish marble, gilded stucco, mahogany in doors and windows; and important works of art include frescoes by the principal artists of the period, Giaquinto, Tiepolo and Mengs, and their Spanish followers Bayeu and Maella.

The decoration of the Throne Room has been preserved intact from the reign of King Carlos III. The ceiling fresco, completed in 1766, was painted by Tiepolo; it represents the Allegory of the Spanish Monarchy, with personifications of the different Spanish possessions around the world. The carved gilt furniture and the embroidery of the velvet wall-hangings were manufactured in Naples, where Carlos III had reigned previously. The mirrors, enormous for the period,

are from the Royal Factory of La Granja, and the rock-crystal chandeliers were purchased in Venice in 1780. In 1650, Velázquez brought from Rome the bronze lions flanking the throne dais; originally, they were placed in the Throne Room of the Old Alcázar, which was on virtually the same site.

The Palace gardens are known as Campo del Moro (Moor's Field), but they originated during the reign of King Felipe II. Their present appearance dates from 1890. The square situated to the east of the Palace, and known for this reason as the Plaza de Oriente, has recently been remodelled. It contains several of the statues of the kings of Spain carved during the reign of King Fernando VI.

El Pardo Palace

Set in the wooded parkland known as the Monte de El Pardo, an area of some 16,000 hectares to the North of Madrid, is the Palace of La Zarzuela, residence of Their Majesties The King and Queen of Spain. During the Middle Ages, this parkland (which even today preserves considerable ecological treasures) was used by the Kings of Castile. Over the centuries a small settlement developed, where the Casita del Príncipe (Prince's House) is situated, together with the Convent of Concepcionistas Franciscanas and the Capuchin Friary founded by King Felipe III. The latter contains some notable works of art, including a sculpture of the Recumbent Christ, by Gregorio Fernández, and the Virgin of the Angels, by Francisco de Rizi. In the first half of the 15th century, King Enrique IV of Castile ordered a small castle to be built at El Pardo, and this was rebuilt by the Emperor Carlos V in 1553, being completed in 1558 (in the reign of Felipe II). The Palace of El Pardo inherited its general layout from the mediaeval castle, with towers at the corners and surrounded by a moat. Still preserved from the interior decoration of the Palace, is a ceiling painted by Gaspar Becerra during the reign of King Felipe II, and paintings from the reign of King Felipe III by artists such as Carducho and Cabrera.

A prominent feature of the interior decoration of the Palace is the tapestry collection, woven at the Royal Factory of Madrid following cartoons painted by Bayeu, Castillo and above all Goya, who produced five of his best-known series for this Palace. Among the other works of art displayed here is an equestrian portrait of Don Juan José de Austria, by Ribera, La Cuerna by Velázquez, and furniture dating from the 18th and 19th centuries. Since 1983 the Palace has been adapted as a residence for foreign Heads of State on official visits to Spain. Apart from the palacete (or villa), the property includes wooded parkland and gardens with ornamental fountains. The interior of the palacete is decorated with 19th-century wallpaper, furniture, paintings and carpets from the reigns of Fernando VII and Isabel II.

Prado Museum

Very few cities in the world can offer such a wide variety of cultural attractions as Madrid. The most famous is the Museo del Prado, which contains such a wealth of artistic masterpieces that it cannot be fully appreciated in a single visit. Its building is the best Neoclassical work in Madrid. Begun in 18th century and finished in early 19th century, it houses one of the finest collections of art in the world. Visits are restricted to 75 minutes from Tuesday to Friday, and to 1 hour from 9 am to 11 am on Saturdays. It closes on Monday. The core of the museum, first opened in November 1819, is the Spanish Royal art collection, supplemented by later purchases and works removed from religious houses following their dissolution in the 1830s. The royal collection itself reflects the shifting tastes and alliances of Spain's kings in the sixteenth and seventeenth centuries. There are of course comprehensive examples of works by the Spanish court painters Diego de Velázquez and Francisco de Goya. Close ties with Italy, France and especially the southern (Catholic) Netherlands led to the presence of many superb works by Titian, Rubens and Hieronymus Bosch, among others.

Botanical Garden

Located across the street Alfonso XII, at the southwest corner of Parque de Retiro, the garden contains more than 104 species of trees and 3,000 types of plants. Also on the premises there are an exhibition hall and a library specialized in botanic. The park is open daily from 10 am to 9 pm except in August. It was founded in the 18th century, promoted by Carlos III and constructed by Juan de Villanueva in 1781.

El Escorial

In 1557, Felipe II, King of the Spanish Empire, defeated the French at the battle of San Quintín. The victory was achieved on August 10th, the feast of San Lorenzo. Wishing to show gratitude for the victory, Felipe II decided to build a temple in honour of this Saint. Carlos I was the founder of the Empire, and his son, Felipe II, also wished to construct a magnificent mausoleum for his father, as well as a church, pantheon, study centre and place of retreat and meditation for himself. He decided that it should be located at San Lorenzo de El Escorial, where he also planned the construction of an immense monastery. Thus the Monastery became a monument which would reflect the imperial ideals of Felipe II throughout future centuries. The building is a symbol of the might of the Spanish empire in the 16th century. The Church, with its forty-three altars, each of which is hung with paintings, occupies the central part of the complex. The Mausoleum of the Kings holds the remains of all the Spanish monarchs from Carlos I to Alfonso XIII, as well as those of Juan de Borbón, father of Juan Carlos I. A marble gallery leads to the Mausoleum of the Infants.

Ávila
The famous walls are the symbol of the city, but Ávila is also a city of contrasts: the hustle and bustle of the Mercado (market) contrasting with the peace of the religious buildings and their cloisters. With its churches and convents, beautiful palaces and impressive cathedral, Ávila has a distinctive character and identity in which the spirit of Santa Teresa de Jesús and of San Juan de la Cruz still vibrate. The house where Santa Teresa de Jesús was born is now a well known Church containing the garden and playground where the Saint spent many hours. The church itself has a Neoclassical and Baroque façade, and there is also a Carmelite Convent. Personal objects, relics, and images related to the life of the Saint can be seen.

Alcalá de Henares
The city of Alcalá de Henares (population 180,000) is located 30 kilometers (18 miles) northeast of Madrid. The city has an important historical tradition: Romans called it *Complutum*, and its current name is of Arab origin. The city's many monuments and buildings form part of Spain's national heritage. Alcalá de Henares was the first planned university city in the world, founded by Cardinal Jiménez de Cisneros in the early 16th century. It was the original model for the *Civitas Dei* (City of God), the ideal urban community which Spanish missionaries took to the Americas, and also for universities in Europe and beyond. The University of Alcalá dates back seven centuries and has an historical heritage with which few classical universities of Europe can compare. The university moved to Madrid in 1836. In 1977 a new University of Alcalá was founded, using the old college buildings in the historic city centre and a new campus outside of town. Alcalá de Henares is best known as the birthplace of Miguel de Cervantes, author of *Don Quijote*, and some rare editions of the book can be seen in the casa consistorial (town hall). The city was named a World Heritage Site by UNESCO in 1998.

Toledo
The city in itself is the most characteristic example of Spanish civilization. It is like an immense museum containing some of the most oustanding artistic treasures in Spain. Its old Gothic and Renaissance buildings and its narrow streets provide a vivid portrait of the city and its splendid past. At its heart one may find the works of a painter who epitomises the spirit of the city—El Greco. Today, Toledo is still the spiritual capital of Spain and has officially been declared a National Heritage Site. Suggested visits: the Cathedral, Santo Tomé Church, the Sinagogue, Tavera's Museum, the Alcázar, San Juan de los Reyes and the craft manufacture of its well-known Damascene work.

Segovia
Segovia is Spain and Castile at its best—twisting alleyways, the highest concentration of Romanesque churches in all Europe, pedestrian streets where no cars are allowed, all surrounded by the city's medieval wall which itself is bordered by two rivers and an extensive green-belt park with miles of shaded walks. On the north-west end of the wall is the famous Alcázar castle, a source of inspiration for Walt Disney, and where Queen Isabel promised Columbus the financial backing he needed to discover America. To the south-east is the world-renowned Roman Aqueduct, the largest and best preserved of its kind anywhere, which served as the mintmark on all coins struck in the city from 1455 to 1864. The tallest building in Segovia is still the 16th-century Cathedral, a prominent landmark that can be seen on all approaches to the city.

La Granja
The Royal Seat of La Granja is on the northern side of the Guadarrama Mountains, some 90 kilometres from Madrid. King Felipe V retired to La Granja in 1724, and during the following twenty years enlarged the gardens and the Palace, which was used as a Summer Residence by all his successors down to King Alfonso XIII. Restoration work has recently been carried out on the buildings, and the collections in the State Rooms have been restored and rearranged, with the aim of recreating the atmosphere of the time of Felipe V.

Chinchón
Chinchón is one of the most picturesque and best known towns within the Autonomous Community of Madrid, and the fact that it lies very close to the capital city has not spoiled its unique personality. It stands upon hills in a dark grey and ochre colored landscape, its houses grouped around the main Square from which narrow streets wind about, still bearing witness to the life and the history of the town. The Main Square of Chinchón is one of the finest examples of a medieval square and is widely considered to be one of the most beautiful squares in the world because of its balance and proportions. Numerous activities were traditionally held in this square: from royal festivals, proclamations, travelling theater groups, games, bullfights, executions, eucharistic plays, religious, political and military events and many others, as well as its use as a cinema set. Manuel Alvar, savant and member of the Royal Academy, has written that "the town's main square owes its balance to the perfection of its architectural ensemble".

Aranjuez
The old quarter of Aranjuez is a Historic-Artistic Site. Royal palaces and gardens on the banks of the Tagus form the layout of the town. The ideas of the Enlightenment, applied to the urban development of cities, are embodied here in a balance between nature and man, with watercourses and well-designed gardens lying among the woods and palace architecture. Aranjuez was declared a World Heritage Site by UNESCO in 2001. The Strawberry Train and the festival to commemorate the Revolt of Aranjuez, of National Tourist Interest, are some of the cultural musts awaiting the visitor to this town in the Madrid region. The first thing the visitor can enjoy when approaching Aranjuez is its lush greenery, which forms a sharp contrast to the surrounding arid landscape. The principal points of interest are the 18th-century Palacio Real (Royal Palace), the Casa del Labrador (farm worker's cottage) and some exceptionally fine gardens, especially the Jardín del Príncipe (Prince's Gardens).

General Information About Excursions

- UNICONGRESS reserves the right to cancel or modify the tours or excursion program if a minimum participation of 25 people is not reached or under certain circumstances that may occur beyond the control of the organizers.
- Tours and excursions include transportation in deluxe motor coach, bilingual tourist guide and entrance to museums or monuments where applicable.
- Pre- and post-conference tours include stays in 3- or 4-star hotels and half board.
- Full day excursions include lunch with beverages.
- A tour desk will be at the participants' disposal in the registration area.

E.4 Activities for Accompanying Persons

Accompanying persons are invited to join the Congress tours described above. Besides, here are some ideas to enjoy your time in Madrid on your own:

Best of the Week: www.guiadelocio.com/english/

Opera House: www.teatro-real.com/

Outlet Shopping: www.lasrozasvillage.com/lasrozas/home.asp?lan=en

Karting: www.kartcsainz.com

Real Madrid Stadium Tour: www.realmadrid.es/portada_eng.htm

Planetarium: www.planetmad.es/

Zoo: www.zoomadrid.com

Funfair: www.parquedeatracciones.es/

Aquopolis: www.aquopolis.es/villanueva/

Other Museums: www.softdoc.es/madrid_guide/culture/other_museums.html

F. Travel

F.1 General Information

Madrid can be reached by air, train, bus or car. Detailed information to help participants prepare their travel arrangements appears below (rates correspond to 2005).

BY AIR

Official Airline—IBERIA is the official carrier. Tickets are available for domestic flights, European flights, and international flights with a 30% discount on business, tourist, and excursion fares, subject to route flown and availability. This offer is only valid for return tickets in flights from IBERIA or Air Nostrum. To benefit from this offer, reservations and arrangements must be made either at ATLANTA VIAJES offices (phone: +34 913 104 348 / fax: +34 913 195 322 / e-mail: `madrid@atlantaviajes.es`) or at any IBERIA office. Registration to the Congress is required to benefit from these discounts.

Barajas International Airport

All flights arrive at Barajas International Airport. Barajas Airport is 13 km away from the city and is linked to Madrid by the M30 and M40 motorways.

Airport information phone: +34 902 353 570.

Baggage lockers are available 24 hours a day. Rates will be charged per day or part of day from the time of deposit until midnight of the same day. Cash only. Fees 1st day are 2.75 €; 2 days to 2 weeks: 4.87 € per day large locker or 3.48 € per day small locker.

Regular Bus

Regular bus service is available from the airport to the bus terminal at Avenida de América (city center) with various intermediate stops.

Metro

Line 8 (pink line) takes you to the City Centre (Nuevos Ministerios Station) from the airport. Prices are:

- 1.00 € for a MetroMadrid single trip (Fare zone A);
- 1.30 € for a combined Metro single ticket (Fare zones B1, B2, B3);
- 5.80 € for a ten-trip ticket (Metrobus). Ten-trip tickets are also valid on the buses.

Furthermore, luggage can be checked in at the Nuevos Ministerios Station directly to one's destination.

Airport Parking

Price per hour: 1.30 €; 24 hours: 11.35 €. Long stay parking rates: first and second days, 9 € per day; third, fourth and fifth days, 8 € per day; from the seventhday onwards, 4 € per day. Parking pass: weekend 20.50 €; five days 37 €; one week 48 €; eleven days 59 €; two weeks 72 €.

Taxis

A one-way trip from Madrid Barajas Airport to the city center costs around 25–30 Euros. There should be no problem in getting a taxi from the airport. Taxis can be hailed simply by waving one's hand. They are also available by calling the following numbers:

+34 914 055 500
+34 914 475 180
+34 914 459 008

Car Rental

Major car rental agencies (Avis, Europcar, Hertz, Nacional Atesa, Pepecar) have their offices at the airport.

BY TRAIN

Trains arriving from abroad and from the south, east, and west of Spain, including the high-speed AVE trains, arrive at the Atocha Railway Station (metro Atocha Renfe - Line 1). Trains to and from the north arrive at Chamartín Train Station (metro Chamartín - Line 10). Many trains stop at both stations. Railways in Spain are run by the state company RENFE (phone: +34 902 240 202).

BY BUS

Buses are generally the cheapest form of transport in Spain. The main bus station for international and long distance travel is the Estación Sur de Autobuses, located on the south of the city center (phone: +34 914 684 200).

BY CAR OR PRIVATE TRANSPORTATION

Madrid has six principal highways entering and leaving the city, from N-I to N-VI. It has also two major ring roads; the inner one is known as M30, the outer one is known as M40.

- N-I / A1 (Burgos Highway)—Also known as the Autovía del Norte, this highway connects Madrid to Burgos and Santander, to the cities of the Basque regions (Vitoria, Bilbao, San Sebastián), to France via Irún, and to ferries from the British Islands.
- N-II / A2 (Barcelona Highway)—This is a direct highway to Barcelona and the Costa Brava, via Guadalajara, Zaragoza, and Lleida. Also connects to Southern France via Portbou.
- N-III / A3 (Valencia Highway)—Used for travelling to and from Cuenca, Albacete, Murcia, and the following Mediterranean cities/coastal areas: Alicante (Costa Blanca), Valencia, and Castellón (Costa del Azahar).
- N-IV / A4 (Andalucía Highway)—This is the route to and from the following cities: Cuidad Real, Jaén, Córdoba, Sevilla, Granada, Almería, Malaga, Cádiz, Jerez de la Frontera, the resorts on the Costal del Sol and the Costa Cálida, Gibraltar, and the ferries to Morocco.
- N-V / A5 (Extremadura Highway)—Highway to Talavera, Trujillo, Cáceres, Mérida, Badajoz, and Lisbon and southern Portugal. It is also an alternative route to Western Andalusia.
- N-VI / A6 (A Coruña Highway)—Leads to: El Escorial, Segovia, Ávila, Salamanca, Valladolid, Zamora, León, the cities of Galicia and Asturias, and northern Portugal.

F.2 Congress Agent

UNICONGRESS has been appointed by the Organizing Committee to handle registration for the Congress, and reservation of accommodation and tours, etc. for Congress participants. Please send all correspondence related to the Congress to:

ICM 2006 Technical Secretariat
c/o UNICONGRESS
Bárbara de Braganza, 12 - 3º D
28004 Madrid
Phone: +34 913 104 376
Fax: +34 913 195 746
E-mail: icm2006@unicongress.com

F.3 Tourist Information

A trip to Spain is a celebration of diversity, an opportunity to enjoy our excellent climate, outstanding cuisine, and joie de vivre. But it is also a chance to discover our exceptional cultural and artistic heritage, to experience our unique environment, to get acquainted with the customs of our people and to share with them their festivals and traditions.

Climate

Madrid summer temperatures reach their highest (over 35ºC - 95º F) in July and early August. During the second half of August, and into September, the temperature is cooler, often dropping between 5 and 10 degrees, particularly at night. Most buildings and public facilities are air conditioned. Rain is infrequent but there are occasional summer storms.

Clothing

Short-sleeved shirts, shorts, sun glasses and sun hats. Sandals are a very good idea, and Madrid is a good place to buy them. Sun cream if you have a fair complexion. Formal dress is not required at restaurants or when attending official events, nevertheless you are expected to be appropriately attired.

Madrid Tourist Information

Relevant websites with useful information:

`www.softdoc.es/madrid_guide/info/`
`www.munimadrid.es/`
`www.tourspain.es`

Public Transportation

`www.emtmadrid.es/`
`www.metromadrid.es`

Credit Cards—All major credit cards are accepted in the majority of hotels, restaurants and shops.

Currency—The Spanish currency is the Euro.

Electricity—The electrical supply in most areas of Spain is 220 V, 50 Hz. Plug sockets are European continental standard (two rounded pins).

F.4 About Madrid

Madrid is renowned for cultural tourism and leisure, history and modernity, in a lively and cosmopolitan atmosphere, with first-rate facilities and professional services.

General Data

Madrid is the capital of Spain since 1562. It is located in the geographic centre of the Iberian Peninsula, at 646 metres above sea level. Because of its central location and high altitude, the climate of Madrid is characterized by warm dry summers and cool winters.

Distance between Madrid and main Spanish cities: Toledo: 71km, Segovia: 87km, Salamanca: 200km, Valencia: 352km, Granada: 423km, Córdoba: 394km, Sevilla: 462km, Barcelona: 621km.

Madrid has a population of over four million inhabitants. It is a cosmopolitan city in which the main offices of Public Administration are found, together with the seats of Government and the Spanish Parliament. It is also the main residence of the Spanish Royal Family.

Madrid also plays a major role in both finance and industry. Much of the industry is located in the southern part of the city, where important textile, food and metallurgical plants are concentrated.

Culture and Museums

Madrid is one of the major capitals of the arts. Its galleries and museums are among the finest in the world. It is necessary to set aside a significant amount of time if you want to capture the full flavour of what Madrid has to offer.

If you are unable to stop over for very long, you will almost certainly find that you have more than enough to keep you busy in Madrid's three most important museums along the *Walk of the Art*: Prado, Thyssen and Reina Sofía. These three museums are located near the city centre, all within walking distance of one another, forming what is known as the *golden triangle*. Although it is possible to visit all three museums in a single day, those who try will no doubt end their tour with sore feet. For art lovers, a single visit to any of these three will certainly be insufficient.

Madrid is also a lively metropolis with many pubs, cafés, discotheques and nightclubs open late into the night, where you could discover, for example, flamenco dancing.

Gastronomy

Since Felipe II made Madrid the capital of Spain, numerous recipes and culinary influences from all the regions of the country have been incorporated into its cuisine, so that it is practically impossible to say which dishes are original and which are imported. Today Madrid offers a more Spanish than regional type of cooking.

Typical dishes are mainly hotpots, such as the well-known *cocido madrileño* with chick-peas. Among regional specialities the delicious asparagus from Aranjuez and the very typical *sopa de ajo*—a soup made of garlic—are delicious. There are many dishes of lamb and veal, although surprisingly considering its geographic location, Madrid is a real paradise for the lovers of all kinds of fish. It has the second biggest fish market in the world (after Tokyo), and in shops as well as in many restaurants you will find a wide selection of fish of extraordinary quality. Ideally suited to this kind of meal are the young and aromatic wines of the region, *vinos de Madrid*. To round off your dinner in a very typical way, try a glass of *anisado de Chinchón*—anisette schnapps.

In addition to these specialities, *tapas* are a venerable gastronomic tradition. Served as appetizers with wine or beer, these savoury titbits (such as Serrano ham or *tortilla de patata*) are a distinctive feature in many bars and restaurants throughout the city.

G. Mail and Messages

All mail, telegrams, and faxes for people attending the Congress should be addressed to UNICONGRESS at the address given above (A.3).

Personal Messages

Participants wishing to exchange personal messages during the ICM 2006 should stick their messages on the Message Board located in the lobby of the Palacio Municipal de Congresos.

Public E-Mail Service

During the Congress days, public e-mail service will be available to ICM 2006 participants. For this, a mail server and some client computers are offered in the Palacio Municipal de Congresos.

H. Miscellaneous Information

H.1 Language

Announcements, correspondence, and all other business matters will be written in English.

H.2 Invitation Letter

An official invitation letter will be sent by the Organizing Committee upon request. Requests should be addressed to the ICM 2006 Technical Secretariat (`icm2006@unicongress.com`). This personal invitation is intended only to facilitate travel and visa arrangements to participants. Visa applications are the sole responsibility of participants.

H.3 Bank Services

Euro is the only currency used in Spain. Money exchanges by cash or traveller's cheques can be made in most of the banks located in the City Centre or at Barajas International Airport. There are also money exchange services in all star-rated hotels.

Bank offices near the Palacio Municipal de Congresos:

- Cajamadrid
- Ibercaja
- La Caixa
- Banco Popular
- BBVA

Office hours: from Monday to Friday, 8.15 am to 2 pm. Banks are closed on Saturday and Sunday. A Cajamadrid cashier is located in the Campo de las Naciones underground station.

H.4 Shopping Hours

Opening hours are 10 am to 10 pm for major department stores, from Monday to Saturday.

H.5 First Aid, Health and Accident Insurances

The Congress fee does not include insurance for participants against accidents, sickness, or loss of personal property. Thus, participants are strongly advised to make their own arrangements for short-term health and accident insurance in advance. In any case, the organizers refuse all liability to cover health or accident expenses of participants, unless expenses are due to an act of negligence by ICM 2006.

During the Congress, first aid will be available in the Palacio Municipal de Congresos. In case of emergency, please contact the registration counter. In case of illness, you may go to the hospitals or clinics listed below.

- Hospital Universitario de La Paz: +34 917 277 000
- Hospital Universitario Ramón y Cajal: +34 913 368 000
- Hospital Universitario Puerta del Hierro: +34 913 162 240
- Hospital General Universitario Gregorio Marañón: +34 915 868 000
- Hospital Universitario 12 de Octubre: +34 913 908 000

I. Registration

Registration is required in order to be admitted to the venue and for participation in the scientific program of the Congress and other ICM 2006 activities.

- **Full registration** includes conference materials, the proceedings of the Congress, free coffee during coffee breaks, a public transport ticket valid for the duration of the Congress, and admittance to the opening ceremony.

- **Students** who have not completed their Ph.D. have the option of registering at a reduced student rate on presentation of an official student certificate from their university. Student registration does not include the proceedings of the Congress.

- **Registration for accompanying persons** includes a badge, a public transport ticket valid for the duration of the Congress, and admittance to the opening ceremony.

I.1 Submission of Registration Forms

Registration forms will be available on the Congress website from January 1, 2006. Online submission of the registration form is encouraged. It will also be possible to retrieve a PDF file from the Congress website and submit it by fax or post. All registrations must be submitted on official registration forms. Please use a separate form for each participant.

Please use only one method for submission of your registration. Otherwise, multiple registrations may occur and such registrations may even be rejected by the operational system. Telephone requests cannot be accepted. The registration will be considered as binding when it is received by UNICONGRESS and payment of the total fees has been received.

Participants wishing to reserve hotel accommodation and ticket reservations for the tourist program must be registered.

I.2 Data Protection

The protection of individuals with regard to the processing of personal data and the free movement of such data is published in the European Parliament Directive 95/46/EC and of the Council of October 24, 1995. The Spanish LO 15/99 published in the BOE of December 14, 1999 also refers to personal data protection. In accordance with these directives, personal data of registered participants will be processed by ICM 2006 only for the promotion of the Congress. By filling in the registration form, participants authorize ICM 2006 to use their data for the above mentioned purpose. Participants are entitled to change or erase their personal data through the ICM 2006 Secretariat.

I.3 Secretariat and Registration Counter

Reception of participants will take place at the Conference Registration Counter, which is located at level 0 of the Palacio Municipal de Congresos, where participants will be able to pick up their badges and conference material at the following times:

Monday	August 21	9:00 - 20:00
Tuesday	August 22	7:00 - 20:00
Wednesday	August 23	8:00 - 20:00
Thursday	August 24	8:30 - 18:00
Friday	August 25	8:30 - 18:00
Saturday	August 26	8:30 - 18:00
Sunday	August 27	Closed
Monday	August 28	8:30 - 18:00
Tuesday	August 29	8:30 - 18:00
Wednesday	August 30	8.30 - 18.00

Registration Desk

At the registration desk, registered participants will be provided with badges, documents, and vouchers for all events that have been confirmed. These documents will not be mailed before the Congress. In the case of fees which have been forwarded late and have therefore not yet been credited to the account of ICM 2006 on the day of arrival, a copy of the remittance order must be presented.

On-Site Registration

All registrations processed on or after August 16, 2006, will be delivered on the on-site registration desk. The following credit cards will be accepted for on-site registration: VISA, Eurocard, Mastercard, American Express and Diner's Club.

I.4 Opening Ceremony

Prior registration for the opening ceremony is compulsory. The ceremony will be held in Auditorium A. Extra seats will be available in Auditorium B and Polivalente Hall, receiving audio and video from Auditorium A. Placement will be assigned by the Secretariat on receipt of the registration form. In order to attend the opening ceremony, participants must have completed the registration process at the registration counter located in the Palacio Municipal de Congresos, on August 21 or up to 60 minutes before the opening ceremony on August 22. Tickets indicating the room assigned to each participant will be inside the Congress documentation.

I.5 Registration Fees

	UNTIL MAY 15	MAY 16 TO AUGUST 15	FROM AUGUST 16[2]
Full registration	260 €	300 €	350 €
Student[1]	120 €	170 €	210 €
Accompanying person	80 €	100 €	120 €

[1] *Registration as a student requires the attachment of an official certificate from a university.*
[2] *From August 16, all registrations will be considered on-site registration at the applicable on-site fee.*

I.6 Methods of Payment

All payments must be in Euros and made payable to ICM 2006. No confirmation will be sent until the Congress Technical Secretariat has received the full payment. *Remember to state the participant's name and "ICM 2006" on all payments!*

Payment must be remitted as follows:

- Online registration can be paid only by credit card.
- Fax or mail registration can be paid by bank transfer or credit card.
- On-site registration (processed on or after August 16, 2006) can be paid only by credit card or in cash.

Any bank charges which might be incurred must be met by participants themselves, and if still outstanding they will be charged upon registration at the registration counter in Madrid.

Invoices

If you need an invoice, please send a request in writing with your billing details together with the registration form.

I.7 Cancellations

A handling fee of 30 € will be charged for any changes in registration. Any change of name will be dealt with as a cancellation and a new registration.

Cancellation of Registration

All cancellations must be sent to UNICONGRESS in writing (fax, letter or e-mail).

- In case of cancellations before June 30, 2006, deposits will be refunded less 30 € for administrative costs.
- No refund will be made for cancellations received after June 30, 2006, or for registered participants who fail to attend the Congress.

J. Accommodation

UNICONGRESS has reserved a number of rooms at different hotels in three main areas of Madrid, most of them conveniently located on the main transport routes and accessible by subway.

- AREA A: Conference Venue & Airport Area
- AREA B: Madrid North Area
- AREA C: Madrid Central Area

Hotel Categories

- 5-star hotels (luxury class)
- 4-star hotels (first class)
- 3-star hotels (tourist class)

J.1 Hotel Reservation and Submission of Accommodation Form

Accommodation forms will be available on the Congress website from January 1, 2006. Online submission of the accommodation form is encouraged. It will also be possible to retrieve a PDF file from the Congress website at `www.icm2006.org/accommodation/generalinformation` and submit it by fax or post.

Please use only one method when submitting your accommodation form; otherwise multiple reservations may occur and submissions may even be rejected by the operational system. Telephone reservations cannot be accepted.

Only prepaid reservations will be processed. Full payment covering the entire stay is required to guarantee the booking. Online requests can be paid only by credit card. Fax or mail requests can be paid by credit card or bank transfer. *Requests for hotel accommodation received after July 15, 2006, cannot be guaranteed.*

Reservations are made on a first-come-first-serve basis. Availability of rooms in each category is limited. Names of persons sharing rooms must be stated.

Hotel Check-In—If you plan to arrive at your hotel after 6 pm on the scheduled day of arrival, please indicate your arrival time on your accommodation form in the remarks box, as reserved rooms will be kept only until 6 pm.

Hotel Check-Out—Guests must vacate their rooms before noon on the day of departure. Before booking, please read the hotel reservation and cancellation policy carefully.

J.2 Hotel Rates

Prices per day and room with breakfast fall within the following range:

3-star hotels	single room from 70 to 75 €	double room from 70 to 90 €
4-star hotels	single room from 75 to 120 €	double room from 75 to 120 €
5-star hotels	single room from 110 to 130 €	double room from 110 to 130 €

VAT is additional. Payment for the whole stay is required. Rates are valid for participants for the duration of the Congress.

J.3 Low Budget Accommodation

A small number of rooms have been reserved in student dormitories. Further information about low budget accommodation in Madrid is given in the following Internet addresses:

`www.olehostel.com`
`www.madrid.org/juventud/albergues_refugios.htm`
`www.europeanhostels.com`

J.4 Methods of Payment

All payments must be made in € and are payable to UNICONGRESS, Bárbara de Braganza, 12 - 3º D, 28004 Madrid, Spain.

No confirmation will be sent until UNICONGRESS has received full payment. *Remember to state the participant's name and "ICM 2006" on all payments!*

Payment must be remitted as follows:

- Online accommodation requests can be paid only by credit card.
- Fax or mail accommodation requests can be paid by bank transfer or credit card.

Any bank charges incurred must be met by Congress participants themselves, and if still outstanding they will be charged upon registration at the registration counter in Madrid.

Invoice—If you need an invoice, please send a request in writing with your billing details together with the accommodation form.

J.5 Hotel Cancellation and Changes

A handling fee of 30 € per hotel and room will be charged for any change in reservation up until July 15, 2006. After that date no further changes can be accepted.

Cancellation of Accommodation—All cancellations must be sent to UNICONGRESS in writing (fax, letter or e-mail).

- Cancellations before June 30, 2006: full refund less 30 € for administrative fees.
- Cancellations between June 30, 2006, and July 15, 2006: full refund less one night deposit.
- No refund will be made for cancellations received after July 16, 2006, or confirmed rooms for participants who fail to attend.

Accommodation vouchers, together with a receipt, will be forwarded when payment is received. Please keep these vouchers, as you will need them for check-in at your hotel.

K. Financial Support to Participants

The International Mathematical Union and the Executive Committee of the ICM 2006 are making efforts to obtain financial support to enable as many mathematicians as possible from developing and economically disadvantaged countries to participate at the ICM 2006. Applicants need not necessarily be from IMU member countries.

The IMU and the Organizing Committee have established five different support categories:

1. Young mathematicians from developing and economically disadvantaged countries
2. Senior mathematicians from developing and economically disadvantaged countries
3. Senior mathematicians from Latin America
4. Senior mathematicians from Mediterranean developing countries
5. Young Spanish mathematicians

Eligible countries are listed on the Congress website at `www.icm2006.org/financialsupport`. Other young and senior mathematicians who do not fall within these groups are asked to refrain from applying for this support.

Requirements for Applicants

Applicants should preregister for the Congress. The country of the permanent institution of applicants in categories 1, 2, 3 and 4 must be included in the respective list of eligible countries.

Application Form

All participants who wish to apply for financial support are kindly asked to complete the application form, which can be found at `www.icm2006.org/financialsupport`. There is only one application form, to be used for all five categories of support.

Deadline

The deadline for receipt of applications in all five categories is January 1, 2006. Applicants will be informed of the decision of the selection committee as soon as possible after May 1, 2006.

L. Sponsors

International Congresses of Mathematicians are outstanding for several reasons:
- They convene mathematicians from all over the world;
- It is at these events when Fields Medals and other prizes are awarded;
- They are a great forum in which the state of research and development in Mathematics is checked;
- They provide a platform for many satellite events, making Spain a focal point before, during and after the Congress.

Several institutions have already assigned their contribution to the ICM 2006. They are listed on the Congress website at `www.icm2006.org/sponsors/institutions`. Companies and institutions willing to support the ICM 2006 are invited to contact the Technical Secretariat at `icm2006@unicongress.com`.

M. Exhibitors

Full information concerning the participation of exhibitors, floor plans and the reservation procedure is included in the Exhibitors Manual, which is available on the Congress website at `www.icm2006.org/exhibitors/generalinformation`. Companies and institutions interested in participating in the ICM 2006 exhibition or in other promotional opportunities are kindly requested to contact the Technical Secretariat at `icm2006@unicongress.com`.

N. Satellite Conferences

N1. Application for Satellite Conferences

Satellite conferences are the most important scientific activities surrounding the celebration of every ICM. The Executive Committee of the ICM 2006 encourages all members of the mathematical community to get involved in the organization of scientific meetings and workshops on this occasion.

There are a small number of requisites in order for a meeting to be accepted as a satellite conference, on top of which is the scientific quality and the interest of the research topics proposed, as well as the previous experience of the organizers. Other criteria to be considered are the following:

- The conference may be organized by any scientific group in any of the research areas of current interest in Mathematics.
- The conference must have a strong international projection and, therefore, should be well balanced with respect to the participation of local and international specialists.
- For strategic reasons, proximity in time to the ICM 2006 is required.

The Organizing Committee also encourages people to coordinate efforts and avoid potential conflicts or overlapping with similar initiatives from research groups in the same scientific area.

N2. Preliminary List of Satellite Conferences

Title: **6th Meeting on Game Theory and Practice**
Place and dates: Mediterranean Agronomic Institute, Zaragoza (Spain), 10-12 July
Contact person: Fioravante Patrone
E-mail: patrone@diptem.unige.it
Website: www.iamz.ciheam.org/GTP2006

Title: **Methods of Integrable Systems in Geometry: an LMS Durham Research Symposium**
Place and dates: University of Durham (UK), 11-21 August
Contact person: John Bolton
E-mail: john.bolton@durham.ac.uk
Website: maths.dur.ac.uk/lms/2006/IS

Title: **Harmonic and Geometric Analysis with Applications to PDEs**
Place and dates: Sevilla (Spain), 14-18 August
Contact person: Carlos Pérez
E-mail: carlosperez@us.es

Title: **VII Workshop on Symplectic and Contact Topology, GESTA 2006**
Place and dates: Madrid (Spain), 16-19 August
Contact person: Vicente Muñoz
E-mail: vicente.munoz@imaff.cfmac.csic.es
Website: www.ma1.upc.edu/gesta

Title: **Trends and Challenges in Calculus of Variations and its Applications**
Place and dates: Toledo (Spain), 16-19 August
Contact person: José Carlos Bellido
E-mail: JoseCarlos.Bellido@uclm.es

Title: **Algebraic Geometry**
Place and dates: Segovia (Spain), 16-19 August
Contact person: Raquel Mallavibarrena
E-mail: raquelm@mat.ucm.es

Title: **Conference on Associative and Non-Associative Algebraic Structures**
Place and dates: Oviedo (Spain), 18-20 August
Contact person: Santos González
E-mail: santos@pinon.ccu.uniovi.es
Website: orion.ciencias.uniovi.es/icmoviedo

Title: **CIMPA School on Optimization and Control**
Place and dates: Castro Urdiales (Cantabria, Spain), 28 August to 8 September
Contact person: Eduardo Casas
E-mail: eduardo.casas@unican.es
Website: www.cimpa-icpam.org/Anglais/2006Prog/Spain206.html

Title: **Geometry and Topology of Low Dimensional Manifolds**
Place and dates: Burgo de Osma (Soria, Spain), 31 August to 2 September
Contact person: Antonio Costa
E-mail: acosta@mat.uned.es
Website: www.mai.liu.se/LowDim

Title: **Trends and Topics in the Future of Combinatorial and Computational Geometry**
Place and dates: Alcalá de Henares (Madrid, Spain), 31 August to 5 September
Contact person: Manuel Castellet
E-mail: MCastellet@crm.es
Website: www.crm.es/Conferences/0607/CCGeometry/combinatorial_index.htm

Title: **Workshop on Geometric and Topological Combinatorics**
Place and dates: Alcalá de Henares (Madrid, Spain), 31 August to 5 September
Contact person: Francisco Santos
E-mail: santosf@unican.es
Website: www2.uah.es/gtc06

Title: **Noncommutative Algebra**
Place and dates: Granada (Spain), 31 August to 6 September
Contact person: Pascual Jara
E-mail: pjara@ugr.es
Website: www.ugr.es/~nc_alg/nca

Title: **Mathematical Neuroscience**
Place and dates: Sant Julià de Lòria (Andorra), 1-4 September
Contact person: Manuel Castellet
E-mail: MCastellet@crm.es
Website: www.crm.es/Conferences/0607/Neuroscience/Neuroscience.html

Title: **Topics in Mathematical Analysis and Graph Theory**
Place and dates: Belgrade (Serbia and Montenegro), 1-4 September
Contact person: Milan Merkle
E-mail: emerkle@kondor.etf.bg.ac.yu
Website: magt.etf.bg.ac.yu

Title: **Barcelona Analysis Conference**
Place and dates: Barcelona (Spain), 4-8 September
Contact person: Javier Soria
E-mail: soria@ub.edu
Website: www.imub.ub.es/bac06

Title: **Banach Space Theory: Classical Topics and New Directions**
Place and dates: Cáceres (Spain), 4-8 September
Contact person: Jesús M. F. Castillo
E-mail: castillo@unex.es

Title: **Conference on Singularities and Differential Equations**
Place and dates: Tordesillas (Valladolid, Spain), 4-8 September
Contact person: Jorge Mozo
E-mail: jmozo@maf.uva.es
Website: www3.uva.es/tordesillas2006

Title: **Groups in Geometry and Topology, GGT Málaga 06**
Place and dates: Málaga (Spain), 4-8 September
Contact person: Antonio Viruel
E-mail: viruel@agt.cie.uma.es
Website: agt.cie.uma.es/~ggt06

Title: **International Conference on Arithmetic Algebraic Geometry**
Place and dates: El Escorial (Madrid, Spain), 4-8 September
Contact person: Adolfo Quirós
E-mail: adolfo.quiros@uam.es

Title: **Geometry Conference in Honour of N. Hitchin**
Place and dates: Madrid (Spain), 4-9 September
Contact person: Óscar García-Prada
E-mail: oscar.garcia@imaff.cfmac.csic.es

Title: **International Seminar on Applied Geometry in Andalucía, ISAGA'06**
Place and dates: Granada (Spain), 5-9 September
Contact person: Alfonso Romero
E-mail: aromero@ugr.es
Website: gigda.ugr.es/isaga06

Title: **X Encuentro de Álgebra Computacional y Aplicaciones EACA2006**
Place and dates: Sevilla (Spain), 7-9 September
Contact person: Francisco J. Castro Jiménez
E-mail: castro@us.es

Title: **XV Fall Workshop on Geometry and Physics**
Place and dates: Tenerife (Spain), 11-15 September
Contact person: Juan-Carlos Marrero
E-mail: jcmarrer@ull.es

Title: **Conference on Routing and Location 2006 (CORAL 2006)**
Place and dates: Puerto de la Cruz (Tenerife, Spain), 14-17 September
Contact person: Juan José Salazar
E-mail: jjsalaza@ull.es

O. Committees

Honorary Committee

President
His Majesty, The King of Spain

Members
The Prime Minister of Spain
The President of the Community of Madrid
The Minister of Education and Science
The Minister of Culture
The Minister of Foreign Affairs
The Minister of Industry, Tourism and Trade
The Mayor of the City of Madrid
The Rector of the Universidad Complutense de Madrid
The Rector of the Universidad Autónoma de Madrid
The Rector of the Universidad Politécnica de Madrid
The Rector of the Universidad de Alcalá de Henares
The Rector of the Universidad Carlos III de Madrid
The Rector of the Universidad Rey Juan Carlos
The Rector of the Universidad Nacional de Educación a Distancia
The President of the Consejo Superior de Investigaciones Científicas

Executive Committee

President
Manuel de León, Instituto de Matemáticas y Física Fundamental, CSIC, Madrid

Vice President General
Carlos Andradas, Universidad Complutense de Madrid

Vice Presidents
Carles Casacuberta, Universitat de Barcelona
Eduardo Casas, Universidad de Cantabria, Santander
Pedro Gil Álvarez, Universidad de Oviedo

Secretary General
José Luis González-Llavona, Universidad Complutense de Madrid

Treasurer
Alberto Ibort Latre, Universidad Carlos III de Madrid

Vice Treasurer
Miguel Ángel Rodríguez, Universidad Complutense de Madrid

Local Program Committee
Marta Sanz-Solé, Universitat de Barcelona

Parallel Scientific Activities
Fernando Soria, Universidad Autónoma de Madrid

Relations with Latin America, Eastern Europe and Developing Countries
María Luisa Fernández, Euskal Herriko Unibertsitatea, Bilbao

Web and Electronic Communications
Pablo Pedregal, Universidad de Castilla-La Mancha, Ciudad Real

Cultural Activities
Antonio J. Durán, Universidad de Sevilla

Social Activities
Rosa Echevarría, Universidad de Sevilla

Fund Raising & Sponsorship
María Luisa Fernández, Euskal Herriko Unibertsitatea, Bilbao
Emilio Bujalance, Universidad Nacional de Educación a Distancia, Madrid

Publications
Joan Verdera, Universitat Autònoma de Barcelona

Infrastructure and Logistics
Emilio Bujalance, Universidad Nacional de Educación a Distancia, Madrid

Local Program Committee
Chair: **Marta Sanz-Solé**, Universitat de Barcelona

Members
Jesús Bastero, Universidad de Zaragoza
José A. Carrillo, ICREA and Universitat Autònoma de Barcelona
Wenceslao González-Manteiga, Universidade de Santiago de Compostela

Consuelo Martínez, Universidad de Oviedo
Marcel Nicolau, Universitat Autònoma de Barcelona
Tomás Recio, Universidad de Cantabria, Santander
J. Rafael Sendra, Universidad de Alcalá de Henares
Juan M. Viaño, Universidade de Santiago de Compostela

Parallel Scientific Activities
Chair: **Fernando Soria**, Universidad Autónoma de Madrid

Members
Manuel Barros, Universidad de Granada
Miguel Escobedo, Euskal Herriko Unibertsitatea, Bilbao
Ignacio García Jurado, Universidade de Santiago de Compostela
Luis Narváez Macarro, Universidad de Sevilla

Relations with Latin America, Eastern Europe and Developing Countries
Chair: **María Luisa Fernández**, Euskal Herriko Unibertsitatea, Bilbao

Members
Antonio Cuevas, Universidad Autónoma de Madrid
Eugenio Hernández, Universidad Autónoma de Madrid
Ignacio Luengo, Universidad Complutense de Madrid
Marta Macho, Euskal Herriko Unibertsitatea, Bilbao
Raquel Mallavibarrena, Universidad Complutense de Madrid
José Leandro de María, Universidad Nacional de Educación a Distancia, Madrid
Ernesto Martínez, Universidad Nacional de Educación a Distancia, Madrid
Vicente Muñoz, Instituto de Matemáticas y Física Fundamental, CSIC, Madrid
Domingo Pestaña, Universidad Carlos III de Madrid
José Manuel Rodríguez, Universidad Carlos III de Madrid

Cultural Activities
Chair: **Antonio J. Durán**, Universidad de Sevilla

Members
Antonio F. Costa, Universidad Nacional de Educación a Distancia, Madrid
Guillermo P. Curbera, Universidad de Sevilla
Raúl Ibáñez, Euskal Herriko Unibertsitatea, Bilbao

Web and Electronic Communications
Chair: **Pablo Pedregal**, Universidad de Castilla-La Mancha, Ciudad Real

Member
Ernesto Aranda Ortega, Universidad de Castilla-La Mancha, Ciudad Real

Infrastructure and Logistics
Chair: **Emilio Bujalance**, Universidad Nacional de Educación a Distancia, Madrid

Members
M. José Muñoz Bouzo, Universidad Nacional de Educación a Distancia, Madrid
Roberto Canogar McKenzie, Universidad Nacional de Educación a Distancia, Madrid
Francisco Javier Cirre Torres, Universidad Nacional de Educación a Distancia, Madrid
Miguel Delgado Pineda, Universidad Nacional de Educación a Distancia, Madrid
Ana M. Porto F. Silva, Universidad Nacional de Educación a Distancia, Madrid

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.

Eugene, Oregon

University of Oregon

November 11–13, 2005
Friday - Sunday

Meeting #1012
Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: September 2005
Program first available on AMS website: September 29, 2005
Program issue of electronic *Notices*: November 2005
Issue of *Abstracts*: Volume 26, Issue 4

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: Expired

Invited Addresses

Matthew D. Foreman, UC Irvine, *Classification and anti-classification theorems for measure preserving transformations.*

Mark D. Haiman, University of California, Berkeley, *New combinatorial developments in the theory of Macdonald polynomials.*

Wilhelm Schlag, University of Chicago, *Spectral theory and nonlinear PDEs.*

Hart F. Smith, University of Washington, *Wave packets and wave equations.*

Special Sessions

Algebraic Combinatorics and Geometry, **Sara C. Billey**, University of Washington, and **Mark Haiman**, University of California Berkeley.

Algebraic Geometry Motivated by Physics, **Alexander Polishchuk** and **Arkady Vaintrob**, University of Oregon.

Algebraic Topology of Moduli Spaces, **Boris I. Botvinnik**, University of Oregon, **Uwe Kaiser**, Boise State University, and **Dev Sinha**, University of Oregon.

Applications of Algebraic Topology, **Daniel Dugger** and **Hal Sadofsky**, University of Oregon.

Harmonic Analysis and PDEs, **Wilhelm Schlag**, California Institute of Technology, and **Hart F. Smith**, University of Washington.

K-Theory in M-Theory, **Gregory D. Landweber**, University of Oregon, and **Charles F. Doran**, University of Washington.

New Directions in Spectral Theory and Geometric Analysis, **Leon Friedlander**, University of Arizona, and **Patrick McDonald**, New College of Florida.

Noncommutative Algebra and Noncommutative Birational Geometry, **Arkady Dmitrievich Berenstein**, University of Oregon, and **Vladimir Retakh**, Rutgers University.

Partial Differential Equations with Applications, **Alexander Panchenko**, Washington State University, **R. E. Showalter**, Oregon State University, and **Hong-Ming Yin**, Washington State University.

Regular Algebras and Noncommutative Projective Geometry, **Brad Shelton**, University of Oregon, **Michaela Vancliff**, University of Texas at Arlington, and **James J. Zhang**, University of Washington.

Representations of Groups and Algebras, **Jonathan W. Brundan**, **Alexander S. Kleshchev**, and **Viktor Ostrik**, University of Oregon.

Resolutions, **Christopher Alan Francisco**, University of Missouri, and **Irena Peeva**, Cornell University.

Wavelets, Frames, and Related Expansions, **Marcin Bownik**, University of Oregon, and **Darrin M. Speegle**, St. Louis University.

Taichung, Taiwan

Tung-Hai University

December 14–18, 2005

Wednesday - Sunday

Meeting #1013

First Joint International Meeting between the AMS and the Taiwanese Mathematical Society.
Associate secretary: John L. Bryant
Announcement issue of *Notices*: June 2005
Program first available on AMS website: Not applicable
Program issue of electronic *Notices*: Not applicable
Issue of *Abstracts*: Not applicable

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: Expired

Invited Addresses

Lawrence Ein, University of Illinois at Chicago, *Title to be announced.*

Chang-Shou Lin, National Chung Cheng University, *Title to be announced.*

Richard M. Schoen, Stanford University, *Title to be announced.*

Jing Yu, National Tsing Hua University, *Title to be announced.*

Jiu-Kang Yu, Purdue University, *Title to be announced.*

Special Sessions

Affine Algebraic Geometry, **Ming-Chang Kang**, National Taiwan University, and **Kwai-Man Fan**, National Chung Cheng University.

Algebraic Geometry, **Jung-Kai Chen**, National Taiwan University, **Chin-Lung Wang**, National Central University, and **Robert Lazarsfeld**, University of Michigan.

Differential Geometry, **Dong-Ho Tsai**, National Tsing Hua University, and **Bennett Chow**, University of California San Diego.

Discrete Mathematics (Graph Coloring), **Gerard J. Chang**, National Taiwan University, **Douglas B. West**, University of Illinois at Urbana-Champaign, and **Xuding Zhu**, National Sun Yat-sen University.

Dynamics and Differential Equations, **Song-Sun Lin**, National Chiao Tung University, and **Shui-Nee Chow**, Georgia Institute of Technology.

Lie Algebra and Representation Theory, **Shun-Jen Cheng**, National Taiwan University, and **Brian J. Parshall** and **Weiqiang Wang**, University of Virginia.

Number Theory (Arithmetic Geometry over Local and Global Fields), **Liang-Chung Hsia**, National Central University, and **William A. Cherry**, University of North Texas.

Operator Theory and Control, **Fang-Bo Yeh**, Tung-Hai University, and **Nicholas J. Young**, University of Newcastle.

Optimization and Applications, **Soon-Yi Wu**, National Cheng Kung University, and **Shu-Cherng Fang**, North Carolina State University.

Partial Differential Equations and Geometric Analysis, **Chiun-Chuan Chen** and **Yng-Ing Lee**, National Taiwan University, **Sun-Yung Alice Chang**, Princeton University, and **Robert J. Sibner**, Graduate College, City University of New York.

Probability, **Tai-Ho Wang**, National Chung Cheng University, **Ching-Tang Wu**, National Kaohsiung University, and **George Yin**, Wayne State University.

Scientific Computing, **Wei-Cheng Wang**, National Tsing-Hua University, and **Thomas Y. Hou**, California Institute of Technology.

Statistical Modeling and Applications, **Ming-Yen Cheng**, National Taiwan University, and **Jianqing Fan**, Department of Operations Research and Financial Engineering, Princeton University.

San Antonio, Texas

Henry B. Gonzalez Convention Center

January 12–15, 2006

Thursday - Sunday

Meeting #1014

Joint Mathematics Meetings, including the 112th Annual Meeting of the AMS, 89th 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), the winter meeting of the Association for Symbolic Logic (ASL), with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).

Associate secretary: Matthew Miller
Announcement issue of *Notices*: October 2005
Program first available on AMS website: November 1, 2005
Program issue of electronic *Notices*: January 2006
Issue of *Abstracts*: Volume 27, Issue 1

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: Expired

AMS Program Updates

Function, Design, and Evolution of Gene Circuitry is the title of the **Gibbs Lecture** on Thursday evening. The speaker is **Michael Savageau**.

Riemann-Roch for Determinantal Gerbes and Infinite-dimensional Bundles is the title of **Mikhail Kapranov's Invited Address** on Thursday morning.

MAA Program Updates

Serious Data and Serious Tools on the Web for a Serious Problem, 2:30 p.m. on Saturday, includes **Geoff Kuhlmann, Joe Lindquist, Heather Stevenson**, and **Frank Wattenberg**, U.S. Military Academy, as panelists.

Updates—Other Organizations

Shaping a Career in Mathematics is the title of the **AWM Workshop Panel Discussion** on Sunday afternoon. The moderator is **Marie A. Vitulli**, University of Oregon, and panelists include **Janet Anderson**, Hope College; **Dusa McDuff**, SUNY Stony Brook; **Mara D. Neusel**, Texas Tech University; and **Michelle D. Wagner**, National Security Agency.

Social Events

Two-Year College Reception, Friday, 5:45 p.m. to 7:00 p.m.

NSA Women in Mathematics Society, Friday, 6:30 p.m. to 8:30 p.m. Everyone is invited to this annual networking session on Friday evening. Please stop by the NSA booth in the exhibit area for the exact location.

Miami, Florida

Florida International University

April 1–2, 2006

Saturday - Sunday

Meeting #1015

Southeastern Section
Associate secretary: Matthew Miller
Announcement issue of *Notices*: January 2006
Program first available on AMS website: February 16, 2006
Program issue of electronic *Notices*: April 2006
Issue of *Abstracts*: Volume 27, Issue 2

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: December 13, 2005
For abstracts: February 7, 2006

Invited Addresses

Andrea R. Nahmod, University of Massachusetts, Amherst, *Title to be announced.*

Edward Odell, University of Texas at Austin, *Title to be announced.*

Karen V. H. Parshall, University of Virginia, *The British development of the theory of invariants, 1841–1895.*

Michael S. Vogelius, Rutgers University, *Title to be announced.*

Special Sessions

Approximation Theory and Orthogonal Polynomials (Code: SS 5A), **Doron S. Lubinsky**, Georgia Institute of Technology, and **Edward B. Saff**, Vanderbilt University.

Commutative Algebra and Algebraic Geometry (Code: SS 1A), **Laura Ghezzi**, Florida International University, **Huy Tài Hà**, Tulane University, and **Aron Simis**, University Federal de Pernambuco.

Composition Operators and Complex Dynamical Systems (Code: SS 16A), **Brian P. Kelly**, University of Louisiana, Monroe, and **Christopher N. B. Hammond**, Connecticut College.

Financial Mathematics (Code: SS 17A), **Alec N. Kercheval** and **Craig A. Nolder**, Florida State University.

Geometry of Banach Spaces and Connections with Other Areas (Code: SS 11A), **Edward W. Odell**, University of Texas at Austin, **Thomas B. Schlumprecht**, Texas A&M University, and **Stephen Dilworth**, University of South Carolina.

Geometry of Riemannian Manifolds with Additional Structures (Code: SS 2A), **Tedi C. Draghici, Gueo V. Grantcharov**, and **Philippe Rukimbira**, Florida International University.

Harmonic Analysis and Partial Differential Equations (Code: SS 10A), **Mario Milman**, Florida Atlantic University, and **Marius Mitrea**, University of Missouri.

History of Mathematics (Code: SS 18A), **Karen H. Parshall**, University of Virginia.

Imaging, Homogenization, and Shape Optimization (Code: SS 14A), **Michael S. Vogelius**, Rutgers University, and **Shari Moskow**, University of Florida.

Interpolation Theory and Applications (Code: SS 15A), **Michael Cwikel**, Technion, **Laura De Carli**, Florida International University, and **Mario Milman**, Florida Atlantic University.

Invariants of Low-Dimensional Manifolds (Code: SS 9A), **Thomas G. Lennes**, Florida International University, and **Nikolai N. Saveliev**, University of Miami, Coral Gables.

Mathematical Models in Image and High-Dimensional Data Analysis (Code: SS 13A), **Hanna E. Makaruk** and **Robert M. Owczarek**, Los Alamos National Laboratory, and **Nikita Sakhaneko**, University of New Mexico and Los Alamos National Laboratory.

Monomials and Resolutions (Code: SS 3A), **Joseph P. Brennan**, North Dakota State University, and **Heath M. Martin**, University of Central Florida.

Nonlinear Waves (Code: SS 19A), **Andrea R. Nahmod**, University of Massachusetts, Amherst, and **Sijue Wu**, University of Michigan at Ann Arbor.

Partial Differential Equations and Several Complex Variables (Code: SS 6A), **Shiferaw Berhanu**, Temple University, and **Hamid Meziani**, Florida International University.

Qualitative Analysis of Partial Differential Equations (Code: SS 4A), **Congming Li**, University of Colorado.

Recent Developments on Fluid and Geophysical Fluid Dynamics (Code: SS 12A), **C. Cao** and **T. Tachim Medjo**, Florida International University, and **X. Wang**, Florida State University.

Singular Integrals, Geometric Analysis, and Free Boundary Problems (Code: SS 8A), **Marianne Korten** and **Charles N. Moore**, Kansas State University.

Spectral Geometry of Manifolds with Boundary and Singular Spaces (Code: SS 20A), **Juan B. Gil**, Pennsylvania State University, Altoona, and **Patrick T. McDonald**, New College, University of South Florida.

Structure of Function Spaces and Applications (Code: SS 7A), **Jan Lang**, The Ohio State University, and **Osvaldo Mendez**, University of Texas at El Paso.

Notre Dame, Indiana

University of Notre Dame

April 8–9, 2006

Saturday – Sunday

Meeting #1016

Central Section
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: January 2006
Program first available on AMS website: February 23, 2006
Program issue of electronic *Notices*: April 2006
Issue of *Abstracts*: Volume 27, Issue 2

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: December 20, 2005
For abstracts: February 14, 2006

Invited Addresses

Douglas N. Arnold, Institute for Math and Applications, University of Minnesota, *Title to be announced.*

Béla Bollobás, University of Memphis and Cambridge University, *Inhomogeneous random graphs* (Erdős Memorial Lecture).

Steven C. Hofmann, University of Missouri, *Title to be announced.*

Michael Larsen, University of Indiana, *Title to be announced.*

Christopher M. Skinner, University of Michigan, *Title to be announced.*

Special Sessions

Algebraic Structures of Exactly Solvable Models (Code: SS 9A), **Michael Gekhtman**, University of Notre Dame, **Mikhail Shapiro**, Michigan State University, and **Alexander Stolin**, University of Gothenburg.

Analysis and Geometry of Non-linear Evolution and Equations (Code: SS 19A), **Alexandrou A. Himonas** and **Gerard K. Misiolek**, University of Notre Dame.

Combinatorial Algebraic Geometry (Code: SS 2A), **Juan C. Migliore**, University of Notre Dame, and **Uwe R. 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.

Developments and Applications in Differential Geometry (Code: SS 4A), **Jianguo Cao**, **Xiaobo Liu**, and **Brian Smyth**, University of Notre Dame.

Dynamical Systems (Code: SS 10A), **Francois Ledrappier**, University of Notre Dame, and **Amie Wilkinson**, Northwestern University.

Harmonic Analysis, PDE and Geometric Function Theory (Code: SS 14A), **John L. Lewis**, University of Kentucky, and **Steve C. Hofmann**, University of Missouri.

Holomorphic Methods and Heat Kernels in Harmonic Analysis and Quantization Theory (Code: SS 16A), **Brian Hall** and **William Kirwin**, University of Notre Dame.

Mathematical Biology (Code: SS 11A), **Mark Alber** and **Bei Hu**, University of Notre Dame.

Model Theory and Computability (Code: SS 8A), **Steven Allen Buechler** and **Julia Knight**, University of Notre Dame, **Steffen Lempp**, University of Wisconsin, and **Sergei Starchenko**, University of Notre Dame.

New Developments in Optimization (Code: SS 15A), **Leonid Faybusovich**, University of Notre Dame.

Nonlinear Waves (Code: SS 13A), **Mark S. Alber** and **Pavel Lushnikov**, University of Notre Dame, and **Ildar Gabotiv** and **Vladimir E. Zakharov**, University of Arizona.

Number Theory (Code: SS 21A), **Scott T. Parsell** and **Jonathan P. Sorenson**, Butler University.

Numerical Solution of Polynomial Systems (Code: SS 7A), **Christopher S. Peterson**, Colorado State University, and **Andrew J. Sommese**, University of Notre Dame.

PDEs and Geometric Analysis (Code: SS 22A), **Matt Gursky** and **Qing Han**, University of Notre Dame.

Several Complex Variables (Code: SS 6A), **Nancy K. Stanton** and **Jeffrey A. Diller**, University of Notre Dame.

Special Functions and Orthogonal Polynomials (Code: SS 5A), **Diego Dominici**, State University of New York at New Paltz.

Topics in Representation Theory (Code: SS 17A), **Samuel R. Evans**, University of Notre Dame, and **Jiu-Kang Yu**, Purdue University.

Topology and Physics (Code: SS 18A), **Stephan A. Stolz** and **Bruce Williams**, University of Notre Dame.

Undergraduate Mathematical Research (Code: SS 20A), **Francis X. Connolly**, University of Notre Dame, and **Zsuzsanna Szaniszlo**, Valparaiso University.

Water Waves (Code: SS 12A), **David Nicholls**, University of Illinois at Chicago.

Durham, New Hampshire

University of New Hampshire

April 22–23, 2006
Saturday - Sunday

Meeting #1017
Eastern Section
Associate secretary: Lesley M. Sibner
Announcement issue of *Notices*: January 2006
Program first available on AMS website: March 9, 2006
Program issue of electronic *Notices*: April 2006
Issue of *Abstracts*: Volume 27, Issue 2

Deadlines
For organizers: Expired
For consideration of contributed papers in Special Sessions: January 3, 2006
For abstracts: February 28, 2006

Invited Addresses

Ailana M. Fraser, University of British Columbia, *Title to be announced.*

Dmitri Nikshych, University of New Hampshire, *Title to be announced.*

Florian Pop, University of Pennsylvania, *Title to be announced.*

Konstantina Trivisa, University of Maryland, College Park, *Title to be announced.*

Special Sessions

Algebraic Groups (Code: SS 5A), **George J. McNinch**, Tufts University, and **Eric Sommers**, University of Massachusetts, Amherst.

Arithmetic Geometry and Modular Forms (Code: SS 6A), **Paul E. Gunnells** and **Farshid Hajir**, University of Massachusetts, Amherst.

Arrangements and Configuration Spaces (Code: SS 10A), **Graham C. Denham**, University of Western Ontario, and **Alexander I. Suciu**, Northeastern University.

Banach Lattices, Regular Operators, and Applications (Code: SS 3A), **A. K. Kitover**, Community College of Philadelphia, **M. Orhon**, University of New Hampshire, and **A. W. Wickstead**, Queen's University of Belfast.

Banach Spaces of Analytic Functions (Code: SS 2A), **Rita A. Hibschweiler**, University of New Hampshire, and **Thomas H. MacGregor**, SUNY Albany and Bowdoin College.

Discrete and Convex Geometry (Code: SS 1A), **Daniel A. Klain**, University of Massachusetts (Lowell), **Barry R. Monson**, University of New Brunswick, and **Egon Schulte**, Northeastern University.

Galois Theory in Arithmetic and Geometry (Code: SS 8A), **Florian Pop** and **David Harbater**, University of Pennsylvania, and **Rachel J. Pries**, Colorado State University.

Geometric Methods in Group Theory and Topology (Code: SS 9A), **Kim Ruane**, Tufts University, **Jennifer Taback**, Bowdoin College, and **Peter N. Wong**, Bates College.

Global Perspectives on the Geometry of Riemann Surfaces (Code: SS 14A), **Eran Makover** and **Jeffrey K. McGowan**, Central Connecticut State University.

Hopf Algebras and Galois Module Theory (Code: SS 4A), **Timothy Kohl**, Boston University, and **Robert G. Underwood**, Auburn University Montgomery.

Mathematical Challenges in Physical and Engineering Sciences (Code: SS 13A), **Marianna A. Shubov**, University of New Hampshire.

Quantum Invariants of Knots and 3-Manifolds (Code: SS 11A), **Charles D. Frohman**, University of Iowa, and **Razvan Gelca**, Texas Tech University.

Symplectic and Contact Topology (Code: SS 7A), **Weimin Chen**, **Michael G. Sullivan**, and **Hao Wu**, University of Massachusetts, Amherst.

Topological Algebras and Applications (Code: SS 12A), **Alexander A. Katz**, St. John's University, and **Genady Y. Grabarnik**, IBM T. J. Watson Research Center.

San Francisco, California

San Francisco State University

April 29–30, 2006
Saturday - Sunday

Meeting #1018
Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: January 2006
Program first available on AMS website: March 16, 2006
Program issue of electronic *Notices*: April 2006
Issue of *Abstracts*: Volume 27, Issue 2

Deadlines
For organizers: Expired

For consideration of contributed papers in Special Sessions: January 10, 2006
For abstracts: March 7, 2006

Invited Addresses

Lincoln Chayes, University of California Los Angeles, *Title to be announced.*

C. Robin Graham, University of Washington, *Title to be announced.*

Vadim Kaloshin, California Institute of Technology, *Title to be announced.*

Benoit B. Mandelbrot, Yale University, *From pure mathematics to roughness in art* (Einstein Public Lecture in Mathematics).

Yuval Peres, University of California Berkeley, *Title to be announced.*

Special Sessions

Computational Arithmetic Geometry (Code: SS 13A), **Kenneth A. Ribet**, University of California Berkeley, and **Kristin Estrella Lauter**, Microsoft Corporation.

Elliptic Methods in Geometry (Code: SS 3A), **C. Robin Graham**, University of Washington, and **Rafe Mazzeo**, Stanford University.

Enumerative Aspects of Polytopes (Code: SS 10A), **Federico Ardila** and **Matthias Beck**, San Francisco State University.

Fractal Geometry: Connections to Dynamics, Geometric Measure Theory, Mathematical Physics and Number Theory (Code: SS 4A), **Michel L. Lapidus** and **Erin P. Pearse**, University of California Riverside, and **Machiel van Frankenhuijsen**, Utah Valley State College.

Geometric Dynamics and Ergodic Theory (Code: SS 11A), **Yitwah Cheung** and **Arek Goetz**, San Francisco State University, and **Slobodan Simic**, San Jose State University.

Geometry of Gröbner Bases (Code: SS 2A), **Bernd Sturmfels**, University of California Berkeley, and **Alexander Yong**, University of Minnesota and Fields Institute.

Hilbert Functions and Resolutions (Code: SS 12A), **Benjamin Richert**, California Polytechnic State University, and **Sean Sather-Wagstaff**, California State University, Dominguez Hills.

History and Philosophy of Mathematics (Code: SS 1A), **Shawnee L. McMurran**, California State University, San Bernardino, and **James J. Tattersall**, Providence College.

Homological and K-theoretical Trends in Algebraic Combinatorics (Code: SS 6A), **Joseph Gubeladze** and **Serkan Hosten**, San Francisco State University.

Liapunov Exponents and Nonuniform Hyperbolicity (Code: SS 7A), **Anton Gorodetski** and **Vadim Kaloshin**, California Institute of Technology.

Lie Algebras and Applications (Code: SS 9A), **Dimitar Grantcharov**, San Jose State University, **Vera Serganova**, University of California Berkeley, and **Arturo Pianzola**, University of Alberta.

Partial Differential Equations and Their Applications (Code: SS 14A), **Steve Shkoller**, University of California Davis.

Probability and Statistical Physics (Code: SS 5A), **Marek Biskup**, University of California Los Angeles, **Noam Berger**, California Institute of Technology & University of California Los Angeles, and **Balint Virag**, University of Toronto.

Q-series and Partitions (Code: SS 8A), **Neville Robbins**, San Francisco State University.

Salt Lake City, Utah

University of Utah

October 7–8, 2006

Saturday - Sunday

Meeting #1019

Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: July 2006
Program first available on AMS website: August 24, 2006
Program issue of electronic *Notices*: October 2006
Issue of *Abstracts*: Volume 27, Issue 3

Deadlines

For organizers: March 7, 2006
For consideration of contributed papers in Special Sessions: June 20, 2006
For abstracts: August 15, 2006

Invited Addresses

William Arveson, University of California Berkeley, *Title to be announced.*

Alexei Borodin, California Institute of Technology, *Title to be announced.*

Izabella Joanna Laba, University of British Columbia, *Title to be announced.*

Darren Long, University of California Santa Barbara, *Title to be announced.*

Special Sessions

Harmonic Analysis: Trends and Perspectives (Code: SS 1A), **Alex Iosevich**, University of Missouri, and **Michael T. Lacey**, Georgia Institute of Technology.

Cincinnati, Ohio

University of Cincinnati

October 21–22, 2006

Saturday - Sunday

Meeting #1020

Central Section
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: July 2006

Program first available on AMS website: September 7, 2006
Program issue of electronic *Notices*: October 2006
Issue of *Abstracts*: Volume 27, Issue 3

Deadlines

For organizers: March 21, 2006
For consideration of contributed papers in Special Sessions: July 5, 2006
For abstracts: August 29, 2006

Invited Addresses

Suncica Canic, University of Houston, *Title to be announced.*

Bryna R. Kra, Northwestern University, *Title to be announced.*

Ezra N. Miller, University of Minnesota, *Title to be announced.*

Jon G. Wolfson, Michigan State University, *Title to be announced.*

Special Sessions

Ergodic Theory (Code: SS 1A), **Nikos Frantzikinakis**, Pennsylvania State University, **Bryna R. Kra**, Northwestern University, and **Mate Wierdl**, University of Memphis.

Storrs, Connecticut

University of Connecticut

October 28–29, 2006

Saturday - Sunday

Meeting #1021

Eastern Section
Associate secretary: Lesley M. Sibner
Announcement issue of *Notices*: July 2006
Program first available on AMS website: September 14, 2006
Program issue of electronic *Notices*: October 2006
Issue of *Abstracts*: Volume 27, Issue 4

Deadlines

For organizers: March 28, 2006
For consideration of contributed papers in Special Sessions: July 11, 2006
For abstracts: September 6, 2006

Special Sessions

Combinatorial Methods in Equivariant Topology (Code: SS 1A), **Tara Holm**, University of Connecticut, Storrs, and **Tom C. Braden**, University of Massachusetts, Amherst.

Fayetteville, Arkansas

University of Arkansas

November 3–4, 2006

Friday - Saturday

Meeting #1022

Southeastern Section
Associate secretary: Matthew Miller
Announcement issue of *Notices*: September 2006
Program first available on AMS website: September 21, 2006
Program issue of electronic *Notices*: November 2006
Issue of *Abstracts*: Volume 27, Issue 4

Deadlines

For organizers: April 3, 2006
For consideration of contributed papers in Special Sessions: July 18, 2006
For abstracts: September 12, 2006

Invited Addresses

Richard P. Anstee, University of British Columbia, *Title to be announced.*

Arun Ram, University of Wisconsin, *Title to be announced.*

Donald G. Saari, University of California Irvine, *Title to be announced.*

Andras Vasy, Massachusetts Institute of Technology, *Title to be announced.*

Special Sessions

Dirac Operators in Analysis and Geometry (Code: SS 1A), **John Ryan**, University of Arkansas, **Marius Mitrea**, University of Missouri, and **Mircea Martin**, Baker University.

New Orleans, Louisiana

New Orleans Marriott and Sheraton New Orleans Hotel

January 4–7, 2007

Thursday - Sunday

Meeting #1023

Joint Mathematics Meetings, including the 113th Annual Meeting of the AMS, 90th 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 for Industrial and Applied Mathematics (SIAM).
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: October 2006
Program first available on AMS website: November 1, 2006
Program issue of electronic *Notices*: January 2007
Issue of *Abstracts*: Volume 28, Issue 1

Deadlines

For organizers: April 1, 2006
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Davidson, North Carolina

Davidson College

March 3–4, 2007

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 3, 2006
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Oxford, Ohio

Miami University

March 16–17, 2007

Friday - Saturday
Central Section
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: To be announced
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Special Sessions

Geometric Topology (Code: SS 2A), **Jean-Francois LaFont**, SUNY Binghamton and Ohio State University, and **Ivonne J. Ortiz**, Miami University.

Large Cardinals in Set Theory (Code: SS 1A), **Paul B. Larson**, Miami University, **Justin Tatch Moore**, Boise State University, and **Ernest Schimmerling**, Carnegie Mellon University.

Hoboken, New Jersey

Stevens Institute of Technology

April 14–15, 2007

Saturday - Sunday
Eastern Section
Associate secretary: Lesley M. Sibner
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 14, 2006
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Tucson, Arizona

University of Arizona

April 21–22, 2007

Saturday - Sunday
Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: September 21, 2006
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

San Diego, California

San Diego Convention Center

January 6–9, 2008

Sunday - Wednesday
Joint Mathematics Meetings, including the 114th Annual Meeting of the AMS, 91st 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 for Industrial and Applied Mathematics (SIAM).
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: October 2007
Program first available on AMS website: November 1, 2007
Program issue of electronic *Notices*: January 2008
Issue of *Abstracts*: Volume 29, Issue 1

Deadlines

For organizers: April 1, 2007
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Bloomington, Indiana

Indiana University

April 4–6, 2008

Friday - Sunday
Central Section
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: September 4, 2007
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Vancouver, Canada

University of British Columbia

October 4–5, 2008

Saturday - Sunday
Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: March 9, 2008
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Shanghai, People's Republic of China

Fudan University

December 17–21, 2008

Wednesday - Sunday
First Joint International Meeting Between the AMS and the Shanghai Mathematical Society
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: To be announced
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Washington, District of Columbia

Marriott Wardman Park Hotel and Omni Shoreham Hotel

January 7–10, 2009

Wednesday - Saturday
Joint Mathematics Meetings, including the 115th Annual Meeting of the AMS, 92nd 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 for Industrial and Applied Mathematics (SIAM).
Associate secretary: Lesley M. Sibner
Announcement issue of *Notices*: October 2008
Program first available on AMS website: November 1, 2008
Program issue of electronic *Notices*: January 2009
Issue of *Abstracts*: Volume 30, Issue 1

Deadlines

For organizers: April 1, 2008
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

San Francisco, California

Moscone Center West and the San Francisco Marriott

January 6–9, 2010

Wednesday – Saturday
Joint Mathematics Meetings, including the 116th Annual Meeting of the AMS, 93rd Annual Meeting of the Mathematical Association of America (MAA), annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association for Symbolic Logic (ASL), with sessions contributed by the Society of Industrial and Applied Mathematics (SIAM).
Associate secretary: Matthew Miller
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: April 1, 2009
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

New Orleans, Louisiana

New Orleans Marriott and Sheraton New Orleans Hotel

January 5–8, 2011

Wednesday – Saturday
Joint Mathematics Meetings, including the 117th Annual Meeting of the AMS, 94th Annual Meeting of the Mathematical Association of America, annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association for Symbolic Logic (ASL), with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).
Associate secretary: Susan J. Friedlander
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 2, 2011
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: Lesley M. Sibner
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: April 1, 2012
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

The 2005 *Notices* Index

January issue: 1–192	**May issue: 497–592**	**October issue: 1001–1168**
February issue: 193–312	**June/July issue: 593–712**	**November issue: 1169–1312**
March issue: 313–392	**August issue: 713–824**	**December issue: 1313–1464**
April issue: 393–496	**September issue: 825–1000**	

About the Cover

The AMS

Announcements

Authors of Articles

Invited Speakers

Letters to the Editor

Mathematicians

Mathematics

Mathematics Calendar

Mathematics History

Meeting Announcements, Presenters of Papers, and Programs

Meetings and Conferences

2005 Meetings

2006 Meetings

2007 Meetings

2008 Meetings

Prizes and Awards

The Profession

Reference and Book List

Reviews

Stipends for Study and Travel, 900

Surveys

Table of Contents

Visiting Mathematicians

WHAT IS...

THE CITADEL
THE MILITARY COLLEGE OF SOUTH CAROLINA

Dean

School of Science & Mathematics

The Citadel invites nominations and applications for the position of Founding Dean of the School of Science and Mathematics and the Traubert Chair in Science and Mathematics. Candidates should possess an earned doctorate and have a strong commitment to promoting teaching and research at a predominantly undergraduate institution.

The Dean's primary responsibilities include general administration of the School and oversight of curricular, budgetary, academic program and faculty development matters. The School seeks a proven leader who will provide vision for both undergraduate and graduate programs. The successful candidate will be expected to facilitate and strengthen relations with alumni and the local community. The Dean is expected also to lead the School's fundraising and development efforts in close collaboration with the College's professional development staff.

The Citadel, The Military College of South Carolina, was founded in 1842 and is located in historic Charleston, South Carolina. It is a unique, coeducational state-assisted institution committed to educating principled leaders in a challenging intellectual environment. The School of Science and Mathematics offers both graduate and undergraduate degrees in Biology; Health, Exercise and Sport Science; and Mathematics and Computer Science and undergraduate degrees in Chemistry (ACS-accredited) and Physics. There are approximately 320 undergraduate and 75 graduate students in these programs. The School has 43 full-time faculty members actively engaged in teaching, research, and service.

Minimum qualifications:

- Earned doctorate in a basic sciences field or from one of the disciplines included in the School and demonstrated evidence of distinguished teaching, research, and significant scholarly work to qualify for appointment as a tenured full professor.
- A proven record of administrative experience in higher education that should include skills in planning, faculty development, budgeting and resource development.
- Strong interpersonal, communication, and decision-making abilities to interact effectively with the public and a commitment to excellence and diversity in the recruitment and retention of students, faculty, and staff.
- Commitment to shared governance and the values of educational excellence and service consistent with the mission and core values of The Citadel.
- Proven ability to:
  - Develop and maintain relationships with external constituencies
  - Acquire external resources through grants, contracts and gifts
  - Work effectively and collaboratively with the faculty at departmental and college levels
  - Foster teaching, research and professional development in a student-centered environment

Compensation is highly competitive and commensurate with education and experience. Applications should include a statement of educational and leadership philosophy; curriculum vita; a Citadel application (www.citadel.edu/hr); and the names, mailing, e-mail addresses, and telephone numbers of at least three references. Applications, inquiries and nominations should be directed to: Dr. Michael R. Ferrari, Senior Vice President and Managing Director, Higher Education Practice, EFL Associates, 2275 Half Day Road, Suite 350, Bannockburn, Illinois 60015. Phone: 847-821-2797. E-mail: mferrari@eflassociates.com. Please reference job #EA-02AMS. The review of nominations and applications will begin on November 15, 2005 and continue until an appointment is made (122649).

The Citadel is an affirmative action/ equal opportunity employer actively committed to ensuring diversity in all campus employment.

University of Nebraska Lincoln

Intensive Mathematics: a Mentoring, Education and Research Summer Experience

June 28—August 9, 2006

An NSF-funded research and mentoring experience in algebra and analysis for beginning graduate students in mathematics.

There is a $3,000 stipend, plus up to $500 for travel. Room and board are provided on campus.

Participants must be U.S. citizens or permanent residents and intend to enroll in a Mathematics graduate program (which offers a Ph.D. degree) for the Fall 2006 semester.

For more information, visit us on the web at

www.math.unl.edu/immerse

or write to us at

Nebraska IMMERSE
Department of Mathematics
University of Nebraska-Lincoln
203 Avery Hall
Lincoln, NE 68588-0130
adonsig1@math.unl.edu

Deadline for application March 1, 2006

University of Nebraska-Lincoln
An equal opportunity educator and employer with a comprehensive plan for diversity

Joint Meetings Advance Registration/Housing Form

Joint Mathematics Meetings

January 12–15, 2006

Name _____
(please write name as you would like it to appear on your badge)

Mailing Address _____

_____

Telephone _____ Fax: _____

In case of emergency at the meeting, call: Daytime #_____ Evening #: _____

Email Address _____
(Acknowledgment of this registration will be sent to the email address given here, unless you check this box: *Send by U.S. Mail* ☐)

Badge Information: Affiliation for badge _____

Nonmathematician guest badge name _____
(please note charge below)

☐ **I DO NOT want my program and badge to be mailed to me on 12/09/05.**

Membership
✓ all that apply. First column is eligible for member registration fee

AMS	☐	ASA	☐
MAA	☐	AWM	☐
ASL	☐	NAM	☐
CMS	☐	YMN	☐
SIAM	☐		

Registration Fees

Joint Meetings	**by Dec 16**	**at mtg**	**Subtotal**
☐ Member AMS, ASL, CMS, MAA, SIAM	US $203	US $264	
☐ Nonmember	US $315	US $409	
☐ Graduate Student	US $ 41	US $ 51	
☐ Undergraduate Student	US $ 21	US $ 27	
☐ High School Student	US $ 2	US $ 5	
☐ Unemployed	US $ 41	US $ 51	
☐ Temporarily Employed	US $163	US $189	
☐ Developing Countries Special Rate	US $ 41	US $ 51	
☐ Emeritus Member of AMS or MAA	US $ 41	US $ 51	
☐ High School Teacher	US $ 41	US $ 51	
☐ Librarian	US $ 41	US $ 51	
☐ Nonmathematician Guest	US $ 15	US $ 15	
			$ _____

AMS Short Course: *Modeling and Simulation of Biological Networks (1/10–1/11)*

☐ Member of AMS or MAA	US $ 87	US $118	
☐ Nonmember	US $115	US $148	
☐ Student, Unemployed, Emeritus	US $ 38	US $ 57	
			$ _____

MAA Short Course: *Experimental Mathematics in Action (1/10–1/11)*

☐ Member of MAA or AMS	US $125	US $140	
☐ Nonmember	US $175	US $190	
☐ Student, Unemployed, Emeritus	US $ 50	US $ 60	
			$ _____

MAA Minicourses (see listing in text)
I would like to attend: ☐ One Minicourse ☐ Two Minicourses
Please enroll me in MAA Minicourse(s) #_____ and/or #_____
In order of preference, my alternatives are: #_____ and/or #_____
Prices: US $95 for Minicourses #1–6; US $60 for #7–16
$ _____

Employment Center
Applicant résumé forms and employer job listing forms will be on the AMS website and in *Notices* in September and October.

Employer—First Table ☐ Regular ☐ Self-scheduled	US $230	US $310
Employer— Each Additional Table ☐ Regular ☐ Self-scheduled	US $ 80	US $110
☐ Employer—Posting Only	US $ 50	N/A
☐ Applicant (all services)	US $ 42	US $ 80
☐ Applicant (Winter List & Message Ctr only)	US $ 21	US $ 21

$ _____

Events with Tickets
MER Banquet (1/13) US $47 #____Regular #____Veg #____Kosher
NAM Banquet (1/14) US $48 #____Regular #____Veg #____Kosher
AMS Banquet (1/15) US $46 #____Regular #____Veg #____Kosher
$ _____

Other Events
☐ Graduate Student/First Time Attendee Reception (1/12) (no charge)
☐ AMS Workshop *TA Development Using Case Studies* US $20 $ _____

Total for Registrations and Events $ _____

Registration for the Joint Meetings is not required for the Short Courses, but it is required for the Minicourses and the Employment Center.

Payment

Registration & Event Total (total from column on left) $ _____

Hotel Deposit (only if paying by check) $ _____

Total Amount To Be Paid **$** _____

(Note: A US $5 processing fee will be charged for each returned check or invalid credit card. Debit cards are not accepted.)

Method of Payment
☐ Check. Make checks payable to the AMS. Checks drawn on foreign banks must be in equivalent foreign currency at current exchange rates.
☐ Credit Card. VISA, MasterCard, AMEX, Discover (no others accepted)

Card number: _____

Exp. date: _____ Zipcode of credit card billing address: _____

Signature: _____

Name on card: _____

☐ Purchase order #_____ (please enclose copy)

Other Information

Mathematical Reviews field of interest # _____

How did you hear about this meeting? Check one: ☐ Colleague(s) ☐ *Notices* ☐ *Focus* ☐ Internet

☐ This is my first Joint Mathematics Meeting.
☐ I am a mathematics department chair.
☐ For planning purposes for the MAA Two-year College Reception, please check if you are a faculty member at a two-year college.
☐ **Please do not include my name on any promotional mailing list.**
☐ I would like to receive promotions for future JMM meetings.
☐ Please ✓ this box if you have a disability requiring special services.

Mail to:

Mathematics Meetings Service Bureau (MMSB)
P. O. Box 6887
Providence, RI 02940-6887 Fax: 401-455-4004
Questions/changes call: 401-455-4143 or 1-800-321-4267 x4143; mmsb@ams.org

Deadlines *Please register by the following dates for:*

Résumés/job descriptions printed in the *Winter Lists*	**Oct. 26, 2005**
To be eligible for the room lottery:	**Nov. 4, 2005**
For housing reservations, badges/programs mailed:	**Nov. 14, 2005**
For housing changes/cancellations through MMSB: for La Mansion: December 7, 2005 All others:	**Dec. 14, 2005**
For advance registration for the Joint Meetings, Employment Center, Short Courses, MAA Minicourses, & Tickets:	**Dec. 16, 2005**
For 50% refund on banquets, cancel by:	**Jan. 2, 2006***
For 50% refund on advance registration, Minicourses & Short Courses, cancel by:	**Jan. 6, 2006***

***no refunds after this date**

San Antonio Joint Meetings Hotel Reservations

To ensure accurate assignments, please rank hotels in order of preference by writing 1, 2, 3, etc., in the column on the left and by circling the requested room type and rate. If the rate or the hotel requested is no longer available, you will be assigned a room at a ranked or unranked hotel at a comparable rate. Participants are urged to call the hotels directly for details on suite configurations, sizes, and availability; however, suite reservations can be made only through the MMSB to receive the convention rates listed. Reservations at the following hotels must be made through the MMSB to receive the convention rates listed. Reservations made directly with the hotels may be changed to a higher rate. All rates are subject to a 16.75% sales tax. **Guarantee requirements: First night deposit by check (add to payment on reverse of form) or a credit card guarantee.**

☐ Deposit enclosed (see front of form) ☐ Hold with my credit card Card Number_____ Exp. Date____ Signature _____

Date and Time of Arrival _____ **Date and Time of Departure** _____

Name of Other Room Occupant _____ **Arrival Date**_____ **Departure Date**_____ **Child (give age(s)** _____

Order of choice	Hotel	Single	Double 1 bed	Double 2 beds	Triple 2 beds	Triple 2 beds w/cot	Triple -queen w/cot or sofa bed	Quad 2 beds	Quad 2 beds w/cot	Suites Starting rates
	Marriott Riverwalk (hqtrs)	US $148	US $148	US $148	US $168	US $168	US $168	US $168	US $168	US $575
	Student	US $118	US $118	US $118	US $138	US $138	US $138	US $138	US $138	N/A
	Marriott Rivercenter (hqtrs)	US $148	US $148	US $148	US $168	US $168	US $168	US $168	US $168	US $575
	Student	US $118	US $118	US $118	US $138	US $138	US $138	US $138	US $138	N/A
	Hilton Palacio del Rio	US $146	US $146	US $146	US $166	N/A	N/A	US $186	N/A	US $750
	Student	US $117	US $117	US $117	US $137	N/A	N/A	US $157	N/A	N/A
	Marriott Residence Inn	US $120	US $120	N/A	N/A	N/A	N/A	N/A	N/A	all suites
	Student	US $96	US $96	N/A	N/A	N/A	US $96	N/A	N/A	all suites
	Riverwalk Plaza Hotel	US $119	US $119	US $119	US $129	US $139	US $139	US $129	US $139	US $229
	Student	US $95	US $95	US $95	US $105	US $115	US $115	US $105	US $115	N/A
	The Crockett	US $115	US $115	US $115	US $125	US $135	US $135	US $135	US $145	US $135
	Student	US $90	US $90	US $90	US $100	US $110	$110	US $110	US $120	N/A
	Menger	US $118	US $118	US $118	US $128	US $128	N/A	US $138	US $138	US $195
	Student	US $96	US $96	US $96	US $106	US $106	N/A	US $116	US $116	N/A
	St. Anthony Hotel	US $115	US $125	US $125	US $135	US $135 + $15 one time charge	US $135 + $15 one time charge	US $145	US $145 + $15 one time charge	US $250
	La Mansion del Rio	US $115	US $115	US $115	US $140	US $165	N/A	US $165	US $190	US $889
	Student	US $93	US $93	N/A	N/A	N/A	US $143	N/A	N/A	N/A
	Holiday Inn Riverwalk	US $112	US $112	US $112	US $112	N/A	US $112	US $112	N/A	US $199
	Student	US $90	US $90	US $90	US $90	N/A	US $90	US $90	N/A	N/A
	Holiday Inn Express Hotel & Suites	US $109	US $109	US $109	US $109	US $109	US $109	US $109	US $109	all suites
	Student	US $87	US $87	US $87	US $87	US $87	US $87	US $87	US $87	all suites
	Hampton Inn Downtown	US $94	US $104	US $104	US $104	N/A	US $114	US $104	N/A	N/A
	Red Roof Inn Downtown	US $59.99	US $59.99	US $59.99	US $64.99	US $74.99	US $74.99	US $69.99	US $79.99	N/A

Special Housing Requests:

☐ I have disabilities as defined by the ADA that require a sleeping room that is accessible to the physically challenged. My needs are:

_____

☐ Other requests:

_____

☐ I am a member of a hotel frequent-travel club and would like to receive appropriate credit.
The hotel chain and card number are:

_____

If you are not making a reservation, please check off one of the following:

☐ I plan to make a reservation at a later date.

☐ I will be making my own reservations at a hotel not listed. Name of hotel: _____

☐ I live in the area or will be staying privately with family or friends.

☐ I plan to share a room with_____, who is making the reservations.

Meetings and Conferences of the AMS

Associate Secretaries of the AMS

Western Section: Michel L. Lapidus, Department of Mathematics, University of California, Sproul Hall, 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.

Eastern Section: Lesley M. Sibner, Department of Mathematics, Polytechnic University, Brooklyn, NY 11201-2990; e-mail: lsibner@duke.poly.edu; telephone: 718-260-3505.

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.

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 100 in the January 2005 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.

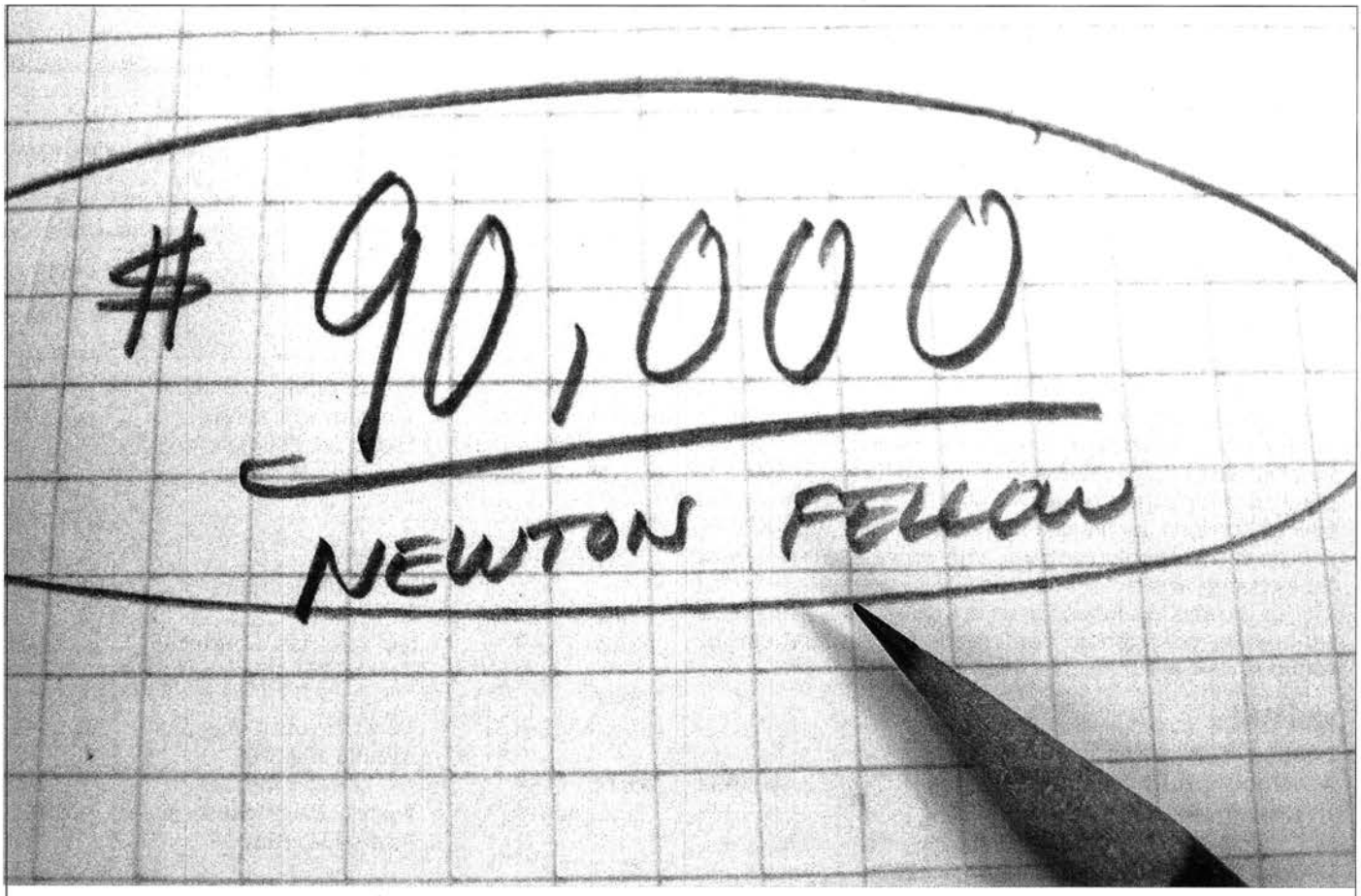
Questions about abstracts and requests for paper forms may be sent to abs-info@ams.org.

Paper abstract forms must be sent to Meetings & Conferences Department, AMS, P.O. Box 6887, Providence, RI 02940. There is a $20 processing fee for each paper abstract. There is no charge for electronic abstracts. Note that all abstract deadlines are strictly enforced.

Conferences: (see http://www.ams.org/meetings/ for the most up-to-date information on these conferences.)

June 4–June 29, 2006: Joint Summer Research Conferences in the Mathematical Sciences, Snowbird, Utah (see November 2005 *Notices*, page 1296).

Co-sponsored conference: 22nd Annual Workshop on Mathematical Problems in Industry, June 12-16, 2006, Olin College, Needham, MA. For details see http://projects.olin.edu/mpi2006/.



You do the math.

The Newton Fellowship Program is looking for mathematically sophisticated individuals to teach in NYC public high schools. Newton Fellows earn competitive starting salaries on par with scientists, engineers and architects. The Fellowship provides an aggregate $90,000 in stipends, full tuition scholarship for a master's, mentoring, coaching, and professional development.

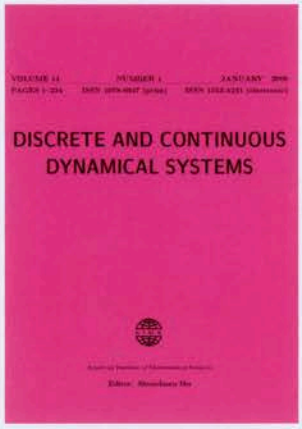
Nobody goes into teaching for the money. The best teachers do it out of love for the subject and a passion to inspire. As a Newton Fellow, you can have it all. So who better to teach math than you?

For a more rewarding future, apply for the Newton Fellowship at mathforamerica.org/newton

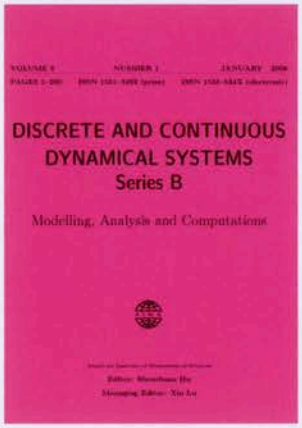
MfA Math for America

The infinite possibilities of mathematical literacy.

Journals from AIMS http://AimSciences.org

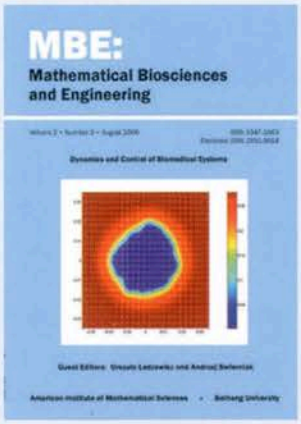


AIMS is an international organization to promote mathematical sciences through its publications and conferences. You are cordially invited to participate.



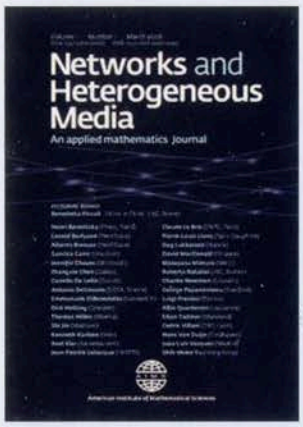
The full text of all AIMS journals is now available electronically for view, search and subscription. Subscriptions include online access to all back volumes. Journals are peer-reviewed to ensure the highest quality and relevance. Submissions can be sent to either an editor or AIMS, electronically. Information on online, order and submission at

http://AimSciences.org



Focused on modeling, analysis and computations, DCDS-B ranks the top 12th among all applied math journals with impact factor of 1.3. DCDS is one of the world leading math journals and ranks the top 14th among all math journals. Data based on ISI's JCR. While MBE is being recognized as a quality journal in biomath, NHM is a high profile addition to the world of applied math

The Sixth AIMS Conference
at University of Poitiers
Poitiers, France.
June 25 - 28, 2006.



American Institute of Mathematical Sciences
P.O.Box 2604,Springfield,MO 65897 USA
General@aimSciences.org; (417)836-5377; Fax(417)886-0559